ACTUAL PROBLEMS OF MODERN SCIENCE

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Bydgoszcz – 2021

Actual problems of modern science. Monograph: edited by Matiukh S., Skyba M., Musial J., Polishchuk O. – 2021. – 758 p.

Monograph is prepared at the Khmelnytskyi National University in cooperation with Bydgoszcz University of Science and Technology, Poland.

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Responsible Secretary: Romanets T.
Technical Secretariat: Horiashchenko S., Lisevych S., Polasik R.
ISBN: 978-83-938655-5-0
DOI: 10.31891/monograph/2021-10-1

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Al. prof. S. Kaliskiego 7, 85-796 Bydgoszcz, Poland, https://pbs.edu.pl/pl/

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UKRAINE - EUROPEAN UNION:

STATE, PROBLEMS AND PROSPECTS

UKRAINE'S GREEN DEAL TO THE EUROPEAN UNION

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DOI: 10.31891/monograph/2021-10-1

1. Introduction

At the end of 2019, the European Commission adopted the European Green Deal (EGD), a program of EU action centered on an ambitious plan for a transition to a climate-neutral Europe and full decarbonisation.This strategy is based on the EU's resource-efficient economy, which in 2050 will have a zero balance of greenhouse gas emissions, and economic growth will be separated from the use of natural resources. The need for such changes arose due to rapid climate change associated with increasing greenhouse gas emissions in the twentieth century due to human activities. Ukraine plans to join this deal, declaring in the National Economic Strategy the intention to achieve climate neutrality in 2060. However, such a transition could be a huge challenge for our country due to outdated technologies in industry, low quality of public administration and too ambitious goals proposed by the European Union for Ukraine.

Such scientists as Andrusevych A., Kozak Z., Kravchuk V., Shore K. [1], Alekankina K. [2] studied the issue of the European green deal from Ukraine.

The climate issue is of great concern between the countries of the European Union and the Ukrainian state, which is cause the need of fruitful cooperation in order to ensure a great future for both.

That is why the main purpose of this article is to identify the main environmental problems of Ukraine, the path of Ukraine with the notes of the Green Deal.

2. European Green Deal

In December 2019, the European Commission adopted Strategies, plans, legislation for the implementation of the EGD, which were developed and approved, mainly during 2020-2021. But the pace of implementation of the Green Deal has slowed slightly, given the priority of responding to COVID-19. However,

the European Commission has emphasized that reconstruction must focus on a more sustainable, green and digital Europe, solutions that are not only good for the economy but also for the environment. This means a constant "green" course and adherence to the implementation schedule of important components of the ECC. This approach has been supported by a number of EU Member States, including Germany and France.

The European Green Deal is a roadmap for actions that will transform the European Union into an efficient, sustainable and competitive economy, identify the means to transform Europe into the world's first climate-neutral continent by 2050, stimulate economic development, improve health and quality of life, and transform climate and environmental challenges for opportunities in all areas and policies of the EU, ensuring a fair and inclusive nature of the green transition.

The European Green Deal covers the following areas: climate change, energy, industrial strategy for the circular economy, sustainable mobility, green agriculture, biodiversity, zero pollution, finance, and EU global leadership. The goals of the European Green Deal have already begun to shape the main trends in environmental, economic, energy, transport, industrial and agricultural policies not only in the EU but also in the global world.

3. Ukraine and the Green deal

Ukraine's intention to join the European Green Deal opens up a number of opportunities related to the potential of Ukraine's integration into the European space in certain sectors. However, in the case of its own passive position and disregard for European trends, Ukraine may, on the contrary, face additional barriers in relations with the EU. Thus, for Ukraine, the realization of the goals of the EGD will mean both new directions of development and significant transformational challenges.

Accordingly, this determines the need for in-depth analysis of all components of the EGD, monitoring of trends in their practical implementation in the EU, active and systematic involvement of civil society to establish dialogue between key stakeholders in both Ukraine and the EU, persistent and systematic implementation of obligations under the Agreement, on the association, its gradual renewal where necessary, as well as the use of EU-proposed investment opportunities, including within the framework of the new priorities of the Eastern Partnership until 2025.

This dialogue has certain results – Ukraine is already a part of the consultations on the implementation of Carbon Border Adjustment Mechanism (CBAM). Official documents of the European Parliament and the European Commission, as well as unofficial information, based on the results of the dialogue with the EU, confirm that for third countries with which there is an association agreement or free trade zone, an individual approach to the application of CBAM can be used. The coordinated systemic policy developed by the government this summer made it possible to achieve this result [3].

The implementation of the Green Deal in Ukraine should have a positive impact on the energy balance and ensure the development of the sector, in particular given the need of [2]:

- creation of a full-fledged competitive environment in the energy market of Ukraine;

- changes in heat generation by renewable energy sources and the implementation of a full-fledged transformation of coal regions, which means the gradual closure of unprofitable enterprises with the parallel creation of alternative jobs in these regions;

- providing consumers with proportional tariffs;

- building a proportional tariff policy in the field of renewable energy sources in order to increase the share of renewable energy and maintain a favorable investment climate in this area;

- maintaining a high share of nuclear generation, taking into account the need to ensure compliance with service life limits, safety and prevention of man-made risks.

Accordingly, the provisions for achieving the environmental objectives of the EGD are enshrined in the reform of the EU's Common Agricultural Policy and the EU's biodiversity and field-to-table strategies.

First of all, it is envisaged to reduce the use of pesticides (by 25% - by 2030), fertilizers and antibiotics (by 25% - by 2030) in agriculture, as well as the introduction of a ban on food imports from markets where countries do not comply with EU legislation. environmental protection.Instead, the Ukrainian government is already showing a low figure: while the EU wants to change it from 3.14 to 1.57 kg / ha, in Ukraine it is already 0.75 kg / ha.

Focusing on EU agricultural policy on food security and reducing the impact of agriculture on the environment will have a sharp impact on strengthening the requirements of EU member states to Ukrainian food exporters.

And this is a challenge for Ukraine, namely for its agricultural exporters. In this regard, the main need is to bring the agricultural sector in line with EU requirements. The reorientation to ecologically clean agri-food production and development of smart agriculture should start today.

Greening of the transport sector plays a key role in achieving the ambitious goals of the European Green Agreement.

The EU Strategy for Sustainable and Intellectual Mobility will focus on achieving the objectives of the EGD, as well as the EU's priorities in the field of industrial cooperation and biodiversity.

Thus, emissions in the transport sector should be reduced by 90% by 2050. The maximum transition is expected to vehicles with zero emissions, as well as those that will combine electricity and hydrogen in their operation.

Another priority for Ukraine within the EGD is to control pollution of the Black Sea to preserve its biodiversity and support and restore ecosystem functions.

It is critical for Ukraine to reduce the level of plastic pollution in the Black Sea (83% of marine litter found in the Black Sea is plastic). It is important to work on expanding garbage monitoring programs, including microplastics, which pose the most serious threat to the Black Sea fauna and flora.

Ukraine is actively involved in the implementation of the Common Maritime Agenda for the Black Sea and the Strategic Research and Innovation Program for the Black Sea to achieve the eco-goal - healthy marine and coastal ecosystems of the Black Sea.

There is a clear awareness in the EU that it is the regions and cities that play a vital role in achieving national and pan-European climate and energy goals. They are the main executors of the European Green Deal. Its success will largely depend on the ability of local and regional authorities to implement policies adopted at European level, as well as on the ability of national governments and EU institutions to understand and take into account the specific needs of each region, each territory.

The EU directly involves cities and regions in the development and implementation of investments related to the Green Deal, in particular through the

EU Committee of the Regions. This strengthens cohesion mechanisms and regional funds for cities and regions to gain direct access to EU resources, as it is local and regional authorities that know best about the real situation on the ground.

The EU is currently implementing a number of initiatives to support local and regional authorities that want to be active in implementing the "green deal", including: Covenant of Mayors, Covenant of Green Cities, Challenge for 100 Smart Cities, Declaration of European Circular Cities, Platform for Fair transition, etc.

In June 2020, the Committee of the Regions of the EU set up a new working group "Green Deal Going Local" to ensure the direct participation of EU cities and regions in identifying, implementing and evaluating the many initiatives envisaged by the European Green Deal. to achieve climate neutrality by 2050.

In Ukraine, most of the environmental reforms currently being implemented in implementation of the Association Agreement with the EU have a clear regional component - they entrust new functions to local authorities and create new opportunities for the regions. The effectiveness of the implementation of the Association Agreement directly depends on the implementation on the ground of the necessary new mechanisms, standards, practices and is closely linked to the state regional policy, including in the environmental sphere.

Ukraine is currently adapting environmental legislation to EU norms and standards, completing local self-government reform and decentralization of power, holding local elections on a new territorial basis - so the renewed regions today have a good opportunity to become not only observers but also active participants in the approximation process. and implementation of the Environmental Association Agreement.

As in the EU, Ukraine needs to establish an effective dialogue between central and regional authorities, local governments, civil society and experts in order to jointly develop approaches and solutions to carry out the necessary transformations and achieve ambitious environmental goals. , which will have a positive impact on the life of every Ukrainian [4].

Energy and energy efficiency are the areas of EGD that have attracted the most attention in Ukraine.

There has been a lot of talk lately about hydrogen production and supply. Cooperation on this issue has great but long-term prospects. The only thing that is

usually forgotten here is the need for plenty of fresh water for hydrogen production in water-deficient Ukraine.

Instead, the latest EU trends in the transition to electricity in heating farms (target - 40% by 2030) do not find support in Ukraine. Currently, the share of electric heating is very low (about 2%), and there is no target at all. Therefore, there is no room for bilateral initiatives.

While European industrial policy has a clear focus on decarbonisation, the main business proposals in Ukraine are how to avoid it. Although there are more than enough opportunities for Ukrainian producers - to take at least the opportunity to participate in green alliances or the opportunity to occupy new environmentally friendly niches that are emerging in the EU in connection with the decarbonisation process.

Despite the expectation that environmental protection (in its classical sense) will finally become a priority issue on the political agenda - this is not happening, although the potential and opportunities in this context are more than enough.

However, in terms of the share of the nature reserve fund (NRF), Ukraine and the EU plan to move in the same direction. We want to increase the NPF from 6.8% to 15% of the total area, the EU - from 23% to 30%.

To take advantage of this similarity, proper implementation of environmental commitments under the Association Agreement and political leadership is needed to promote mutually beneficial initiatives for Ukraine and the EU, such as a joint environmental monitoring space, the creation of an additional cluster of the NATURA 2000 network.

One of the most serious issues that arises when discussing Ukraine's place in the EGD is the financing of Ukraine's green transition. The EU supports all its initiatives on decarbonisation and climate neutrality with financial instruments; there is no such practice in Ukraine yet. Also, data on climate budget expenditures are not collected, and the implementation of environmental principles in the financial system of Ukraine is just beginning. Although it is important not only to attract green investment and use EGD instruments that are available or may be available to Ukraine, but also to create a carbon pricing system and targeted financing of the green transition, in particular through "green" government bonds [5].

4. Effects of the European Green Deal for Ukraine

Thus, climate change becomes an unconditional priority of the EU, and for Ukraine it means the need to clearly articulate climate policy, namely certain climate goals under the Paris Agreement, the relevant energy strategy, taking into account climate change. Opportunities are hidden in the low current energy efficiency and high carbon intensity of Ukraine's economy, which are caused by both high depreciation of fixed assets and a significant share of fossil fuels in the energy balance. The creation of an effective international mechanism will attract significant amounts of "green" funding. It is obvious that the new non-tariff barriers to trade will be "climatic", and in climate-friendly areas such barriers will be reduced.

Also, the implementation of the EGD creates a number of strategic opportunities for Ukraine for development. The conclusion of an industrial visa-free regime will encourage the integration of Ukrainian industries into new EU industrial processes. Expected restrictions on the "environmental friendliness" of goods and services placed on the EU market may create new opportunities for Ukrainian producers. In the field of agriculture, this may be to strengthen the development of organic production, in the field of energy - cooperation on hydrogen energy. In the field of nature protection - the integration of protected areas of Ukraine into the NATURA 2000 network through the creation of special financial instruments. Effective domestic reforms in the areas of EU integration and climate change are a prerequisite for seizing opportunities and reducing the likelihood or impact of threats arising from the ECA for Ukraine.

Strengthening the quality requirements for certain products and technologies is likely to create additional challenges for "industrial visa-free travel", as EU plans create a difficult "moving target" for Ukraine in this area. The strengthening of the secondary raw materials market in the EU is likely to lead to a reduction in exports of secondary raw materials to Ukraine, which will affect processing plants, which are currently dependent on imports of such raw materials. The EU's desire to reduce road haulage in order to reduce emissions may have an impact on the issuance of permits to Ukrainian hauliers. The high priority of nature protection in the EU may in practice mean meticulous attention on the part of the EU and its financial institutions to the implementation of the relevant obligations of Ukraine, in particular in the implementation of investment projects in the energy sector.

A separate group of threats from the introduction of EGD is the consequences for the environment in Ukraine. The development of the electric car market in the EU and, accordingly, filling the Ukrainian market with used electric cars from Europe, on the one hand, will have a positive impact on reducing pollution in cities, but on the other hand, the use of "dirty" electricity may lead to new environmental problems in Ukraine. The development of inland water transport will require addressing a number of environmental issues related to the construction of new waterways or the operation of previously created [1].

5. Conclusion

Thus, Ukraine's path together with the European Green Deal will be very difficult. Some mechanisms in agriculture, for example, have already been established, others need to be clarified. A lot of work needs to be done: to adapt to EU standards in the production of certain sets of exports, to develop a road route to combat environmental problems, to address the issue of decarbonisation. But the main thing is that the first steps have already been taken and further cooperation between Ukraine and the EU is expected.

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ANALYSIS OF PLANT MARKET PRODUCTS OF UKRAINE

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DOI: 10.31891/monograph/2021-10-2

In the system of socially-oriented market economy, the market of agro-food products occupies a leading place in determining the food security of each state, increasing the competitiveness of the agricultural sector and further development of rural areas. An important factor for Ukraine's future economic growth is the construction of a full-fledged agro-food market, which should develop taking into account the trends of globalization and liberalization of world markets, the ideas of sustainable development of agro-industrial production. We will conduct a detailed analysis of the development of crop markets. Thus, the study of the state of the market of plant food products, we analyzed the following food markets: grain and grain products and sugar.

Functioning of markets of grain, legumes and products of their processing. The most important component of the agro-industrial complex is the grain industry, which determines the basis of economic security of the country. Grain production occupies a leading place in the structure of the agro-food sector of Ukraine's economy. The well-being of the population, guaranteeing national food security, and the country's export opportunities depend on the level of efficiency of its development. Ukraine is also one of the largest exporters of grain in Europe. To maintain its position in the international arena for the sale of grain to domestic producers, it is necessary to constantly invest in improving the efficiency of the industry, to introduce innovative technologies for the production of competitive products.

Consider the dynamics of production of cereals and legumes in 1990-2020. If before the 1990s the production of grain and legumes in the country averaged 51,00 million tons, in 1995 – 33,93 million tons, and in 2000 – only 24,46 million tons, in 2005 – 34, 02 million tons. And only in recent years, grain production is growing dynamically: in 2010 – 39,27 million tons; in 2013 this figure increased to the level of 63,05 million tons, and in 2018 – the volume of production of grain and cereals reached the level of 70.06 million tons, mainly due to increasing their yield to the world average, and in 2020 the river has already decreased to 64,93

million tons. This harvest of grain crops is primarily due to a significant increase in the production of grain corn, the share of which reached 40% of the total gross grain harvest (on average over ten years 21%).

Table 1.Production of cereals and legumes in 1990-2020, thousand tons [1, p. 62]

Years	Cereals and legumes	Including								
		wheat	rue	barley	oat	millet	buck weat	rice	corn on the cob	grain and legume crops
1990	51009,0	30373,7	1259,5	9168,9	1303,0	338,0	420,1	117,6	4736,8	3265,9
1995	33929,8	16273,3	1207,9	9633,2	1116,4	267,5	340,5	80,1	3391,8	1569,9
2000	24459,0	10197,0	968,3	6871,9	881,4	426,1	480,6	89,7	3848,1	652,0
2005	38015,5	18699,2	1054,2	8975,1	790,7	140,6	274,7	93,0	7166,6	757,5
2010	39270,9	16851,3	464,9	8484,9	458,5	117,1	133,7	148,0	11953,0	592,3
2013	63051,3	22279,3	637,7	7561,6	467,3	102,0	179,0	145,1	30949,6	371,5
2013	62285,3	21927,8	637,2	7351,9	461,4	99,1	178,3	64,1	30862,0	351,6
2014	63859,3	24114,0	478,0	9046,1	612,5	178,0	167,4	50,9	28496,8	481,1
2015	60125,8	26532,1	391,1	8288,4	488,5	213,2	128,1	62,5	23327,6	502,1
2016	66088,0	26043,4	391,6	9435,7	499,9	189,7	176,4	64,7	28074,6	876,6
2017	61916,7	26158,0	507,9	8284,9	471,4	84,4	180,4	63,9	24668,8	1238,8
2018	70056,5	24605,8	393,8	7349,1	418,5	80,5	137,0	69,2	35801,1	954,6
2019	75143,2	28327,9	334,7	8916,8	422,0	169,7	85,0	54,6	35880,1	709,8
2020	64933,4	24877,4	456,8	7636,3	510,0	256,1	97,6	60,7	30290,3	600,0

According to preliminary data of the FAO of the Ukrainian Club of Agrarian Business in 2018-2019, grain production increased by 7,9 million tons than in 2017-2018 and reached almost 70 million tons. The largest growth was achieved by corn production (Table 2). Together with the growth of gross grain production, the volume of exports in 2018-2019 amounted to 47,5 million tons, which is 6,5 million tons more than last year. Feed grain consumption increased by 11% or 1,2 million tons, again, mainly due to corn [2].

To assess the efficiency of the grain industry, the indicators of profitability of production are analyzed, which allows to compare the efficiency of different enterprises and the profitability of different types of products. The dynamics of profitability indicators of grain and legume production in 2008–2019 is shown in table. 3. The analysis of the statistical data of Table 3 showed the existence of gaps and problems in the system of production and sale of agricultural products, as it can be argued that neither the market mechanism nor the system of state regulation

during 2008-2019 could ensure a stable level of profitability of legumes and cereals products.

During this period, significant fluctuations in the level of profitability were observed, especially for cereals such as rye, oats, millet, buckwheat, sorghum and rice. It should also be noted that the level of profitability of rye, sorghum and buckwheat production is quite unstable. Unprofitable buckwheat production during 2008–2009 became sharply unprofitable. For example, during 2010–2016, the level of profitability of production of the above-mentioned crop reached 70,2%, 58,9%, 24,5% and – 1,3%, 87,5%, respectively.

Table 2. Automated balance of supply and demand of grain of Ukraine according to FAO for 2014-2019, thousand tons [2]

Cereal balance	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**2018/19**
Initial stocks, thousand tons	6831	8981	6044	6454	6305
Harvest area, thousand hectares	14627	14641	14337	14560	14782
Yield, c / ha	4.4	4.1	4.6	4.3	4.7
Production, thousand tons	63859	60126	66088	61917	69800
Imports, thousand tons	197	211	223	279	237
Total supply, thousand tons	**70888**	**69318**	**72355**	**68649**	**76342**
Exports, thousand tons	35179	39924	45212	40956	47472
Feed consumption, thousand tons	14933	12728	10226	10610	11671
Food processing, thousand tons	6208	5835	5685	5578	5392
Industrial consumption, thousand tons	1294	1057	1258	1577	1142
Seeds, thousand tons	2236	2325	2217	2221	2266
Losses, thousand tons	2056	1405	1303	1403	1756
Internal distribution, thousand tons	**61906**	**63273**	**65901**	**62344**	**69789**
Final stocks, thousand tons	8981	6044	6454	6305	6554

Table 3. The level of profitability of production of cereals and legumes in agricultural enterprises in 2008–2019,% [3, p. 13–14; 4]

Plant products	Profitability (%)									
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2016**	**2017**	**2018**	**2019**
Winter and spring wheat	17,6	5,8	9,6	17,6	11,8	2,4	31,7	24,7	28,5	33,2
Winter and spring rye	13,4	- 15,5	-18,0	11	5,5	- 15,3	24,6	22,1	17,0	21,8
Winter and spring barley	19,8	- 4,9	-0,4	16	11,4	0,6	25,4	28,0	31,0	25,3
Oat	20,0	- 14,4	-15,1	21,8	9,9	- 2,6	34,4	23,8	21,0	25,2
Corn for grain	10,6	21,5	29,9	38,6	19,8	1,5	45,7	45,5	33,4	42,5
Millet	14,2	- 21,2	11	32,8	-12,5	3,0	30,2	23,0	21,8	31,1
Buckwheat	-0,7	-2,1	70,2	58,9	24,5	- 1,3	87,5	50,3	43,5	38,3
Sorghum	- 24,2	- 40,4	7,1	2,9	-11,4	- 23,4	21,4	18,7	21,2	17,8
Rice	39,1	61,7	26,4	12	12,3	18,1	33,1	28,0	26,6	27,1
Other cereals and legumes	14,7	37,3	20,1	12,9	9,3	- 5,0	41,1	33,8	36,7	35,4

Note that the most stable level of profitability during 2008-2019 is wheat, corn for grain and rice. It should also be noted that on average during 2008–2019 the most profitable is the production of rice and buckwheat, and the most unprofitable is the production of sorghum. In general, the average profitability of production of cereals and legumes during the period under review was positive and ranged from 1,5% to 26,1%.

The main reasons for the decline in the profitability of the grain industry in recent years are the underdevelopment of the agricultural market and sales infrastructure grain, the lack of an effective mechanism for state regulation of pricing of grain products in terms of both overproduction of grain and crop failure, high credit rates and imperfect budget support for the industry, etc.

To assess the effective functioning of the grain market in Ukraine, we have grouped the main statistical indicators on: gross harvest and areas from which the harvest and yield and share of grain production during 1990-2020 were collected and presented in table. 4. Analysis of the statistics of Table 4 shows that despite

the high and in some cases uneven dynamics of gross grain harvest during 1990-2020, the total sown area of cereals during this period remained relatively stable. On average, about 14,5 thousand hectares were allocated for grain sowing annually, which is from 45% to 58% of the total sown area of crops in 1990–2020. However, it should be noted that the structure of the total sown area of cereals has changed significantly. During 1990–2020, the sown areas of almost all cereals decreased – wheat, rye, barley, oats, millet, buckwheat, rice and legumes; instead, only corn and grain sorghum crops increased.

The strategic crop market, which, like the grain market, shapes both economic and food security, is the sugar market.

The main indicators that characterize this safe market are: the size of sown areas, yield, gross harvest and profitability. Complexly, these indicators are grouped in table. 5.

Observing the dynamics of the development of the above indicators in 1990-2020, regulating the state sugar market, we note that since 1990, we have seen a decline in all indicators of sugar beet production, except yield. The sown areas in 2020, compared to 1990, decreased by 7,3 times. Their slight expansion was observed only in 2001, when they increased by 13% compared to the previous year 2000; in 2006 – when the growth of sown areas was recorded by 25%, compared to 2005, and during 2010–2011.

It should also be noted that the indicator of sown areas and areas from which the sugar beet harvest was harvested in 1990–2020 is somewhat different. They, in turn, as of 2020 decreased by 7,8 times compared to 1990. However, we note that the yield of sugar beet from 1990 to 2000 has a declining dynamics, only in 2006 the yield exceeded the same indicator in 1990 and began to grow, reaching 445 c / ha in 2020. As for the profitability of sugar beet cultivation for the period 1990-2020, it should be noted that the highest level of this indicator is observed in 2009 – + 37 %, when the gross harvest of sugar beet was only 10067,5 thousand tons and was the lowest for the study period 1990-2020. This situation is due to a sharp decline in wholesale prices for sugar beet for relatively small gross harvest, resulting in profitability reached negative value.

Table 4. The main indicators of grain production in 1990–2020 [3]

Years	Winter and	Winter and	Winter and	Oat	Millet	Buckwheat	Rice	Corn for	Sorghum	Other cereals
The area from which the crop was harvested, thousand hectares										
1990	7557,7	517,2	2712,0	485,9	196,8	362,3	27,7	1223,1	24,9	1414,2
1995	5479,4	604,7	4413,2	560,1	157,7	447,6	22,0	1161,3	10,4	1085,0
2000	5161,6	638,1	3689,1	481,0	366,5	528,9	25,2	1278,8	14,4	383,2
2005	6571,0	608,9	4350,4	450,0	396,2	396,2	21,4	1659,5	20,1	401,2
2010	6284,1	279,1	4316,9	310,8	198,6	198,6	29,3	2647,6	28,7	391,2
2012	5629,7	297,8	3293,0	301,0	152,5	273,3	25,5	4371,9	136,9	303,4
2016	6189,1	143,6	2859,2	208,6	107,7	153,7	12,0	4252,2	70,2	320,6
2017	6361,2	171,0	2501,5	197,8	56,1	185,3	12,7	4480,7	71,0	503,5
2018	6603,9	148,4	2484,3	195,8	54,8	113,3	12,6	4564,2	41,9	555,8
2019	6817,6	115,5	2612,7	182,5	92,2	69,1	10,6	5004,9	-	348,2
2020	6595,7	138,5	2395,1	199,6	159,3	83,6	11,2	5431,9	-	315,2
Yield, c / ha										
1990	40,2	24,4	33,8	26,8	17,2	11,6	42,5	38,7	9,6	23,1
1995	29,7	20,0	21,8	19,9	17,0	7,6	36,4	29,2	8,9	14,5
2000	19,8	15,2	18,6	18,3	11,6	9,1	35,6	30,1	11,5	17,0
2005	28,5	17,3	20,6	17,6	11,7	6,9	43,4	43,2	26,8	18,9
2010	26,8	16,7	19,7	14,8	13,7	6,7	50,5	45,1	21,4	15,1
2012	28,0	22,7	21,1	20,9	10,3	8,7	62,1	47,9	15,2	15,6
2016	42,1	27,3	33,0	24,0	17,6	11,5	53,9	66,0	38,9	27,3
2017	41,1	29,6	33,1	23,9	15,0	9,7	50,5	55,1	27,9	24,6
2018	37,3	26,6	29,6	21,4	14,6	12,1	54,9	78,4	46,3	17,2
2019	41,6	28,9	34,2	23,2	18,1	12,3	52,2	71,9	-	20,4
2020	38,0	33,2	32,2	25,6	16,1	11,6	54,0	56,2	-	19,3
Gross collection, thousand tons										
1990	30373,7	1259,5	9168,9	1303,0	338,0	420,1	117,6	4736,8	24,0	3265,9
1995	16273,3	1207,9	9633,2	1116,4	267,5	340,5	80,1	3391,8	9,3	1569,9
2000	10197,0	968,3	6871,9	881,4	426,1	480,6	89,7	3848,1	16,5	652,0
2005	18699,2	1054,2	8975,1	790,7	140,6	274,7	93,0	7166,6	53,9	757,5
2010	16851,3	464,9	8484,9	458,5	117,1	133,7	148,0	11953,0	61,4	592,3
2012	15762,6	676,8	6936,3	629,7	157,4	238,7	159,8	20961,3	208,5	473,3
2016	26043,4	391,6	9435,7	499,9	189,7	176,4	64,7	28074,6	273,7	876,6
2017	26158,0	507,9	8284,9	471,4	84,4	180,4	63,9	24668,8	198,5	1238,8
2018	24605,8	393,8	7349,1	418,5	80,5	137,0	69,2	35801,1	194,0	954,6
2019	28327,9	334,7	8916,8	422,0	169,7	85,0	54,6	35880,1	-	709,8
2020	24877,3	456,8	7636,3	510,0	256,1	97,6	60,7	30290,3	-	600,0
The share of crop production,%										
1990	59,5	2,5	18,0	2,6	0,7	0,8	0,2	9,3	0,0	6,4
1995	48,0	3,6	28,4	3,3	0,8	1,0	0,2	10,0	0,0	4,7
2000	41,7	4,0	28,1	3,6	1,7	2,0	0,4	15,7	0,1	2,8
2005	49,2	2,8	23,6	2,1	0,4	0,7	0,2	18,9	0,1	2,0
2010	42,9	1,2	21,6	1,2	0,3	0,3	0,4	30,4	0,2	1,5
2012	34,1	1,5	15,0	1,4	0,3	0,5	0,3	45,4	0,5	1,0
2016	39,4	0,6	14,3	0,8	0,3	0,3	0,1	42,5	0,4	1,3
2017	42,2	0,8	13,8	0,8	0,1	0,3	0,1	39,8	0,3	2,0
2018	45,1	0,6	10,5	0,6	0,1	0,2	0,1	51,1	0,3	1,4
2019	38,2	0,8	9,3	0,9	0,2	0,3	0,2	47,2	-	1,2
2020	36,8	1.3	7,8	1,2	0,3	0,4	0,2	43,4	-	0,9

Table 5. The main indicators of sugar beet production in Ukrainein 1990–2020 [1; 4, p. 172]

Years	Sowing areas, thousand hectares	Areas from which the crop was harvested, thousand hectares	Yield, c / ha	Gross harvest of beets, thousand tons	Profitability ,%
1990	1607	1605	276	44264,5	29,5
1995	1475	1448	205	29650,4	31,2
2000	856	747	177	13198,8	6,1
2001	970	853	183	15574,6	1,5
2002	897	763	189	14452,5	– 8,6
2003	773	666	201	13391,9	6,2
2004	732	697	238	16600,4	-0,8
2005	652	624	248	15467,8	4,8
2006	815	787	285	22420,7	11,1
2007	610	578	294	16977,7	–11,1
2008	380	377	356	13437,7	7,1
2009	322	320	315	10067,5	37,0
2010	501	492	279	13749,2	16,7
2011	532	516	363	18740,5	36,5
2012	458	449	411	18439,0	15,9
2013	280	271	399	10789,4	3,1
2016	292	291	482	14011,3	24,6
2017	316	314	475	14881,6	12,4
2018	276	275	509	13967,7	– 11,4
2019	222	205	503	9150,2	3,5
2020	220	205	445	10204,5	8,9
Growth rate (%) 2020/1990	- 86,31	-87,23	+61,23	-76,95	-69,83

Let’s study the level of self-sufficiency in sugar, analysing the structure of production and consumption of sugar in 2005-2020. According to Figure 1, note that during 2005–2012 and 2016–2018, domestic production could meet the needs of the domestic market. The exception was only in 2008, when state demand was covered by only 83%. Also in 2013 and 2015, domestic demand was covered only by 75% and 95%, respectively.

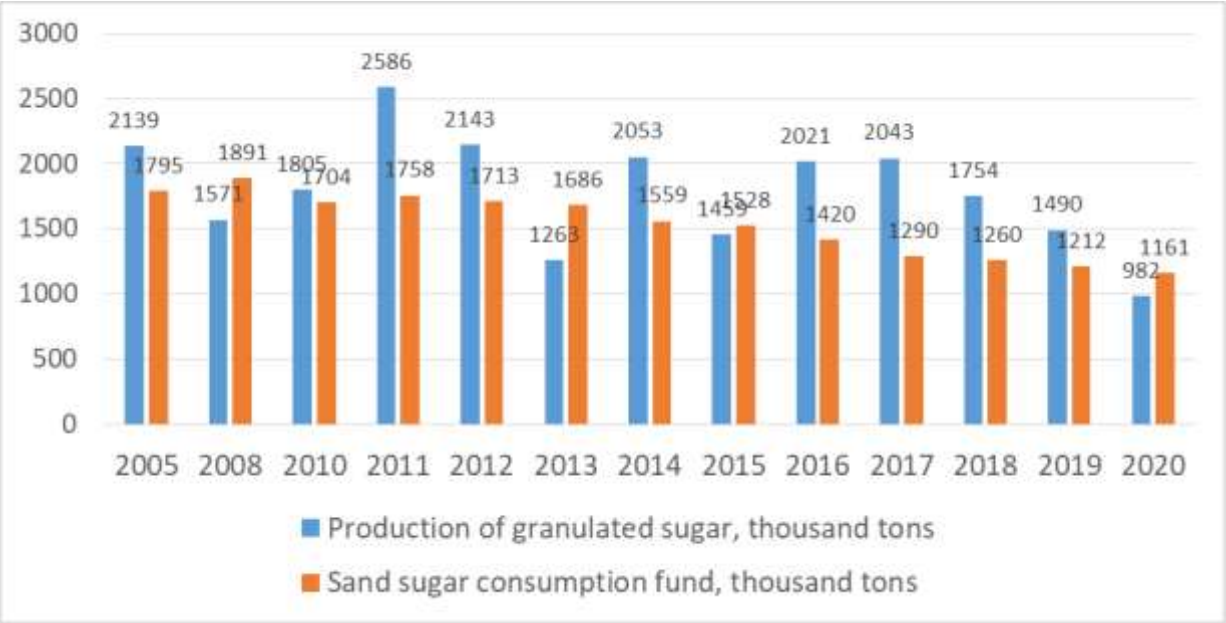


Figure 1. Dynamics of sugar production and consumption in 2005–2020, thousand tons [4]

We describe the main exporters in the sugar market in Ukraine (Fig. 2). According to the results of 2018-2020, “Radekhiv Sugar” LLC became the leader in sugar exports, shipping 138,5 thousand tons of sugar worth $ 46,3 million. USA. The second place in the ranking was taken by PJSC “Food Company Podillya” – 74,5 thousand tons (26,6 million US dollars). The third step was assigned to PJSC “Teofipolsky Sugar Plant” – 35,7 thousand tons of sugar (14,0 million US dollars). Note that although sugar exports in 2018-2020 decreased by almost a third, there were no significant changes in the rating of exporters.

Analyzing the indicators of Ukraine’s foreign trade in sugar in 2019, we note that exports of Ukrainian sugar decreased by 27% to 409,8 thousand tons, which in monetary terms corresponds to 144,3 million dollars USA. Note that changes have taken place both in the geography of deliveries and in the rating of exporters. Although Uzbekistan remained the leader in imports, shipments to this country decreased significantly – from 210 thousand tons in 2018 to 96 thousand tons in 2019 due to changes in the tax policy of Uzbekistan, which raised tariffs on imports of Ukrainian products [6].

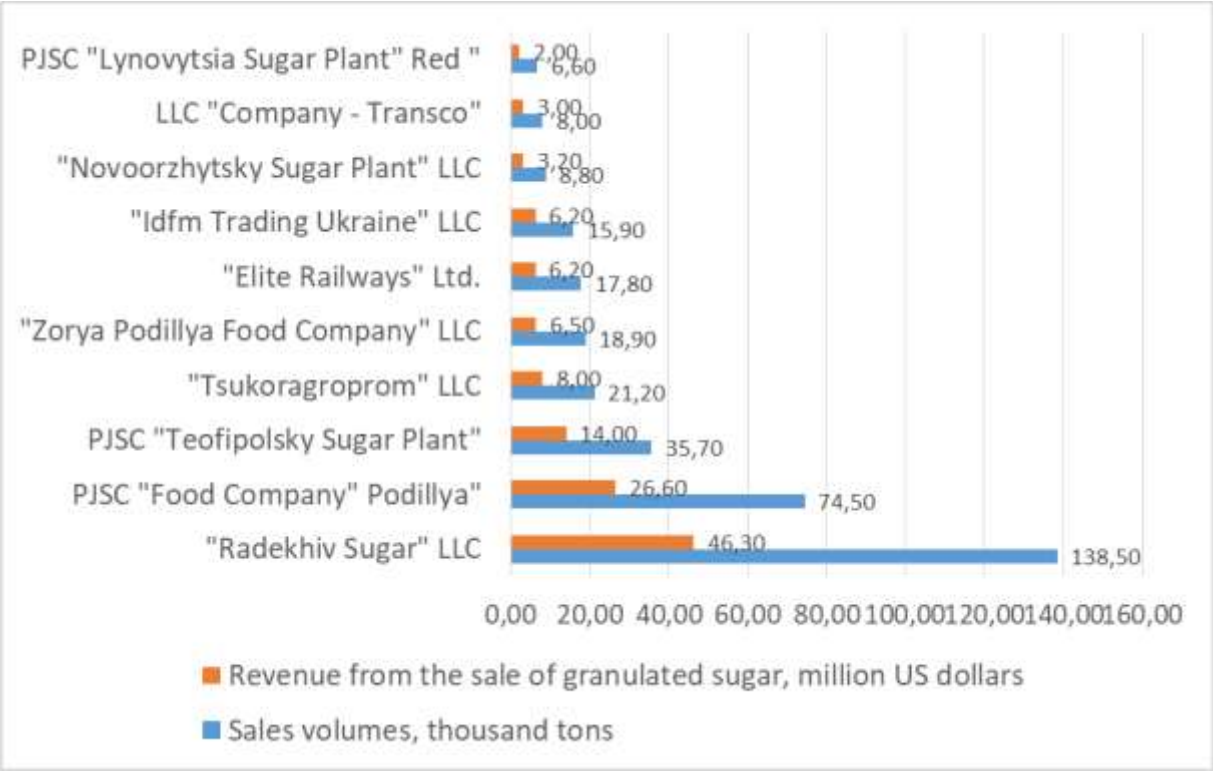


Figure 2. The main exporters of sugar in Ukraine in 2020 [5]

The main importers of Ukrainian sugar in 2020 (Fig. 3) were the countries: Sri Lanka, Georgia and Turkey. According to customs services, Sri Lanka bought the most domestic sugar products – 112,2 tons for 57 million dollars USA.

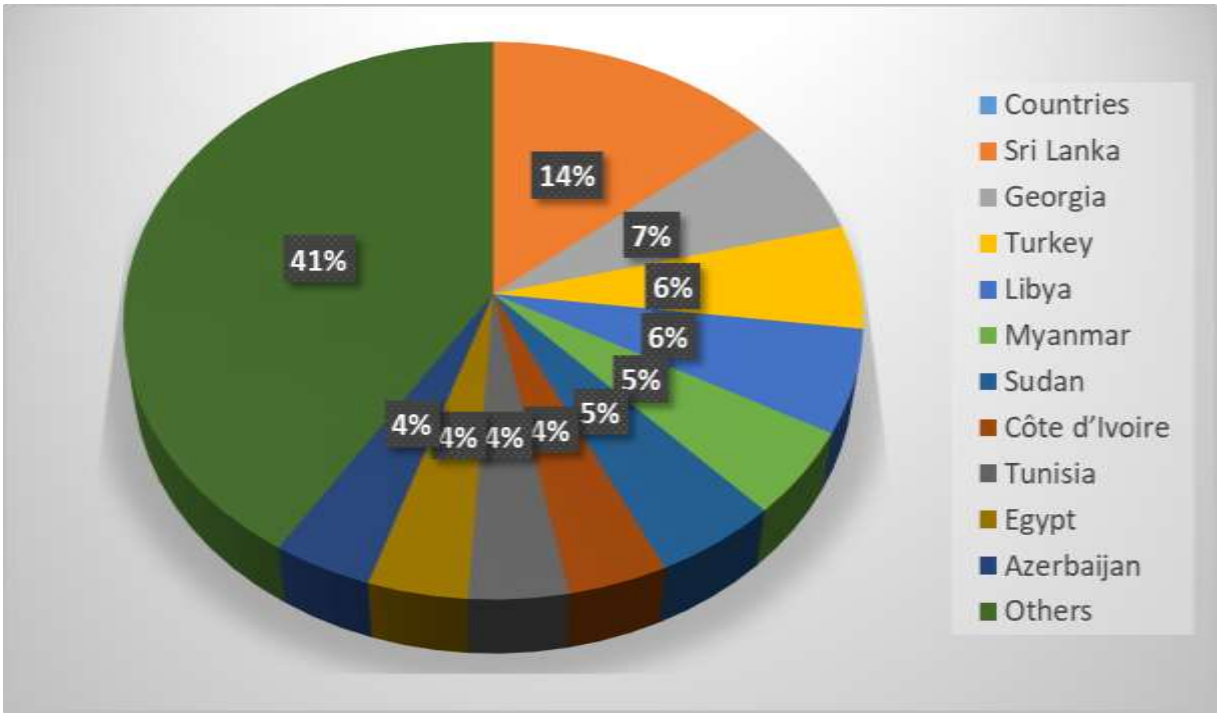


Figure 3. The structure of the geography of sugar imports to Ukraine in 2020,% [7]

Also in the top three are Georgia and Turkey, which bought 47,9 tons and 42,5 tons of sugar, respectively. Significant deliveries were also made to African countries. Libya imported $ 21 million worth of sugar. United States, Côte d'Ivoire – $ 16 million USA, Egypt – by $ 15 million dollars. Ukrainian sugar was bought even by those countries that have always consumed cane sugar.

The above allowed us to draw the following conclusions:

- given the trend of gradual consolidation of sugar companies, in Ukraine during 2014-2020 is expected to reduce the number of operating sugar factories by a third, as well as a further reduction in production capacity;

- reduction of sown areas for sugar beet to 276 thousand hectares and reduction of its gross harvest will reduce sugar production in the country by 33%, which will help stabilize the situation on the market of demand and supply of sweet products;

- maintaining the growing trend of sugar exports and expanding its geography will contribute to the unloading of the domestic market and the formation of a list of countries – permanent markets for Ukrainian products;

- if the volume of sugar in the domestic market decreases, prices are expected to rise to an economically reasonable level, etc.

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MOTIVATIONAL POTENTIAL OF A LEADER IN ENTERPRISE DEVELOPMENT MANAGEMENT

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DOI: 10.31891/monograph/2021-10-3

1. Introduction

The successful functioning of any enterprise is ensured by its ability to respond in a timely manner to market signals - changing in response to new conditions or requirements of its participants or initiating changes in anticipation of circumstances, forming plans for proactive development. Given that in a highly competitive environment, such as the modern market, development as a way to improve competitiveness should be an inherent feature of the dynamic state of each subject of market relations, the problem of effective development management will not lose its relevance as long as competition exists. Obviously, it should be considered in different contexts – both in terms of the essence of technological change in the processes of production, marketing and customer service, and through the prism of managing the behavior of participants in innovation, who act as economic actors.

The research of features and regularity of management of innovative activity of industrial enterprises in the epoch of globalization and dynamic market changes are held by a great amount of modern scientists. Their researches are based on the works of prominent scientists such as J. Shumpeter, P. Romer, B. Santo, E. Penrouz and others. Among native scientists that did a substantial contribution to the research of influence of innovative factors on the economy growing and development of enterprises, we would like to distinguish K. Kovtunenko[1], Yu. Kovtunenko [2], P. Pererva, S. Nagy, M. Maslak [3], L. Smoliy, A. Revutska, I. Novak [4] and many other. However, the question of creation of the effective motivated basis of management of innovative activity of industrial enterprises refers to the questions that are still urgent. In particular, it touches the forming of management mechanisms, that would give an opportunity in the mode of selforganization to aim the workers of enterprises to look for the ways and directions of improvement of processes and technologies, modification of prototypes and creation of new products. The position of the authors is that, to

solve this task it's reasonable to use fundamental approaches and methodology of the behavioral economics.

2. Results

Innovative activity by its content differs much from the ordinary routine activity that is related to fulfillment of the industrial tasks. It cannot be clearly defined by its results and structured by the stages, rationed after the charges of time and recourses, as it contains a lot of novelty. Therefore, the innovative process is the complex of many iterations. First, the vagueness of end-point of innovative activity influences the amount of iterations – if it is a success to materialize a conception of novelty in products that have the consumer value. Secondly is a vagueness of that, how a market will perceive novelty – if the materialized in a product suggestions of enterprise will coincide in relation to the parameters of novelty to expectations of consumers. On the other hand, could they persuade consumers in the value of their products? All this causes great risks of innovative activity, requiring for its minimization qualified analytical researches of the market and engineering and technical support with design and technical works. Despite the understanding of this problem by management of enterprise, the statistics of many years shows rather low level of innovations, that successfully gone through the stage of commercialization and get the recognition on the market. That is why it is clear, that we cannot manage the activity from the position of strict control clearly attaching to the terms and results the size of reward to the performers-the participants of innovative process.

The "strict approach" to manage the personnel, according to K. Legge "is focused on close integration of skilled politics in area of human resources with the organizational strategy, orientated on the use of human resources by the same rational method, as any other resources from which organization aims to get a maximal income [5, p.33]. It's clear that in the basis of this approach is the thesis about the absolute resonabless of economical behavior of people, that work in the organization.

The term "economical behavior" sufficiently often meets in the economic literature. Mostly he is interpreted as "dependence of behavior of people on economic factors…. The influence of people on these factors by an acceptance and realization of certain decisions" [6, p. 125], "form of activity of man as an economic agent, his or her realized activity in the field of a manage [7, p. 9]. In

opinion of V. Radaiev, a concept "economic behavior" arose up as a reflection of realization of that character of economic actions of man depends on his or her idea about rationality and its limits. He marks - "in order that the actions of man were considered economic, he or she is under an obligation to behave rationally" [8, p. 71]. Such interpretation of economic behavior was formed according to the works of classics \ of economic theory – G. Bekker, P. Samuelson, Ph. Haiek, P. Heine and many others.

Though, nowadays it's clear that people are not always rational and they depend not only on economical circunstances, but also on socio-psychological, cognitive, valued and other personal characteristics, but we will still follow the position of Nobel prize-laureate G. Bekker, that underlined, that "economical approach is unique in its power, as it's capable to integrate the great amount of varied forms of human behavior" [9, p.31]. Therefore, in the context of our research we will interpret the economic behavior of a person in the organization in accordance with G. Bekker – as a method (character) of his or her economic actions in certain economic or socio-cultural circumstances. In such combination, the motivational basis of innovation activity should be built. It meets the essence of the so-called "flexible approach" according to which management of people is presented in strategic perspective – when "people are perceived as potential assets, but not variable charges" [10, p.23-24].

According to V. Sadovska, L. Axelson, and C. Mark-Herbert (2020) this ensures the sustainability of the business in the market [11]. Researchers have identified the need to rethink value creation in agriculture and related industries to implement a development strategy. This process should be based on innovation, knowledge acquisition and cooperation with external stakeholders. In business networks, this is facilitated by nine factors – opportunities for collaboration, communication, knowledge, production, diversification, entrepreneurship, financing, policy and inclusion, which are evaluated by financial, environmental and social measuring instruments. As the authors rightly point out, the benefit of farmers from participating in business networks is the ability to form a long-term development strategy as opposed to the traditional strategies of enterprises in the industry, which are to reach a “short-term point”.

The philosophy of flexible approach bases on communication, motivation and leadership. Its main aides is to reach such level of favors of personnel to the

aims of enterprise, according to which they would not only stand up for their economic interests in relations with an employer, but aimed at self-realization while coping with the tasks. To reach that it is necessary to attract them in all the processes that require making decisions, creating the right conditions for effective exchange of information, creating the atmosphere of loyalty and trust among the workers in inner organizational space. As J. Gepnard and G. Udg stated it, the workers must be confident, that their interests and interests of the authority should have something in common [12 p. 57]. Moreover, when all the workers share the aims of the organization and can work as one team, such organization will be vital and successful.

Matching of the interests of the members of any economic activity is the basis of the motivation of the personnel. However, because of variety and complexity of relations that occur in the course of the innovation process the motivation of its members deals not only with the questions of adequate economic effect. It covers the question of socio-psychological and even ethic character – in the context of evaluation of personal input of every member to the result and the protection of the right of intellectual property. However, on the enterprise innovation activity, as a rule, is the result of collective work. N. Krasnokutska stated, that innovation activity is … "the activity of a collective, focused on providing of proof of scientific and technical ideas, inventions to the result suitable for practical realization them at the market with the aim of satisfaction of necessities of society in competitive products and services" [13, p.23]. The human factor plays a determinant role in it. Mainly, humans defects – passiveness, no willingness to teach, get new knowledge – are the main reasons that slow down the innovative process, prevent from innovation renovation, development of its technological system.

In any activity effectiveness is the inner response of the performer to the motives, that are proposed by the management of enterprise in order to reward the spent efforts to get desirable (pre-arranged) results. The structure of motives of any individual defines his or her needs, level of actualization that changes in time – depending on circumstances that form some kind of economic situation. The changes in the structure of motivation can be rather essential, having an influence on individual's behavior in the process of solving tasks.

Among the motives, that a person use in his or her work, we can define not only utilitarian that provides his or her life and reproduction, but also those which satisfy the need in self-actualization, self-realization, social recognition, and respect from others. E. Illiin names these motives dynamical [14, p.270] supposing that this terms show their changeability in every organizational context. Paying attention to that organizational context is determined not only by its content (character) of work, but also by the way, the colleagues and the authority evaluate them from the position of importance for the decision of general tasks ,how its results can influence the activity of enterprise in a near perspective, it is possible to admit that this dynamic is multidimensional. And this forms the structure of motives of worker, determines his or her advantages. In its complex motives and stimulus form the general motivational vector.

In a sphere of innovation activity, it must be focused on such solving of innovational task that will coordinate with strategic aims of the enterprise and standards of its activity. In particular, showing on the market innovation products must provide the enterprise with the receiving of the so-called enterprising income. That is income, the size of which exceed its existing level in the sphere of producing of products analogues. By the way, the novelty must be secured in the correct way to save the innovation monopoly for that period, when the consumer value of a new product will stay high. This will give a chance to industrial enterprise realize its strategy of growing or even attacking strategy is the interest to the new product is high and long-termed owing to its unique characteristics.

Nevertheless strategically important for enterprise are aims of saving the position of the market that correspond to "saving" innovation strategy. Usually it bases on improvement of business processes, beginning with its technological aspects up to direct sales or even to organizationally economic. In case of organizational reprojecting of business processes, the creation of new integrative structures is possible in a form of vertical (technological chains) or horizontal (clusters inside of a branch, sphere or among branches, spheres) formations. It is important to reasonably to work with such improvement, analyze all his advantages and risks. It needs competences in the field of not only technological but also organizational planning, skilled research of change of the combined charges – both operating-rooms and transactions, estimations of degree of complexity of resources of such integration formation and others like that.

Motivation of the personnel involved in an innovative process envisages different even combinations of the personal and group interests. In fact in many cases appearance new to conception of new product is an individual result – invention, material embodiment of idea of certain worker. However realization of this idea as acommodity that can be made on certain technology and offered at the market needs participation many, is a command (group) job performance. It is possible to agree with E. Yachontova that distinguished three levels of connected motivation in activity of workers of the enterprise [15]:

- organizational level – means the choice of the optimal forms and methods of material and non-material motivation taking into account the peculiarities of the situation, organizational aims and expactations of the personnel;
- group level – expects the concession of possibility to realize personal motives of the higher level thanks to the work in a group – the motives of of belonging, participation, confession, respect –promoting individual motivation the same; thus it follows to take into account relations between the participants of project command, leader internals of leader and others like that, that give an opportunity to estimate individual responsibility and clearly to estimate payment each in general results – motivation will down differently;
- personal level – is the identification of actual needs of every worker, through which it is possible to influence on his behavior in the context of defined aims.

The selection of such connected levels creates through terms for realization of creative potential of workers of enterprise – whatever structural link they worked in. And more it correlates with motivation of innovative activity, the economic constituent of that is inseparable from social-psychological. And exactly in such combination it is possible to talk about conditioning for realization of economic behavior in a strategic (dynamic) aspect that answers the already above-mentioned interpretation of G. Bekker. Besides, as having a special purpose reference-points on organizational and group levels it is expedient to use conception of "loop of quality" in relation to constituents of innovative process. It gives an opportunity to approach an innovative process to every workplace – in all chainlet of creation of value [16]. All these tasks are best solved if the responsibility for them rests not on formal management (in which the functions of

administration and control predominate), but on leadership management, which makes extensive use of motivational levers to influence people's behavior.

Significant motivational capabilities of a leader and their value for effective leadership is noted in many other scientific sources [17-20]. This can be seen, for instance, through the prism of the five basic abilities motivation function in a leader skills model (modeling the path to a goal; inspiring followers; perceiving each new goal as a challenge; giving followers the opportunity to achieve more; encouraging followers) developed by American researchers J. M.Kouzes, B. Z.Posner [19]. In table 1 we have identified this motivational component, based on the interpretation of these basic characteristics by the authors.

Table 1. Motivational component of the basic characteristics (abilities) of a leader

Basic characteristic of a leader	Definition of the characteristic	Motivational component of the characteristic
Modeling the path to a goal	Ability to clearly define the goal, assess potential risks. The willingness of a leader to discuss with his followers the various possibilities of achieving the goal of developing the best case scenario	Involving team members in decision making
Inspiring followers	Ability to form an attractive image of the future. Ability to make a common goal valuable for each member of the team, addressing the values and motives of followers	Motivation of followers to self-realization in the course of achieving significant goals
Perceiving each new goal as a challenge	Readiness of a leader for systemic change to achieve the goal most effectively. A leader is constantly looking for new ideas and tasks that could improve both himself and his team members	Motivation of followers to recognition by solving those tasks that others could not cope with
Giving followers the opportunity to achieve more	Focus of a leader on the development of his team members. Performing a specific problem, a leader tries to distribute responsibilities so that team members learn something new and open new opportunities.	Motivation for development and self-improvement
Encouraging followers	Ability to maintain a positive mood in the team and in communication with each of the followers. Positive emotions and goals increase faith of followers in themselves and allow them to achieve more	Motivation for achieving goals through self-confidence

Source: author's development of authors based on [19; 20].

Given the value of the motivational component in the basic characteristics of the leader, we consider it necessary to introduce into the terminological field of leadership theory the term ***"motivational potential of a leader"***, *interpreting it as the ability of a leader to correctly identify the range of needs and motives of members of society (his followers) and to use this knowledge for their relevant actualization in the context of awakening and maintaining the active actions of followers to achieve the objectives.* In our opinion, the solution of this problem is impossible without taking into account the mental characteristics of the relationship "manager-subordinate" in the labor collectives of domestic enterprises. Although they were transformed during the development of a market economy, they are not devoid of the rudiments of a planned-administrative economy based on the tradition of authoritarianism, the hallmark of which is the relationship of domination and subjugation. And not only in situations with a high level of uncertainty, when group members find it difficult to agree on the course of action and ways to achieve the desired result and they agree to support their colleague, who takes responsibility, but also routine processes (for example, in the distribution of production tasks). When working on the implementation of operational tasks or strategic plans, managers of domestic enterprises often resort to means of direct administration, without going beyond formal relationships with subordinates, which require not only intellectual but also emotional effort. Leadership is important for the success of a modern enterprise, which is based on the values of human development, development of needs and motives that meet the modern requirements of society. This function of leadership should be based on the appropriate structure of motives that are transformed in the group and ensure the growth of the motivational potential of the leader. In the structure of motivations, leaders need to develop those that promote employee loyalty to the company, the achievement of organizational consensus and fruitful joint activities.

3. Conclusions

The strategic aims of domestic industrial enterprises are integrations in outer economic space on rights for the producer of competitive products. It maybe only on the basis of purposeful and systematic innovative activity, that especially urgent for the machine-building complex of Ukraine. Effective realization of aims of innovative activity is inseparable from her motivation. Because of specific

characteristics of innovative activity it is impossible to manage from positions of hard control, what called to regulate economic behavior of personnel, providing clear connection of stimulation with the achievement of the set aims according to the chart of planned works. Therefore in the field of innovative activity mostly the so-called "flexible approach" is used that promotes variable actions and decisions, determining the possible limits of deviations from desirable results. Such "settled ambiguousness" diminishes force of motivational influence, causing the excessive charges of time and resources. Promoting effectiveness and efficiency of innovative process is possible by means of more clear structure of motivational process – according to aims, charges, results and reward.

Productive and effective cooperation of people is possible due to their understanding of the value of everyone's contribution to solving those tasks that are necessary to achieve the goal set for a given community. The key role in determining both the aim of joint activities and the role (and hence the values) of each participant in its achievement is played by leaders, who are usually the subjects (initiators and motivators) of innovative change. Leaders initiate change and achieve results through the capacity to inspire enthusiasm in members of their society. Enthusiasm is the resulting vector of the motivation structure of an individual and a group of people, which can be attributed to those aimed at meeting the needs of a higher order. In turn, this structure is based on values formed historically in a particular society and is reflected through certain behavioral stereotypes. The development of algorithms and procedures for conducting research on behavioural stereotypes in the organizational space of domestic enterprises is determined by the next stage of scientific work.

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RAW MATERIAL AND RESOURCE POTENTIAL OF FORMATION OF LOCAL INTEGRATED SYSTEMS IN THE AGRO-INDUSTRIAL COMPLEX

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DOI: 10.31891/monograph/2021-10-4

1. Introduction

Harvesting, processing and marketing of agricultural products is an important part of the economy of the agro-industrial complex, which without proper attention can spoil the final total effect of efforts and investments directly into agriculture. The formation of local integrated systems "harvesting – processing – marketing" contributes to the development of rural areas and growth of quality of life through the formation of a single technological process, attracting raw materials of personal farms, organization of production and sale of quality and safe food, formation of a multifaceted competitive agro-industrial complex of the country in the conditions of European integration.

Problems of development of cooperation and integration processes, creation of integrated formations in the field of agro-industrial complex are considered in works of such scientists as V. Andriychuk, O. Berezin [1], G. Cherevko [2], F. Gorbonos, V. Zinovchuk, M. Kropyvko, I. Lukinov, M. Malik [3], V. Matusevych, V. Mesel-Veselyak [3], I. Mishchuk [4], L. Moldavan, O. Onyshchenko, T. Ostashko, P. Sabluk [3], N. Skopenko, V. Yurchishyn and others. The idea of agro-industrial integration was developed in the works of P. Izhevskyy [5], G. Spaskyy, A. Shvets [6], O. Ulyanchenko and M. Krutko [7]. At the same time, there is no comprehensive research on the problems of integration of agricultural entities. Therefore, the purpose of the article is to substantiate the raw material and resource potential of the local integrated systems formation in the agro-industrial complex.

2. Analysis

The creation of local integrated systems is associated with the availability of local resource potential. The resource base for the formation of local integrated systems "harvesting – processing – marketing" is a system of different types of resources that are available to participants in the integration interaction or can be involved in economic activities of the integrated system to ensure the competitiveness of manufactured products in the consumer market and to

maximize the needs of serviced consumers. It is important to ensure not only the availability of resources of relevant species in the required quantity and quality, but also their optimal ratio, adequacy of size and composition to the needs identified to solve the tasks. I. Yaldin adheres that "sustainable development of integrated business structures is represented through coordination of existing and future resource-competence positions of members of the integrated association in terms of accumulation and allocation of resources in the necessary directions (structural, quantitative and qualitative) of transformational changes and support of current parameters of functioning »[8, p. 46].

Local integrated systems "harvesting – processing – marketing" in the activity significantly depend on the state of the raw material base, so the urgent need for their livelihood is the processes of strengthening production interaction, cooperation of participating enterprises with entities of II agro-industrial complex sphere (agriculture) aimed at: sufficient supply of raw materials of the required quality; limiting the impact of natural and climatic factors on the stability of supply of agricultural raw materials; realization of the production interest of rural residents and their needs in the sale of agricultural products; minimizing the risk of dependence on one resource provider.

The main sources of formation of the raw material base are agricultural enterprises, forestry enterprises and households (Fig. 1).

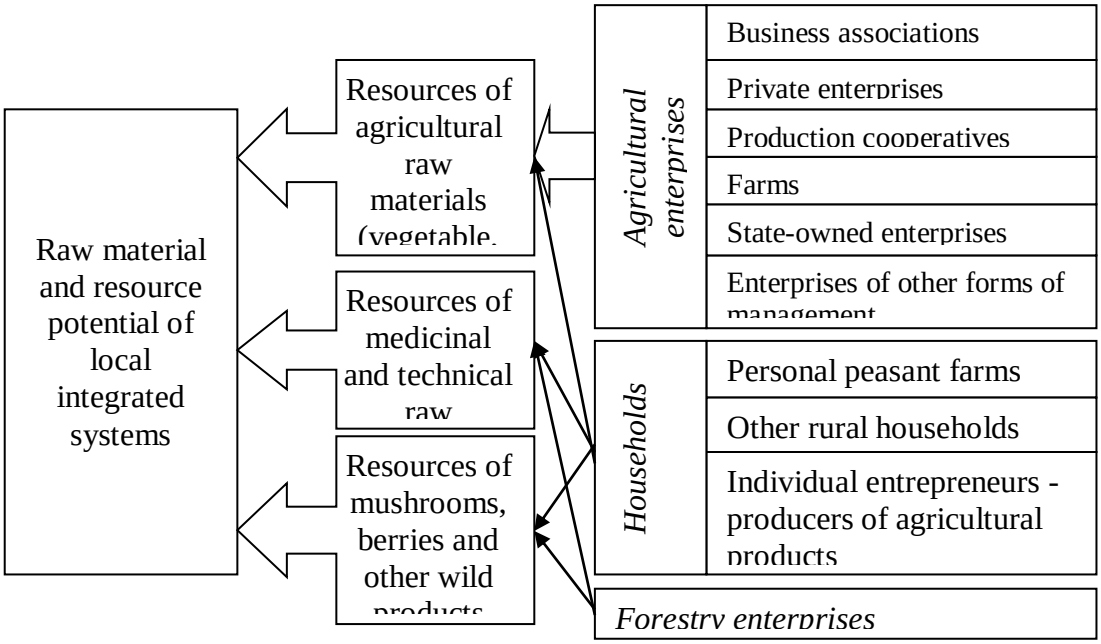


Fig. 1. Sources of formation of raw material and resource potential of local integrated systems "harvesting – processing – marketing"

As can be seen from Table 1, in 2020, 15672 agricultural enterprises, 31851 farms, and 3954.8 thousand private farms operated in the agro-industrial complex of Ukraine.

Table 1. The number of agricultural enterprises, farms and personal farms in Ukraine in 2010-2020 and their individual characteristics [9]

Indicators	Years				2019 to 2010, %	2019 to 2015, %
	2010	2015	2019	2020		
Number of agricultural enterprises, units	14767	13076	13052	15672	106.1	119.9
Number of farms, units	41726	32303	32452	31851	76.3	98.6
Area of agricultural land in farms, thousand ha	4290.8	4343.7	4749.5	4817.8	112.3	110.9
Livestock in farms, thousand heads: – cattle	95.3	106.3	103.3	104.0	109.1	97.8
– pigs	294.8	276.1	284.0	292.9	99.4	106.1
– birds	2878.3	2538.9	4535.2	4749.9	165.0	187.1
Number of personal farms, thousand units	4540.4	4108.4	3975.1	3954.8	87.1	96.3
Area of land plots in private farms, thousand ha: – for personal farming	2873.9	2603.3	2512.6	2517.7	87.6	96.7
– for conducting commodity agricultural production	2841.8	2837.1	6125.7	2772.6	97.6	97.7
Livestock in private farms, thousand heads: – cattle	2454.2	2479.8	2042.5	1865.6	76.0	75.2
– pigs	3319.3	3375.0	2427.3	2246.7	67.7	66.6

According to official statistics and research by scientists [1; 10], among agricultural enterprises in terms of quantity, the largest share is occupied by farms, although the latter are quite small in land use and their share in production remains low. From Fig. 2 we see that 35.4 % of agricultural products in 2020 were produced in households, 53.9 % – in agricultural enterprises and 10.7 % – in farms.

At the same time, the vast majority of agricultural enterprises focus on the production and sale of grain and industrial crops.

To study the state of organization of logistics processes for the promotion of agricultural products, we conducted a questionnaire survey of 20 agricultural enterprises in Lviv region (on the basis of a small sample) [10].

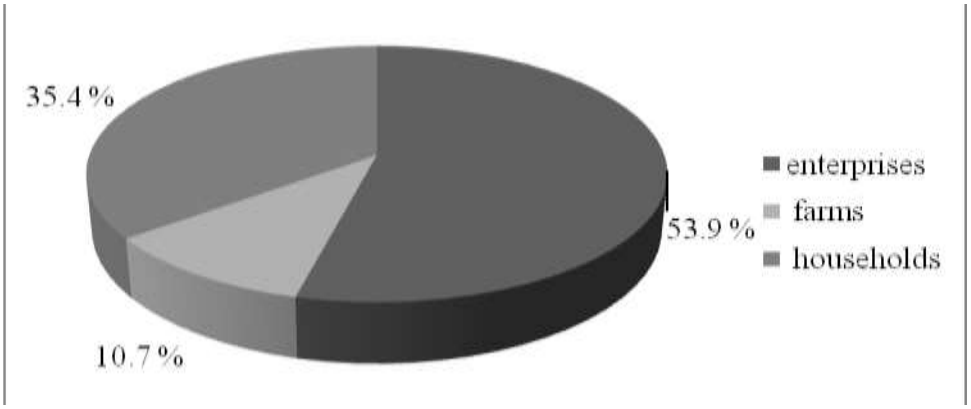


Fig. 2. The place of the main groups of producers of agricultural products of Ukraine in 2020 [9]

The analysis of the survey results showed that the main participants in the logistics chains that ensure the movement of agricultural products in the agro-industrial complex are various commercial intermediaries. More than half of the surveyed agricultural enterprises use their services for the purchase and further sale of agricultural products (Table 2). At the same time, 35 % of agricultural enterprises do not use the services of these intermediaries at all and independently organize the sale of manufactured products.

Table 2. The main types of intermediaries for the sale of products by agricultural enterprises

Types of intermediaries	Number of positive answers	Share in the total number of answers, %	Share of enterprises using intermediary services in the total number, %
Agro-industrial houses	0	0	0
Agricultural and (or) commodity exchanges	2	8	10
Agricultural chambers	0	0	0
Service cooperatives	3	12	15
Procurement formations of commercial type	13	52	65
The company does not use the services of intermediaries	7	28	35

Without rejecting the possibility of involvement in the activities of local integrated systems of agricultural enterprises and even their priority as a source of raw materials (given the relatively large volumes of agricultural production of

standard quality), we believe that the most potential partners in integration are households and farms, who have difficulties in providing infrastructure for their activities, including – in the sale of manufactured products.

From the Table 1 it's shown that the area of agricultural land used by farms in Ukraine increased by 12.3 %. With the implementation of state policy in the agricultural sphere, more and more peasants are joining shares (shares) to their personal peasant households, renting land, and forming farms. At the same time, the tendency to reduce the number of farms in recent years should be considered in the context of the process of their consolidation: if in 2010 one such farm accounted for 102.8 ha of agricultural land, in 2020 - 151.3 ha. At the same time, the level of labor mechanization has significantly increased.

The farm sector is the most dynamic sector of agricultural production. According to official statistics, farms produced in 2020 9649.1 thousand tons of grain and legumes (14.9 % of total production), 2465.4 thousand tons of sunflower (18.8 %), 422.5 thousand tons sugar beets (4.6 %), 291.2 thousand tons of vegetables (3.0 %) (Table 3). 104.0 thousand heads of cattle are concentrated in the country's farms (9.1 % more than in 2010), 292.9 thousand heads of pigs (0.6 % less than in 2010), 4749.9 thousand heads of poultry (65 % more than in 2010). In 2020, this sector of agricultural production produced 77.4 thousand tons of meat (in slaughter weight) (3.1 % of total production), 223.6 thousand tons of milk (2.4 %).

Table 3. Volumes of production of the main types of agricultural products in farms of Ukraine in 2010-2020 [9] (thousand tons)

Types of products	2010		2015		2019		2020		2020
	amount	share in total, %	amount	share in total, %	amount	share in total, %	amount	share in total, %	in % (times) to 2010
Cereals and legumes	4702.5	12.0	7650.2	12.7	11489.7	15.3	9649.1	14.9	2.1 t.
Sugar beets	1154.7	8.4	618.9	6.0	459.7	4.5	422.5	4.6	36.6
Sunflower	1208.5	17.8	2167.0	19.4	3098.9	20.3	2465.4	18.8	2.0 t.
Potato	161.3	0.9	126.0	0.6	94.0	0.5	113.2	0.5	70.2
Vegetables	211.9	2.6	282.5	3.1	293.9	3.0	291.2	3.0	137.4
Meat (in slaughter weight)	47.6	2.3	52.3	2.3	69.2	2.8	77.4	3.1	162.6
Milk	112.1	1.0	177.4	1.7	209.2	2.2	223.6	2.4	199.5

The sector of agricultural enterprises (including farms) is the main source of income for agro-processing enterprises of grain crops, sugar beets, milk and dairy products.

3. Research results

The agro-industrial complex has a certain system of movement of material flows of agricultural products, but its disadvantage in terms of interests of agricultural producers is the reduction of procurement and sale of final products on the most favorable terms, as well as weak interaction of agricultural producers with other partners in logistics chains. Moreover, for some types of agricultural products, agricultural enterprises have been effectively excluded from the creation of logistics chains by processing enterprises and are forced to independently sell finished products and products of its processing. A significant part of crop and livestock products grown in agricultural enterprises and farms is sold to other market participants who do not process agricultural raw materials.

Further prospects of farms, as evidenced by foreign experience of their development, associated with further consolidation and specialization, the establishment of agricultural production using modern technologies, active participation in integration processes in the field of agriculture.

A significant contribution to the production of agricultural products is made by the household sector, which carries out personal farming on 2517.7 thousand ha of land plots and organizes commodity agricultural production on 2772.6 thousand ha.

Today, the vast majority of rural families (almost the majority of villagers – owners of private farms, homesteads) have personal farms, which are a form of self-employment of the rural population, allow them to address food issues and often acquire a marketable nature.

L. Balash emphasizes the importance of this sector of the rural economy, drawing attention to the fact that "in the conditions of a sharp reduction in production in agricultural enterprises, the burden of ensuring food security of the country fell heavily on private farms" [11, p. 8]. The evolution and differentiation of households in rural areas has led to the formation in their composition of a significant layer of personal farms, which in their characteristics meet the world

criteria of farms. The surplus of agricultural products produced in private farms in excess of their needs, forms the commodity resources of agricultural products.

According to the data [9], in 2020 households gave 98.1 % of the total crop of potatoes, 84.6 % – vegetables, 83.2 % – fruits and berries. The role of this sector also increased in the production of exchange goods – grain (volumes increased by 39.2 % compared to 2010 and amounted to 20.4 % in total production) and oilseeds (volumes increased by 36.4 % compared to 2010 and amounted to 12.3 % in total production). In 3954.8 thousand personal farms are kept 1865.6 thousand heads of cattle (68.3 % of the population), 2246.7 thousand heads of pigs (51.0 %), 90914.9 thousand heads of poultry (42.6 %), 2555.1 thousand bee colonies. In 2020, this sector of agricultural production produced 773.5 thousand tons of meat (in slaughter weight) (31.2 % of total production), 6502.4 thousand tons of milk (70.4 %), 7253, 7 million pcs. eggs (44.9 %), 1427 tons of wool (90.7 %). Households provided the processing enterprises with most of the resources of potatoes and vegetables (the most labor-intensive types of agricultural products).

I. Prokopa and T. Berkuta in their monograph [12] state the important role of households in the agro-industrial processes of the country, which will be maintained in the future. In the context of the study, it is important to emphasize:

– households are a family type of rural management, which was, is and will remain an organic component of agricultural production, which develops harmoniously in the aggregate of large, medium and small farms;

– one of the prerequisites for effective progress and further transformation of households as small forms of management in the countryside is to use the relevant experience of foreign countries, where family farming is enshrined in law as the basis of the agricultural system;

– households, like all other forms of management, will not be able to move forward normally without the establishment of agro-food cooperatives in the countryside and other forms of partnership.

In the future, the economy of the population under the influence of external (competition, the need for product certification, increasing requirements for production technology, etc.) and internal (changing the need for self-sufficiency due to increased welfare, reduced working family members due to aging rural population and labor migration and etc.) factors will develop in two ways – reducing the volume of activity and reducing the agricultural activity of households

to the level of "hobby" and expanding production and reorganization of households (private farms) into farms, private enterprises and more. Currently, in the context of European integration, the urgent need of households is: increasing the level of organization of agricultural production according to European standards, increasing the level of marketability of households (especially consumer and commodity type), establishing stable sales of marketable products and agricultural products at the expense of payment for agricultural labor and as rent for property and land shares) through cooperation with local vertical integrated systems such as "harvesting – processing – marketing".

The development of local integrated systems will help solve a number of problems in the functioning of farms and personal households in a market environment (Table 4).

Table 4. Comparative characteristics of the activities of farms and private households in independent operation and in terms of interaction with local integrated systems

Types of services	Needs support under conditions of independent functioning		Needs support for interaction with integrated systems
	Farm	Personal peasant household	
1	2	3	4
Provision of production resources	At market prices	At market prices	Centralized purchases at wholesale prices for all agricultural producers participating in the integration interaction Quality control of production resources in the procurement process
Scientific and innovative support	Limited opportunities to learn and use innovations	Mostly the lack of opportunities for familiarization and use	Access to scientific developments, opportunities to participate in the production of new products (uncommon, new selections, etc.)
Financial resources support	Own funds Credit resources	Own funds	Interest-free loans in the form of services and resources
Information support	Searching for information on your own	Searching for information on your own	Information-consulting and marketing divisions of the integrated system Conducting marketing research, accumulation of information about market needs, competition

1	2	3	4
Logistics support	Sole proprietor Use of services of external contractors	Sole proprietor	Logistics unit of the integrated system Logistics service Control in the process of storage and transportation of products
Ensuring storage of manufactured products	Limited storage capacity High product losses during storage	Limited storage capacity, primitive storage High product losses during	Use of vegetable, fruit storages and refrigerators for storage of production Advanced technologies for storage of agricultural products Product quality control during storage
Sales of agricultural products	Spontaneous choice of sales channels Market formation of the selling price There is no guarantee of product sales	Spontaneous choice of sales channels Small batches of products Market formation of the selling price There is no guarantee of product sales and	Formation of large batches of standard products Purchases of products under previously concluded agreements Preliminary approval of procurement volumes and purchase prices Reduction of losses of agricultural products due to the closed technological cycle
Management	Sole proprietor Use of advisory services	Sole proprietor	Qualified consulting and training on the organization of production on advanced technologies, storage and pre-sale preparation

4. Conclusion

In modern economic conditions, farms and households (personal farms) occupy a prominent place in the production of agricultural products and the formation of resources of agricultural raw materials for processing enterprises of agriculture; the level of marketability of agricultural production in households is much lower than in farms (given the significant amount of domestic personal and industrial consumption, the level of losses of agricultural products). At the same time, the "bottleneck" in their operation is the need for infrastructure – logistics and production services (provision of seeds, agricultural machinery, vehicles, other material resources of industrial origin, as there are problems of lack of financial resources, unacceptable lending conditions, revision of the applied schemes of acquisition of such resources, etc.), and, especially, in sale of the made production (because of instability of sale, a considerable level of monopolization of the

markets, ousting of small local agricultural producers from the food markets, etc.) which can be satisfied through interaction with integrated systems.

Establishing integration ties of small producers of agricultural products (especially farms and households) with local integrated systems contributes to the deepening of specialization of farms, meeting their production needs for the organization of the production process within the value chain by combining the principles of cooperation (spatial and functional) and competition, using the resources of enterprises and organizations of consumer cooperation.

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MANAGEMENT OF AN INNOVATIVE PROJECT TAKING INTO ACCOUNT RISK FACTORS

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DOI: 10.31891/monograph/2021-10-5

1. Introduction

The peculiarities of innovation projects of construction organizations in development, which include: development of complex construction is one of the priority ways of effective functioning of construction organizations, increasing demand for construction products and development of construction using innovation solutions that are beneficial for both the state and construction organizations; the construction industry is specific in terms of project implementation, high investment costs and risks that require diversification of project funding sources; the main interdependent indicators of construction - density and number of storeys, which affect the characteristics of energy consumption; the territory of the construction, combining residential, public buildings and infrastructure, form the ecological environment of a significant number of citizens, taking into account environmental factors when planning the construction, in particular its heat and energy supply; ensuring standards of energy consumption, ecology, provision of social and cultural facilities and comfortable living for future residents in the construction complex. Based on the above, it is established that the assessment of energy-saving innovations in construction should be comprehensive, i.e. done on the basic of economic, energy and environmental factors.

Evaluation of the economic efficiency of energy-saving innovations in the development of territories is closely related to the estimation of energy efficiency. Thus, the indicator of energy efficiency of development of territories will allow to simplify and accelerate considerably the calculation of economic efficiency of investment projects of development of territories.

Risks can be divided into two groups: factorial, aggregate. With the factor-by-factor method, the main task is to accurately assess and select the amount of risk premium for certain types of risk (risk factors). In aggregate methods, no attention is paid to individual risk factors. The purpose of such calculations is to

establish a discount rate based on the minimum additional information about the company.

When using the factor-by-factor method in the amount of risk premium in the general case, three types of risks are taken into account: country risk (political risk); risk of unreliability of project participants; the risk of non-receipt of project revenues (in other terminology - "unsystematic", the risk that relates to just this project).

In addition to the factor-by-factor method of calculating the discount, there are a number of other methods, such as the Weighted Average Cost of Capital (WACC), the Adjusted Present Value (APV) method, and the Beta method, which should be given special consideration, taking into account its following advantages: clarity and relative simplicity of calculation; wide applicability of the method; the possibility of combining the Beta method and the factorial method.

The application of the beta method is based on the following classification of risks associated with the project: they are all divided into the risk of unforeseen completion of the project (for example, due to bankruptcy, insolvency, unpromising geological object) and variation risk, which determines the variability of project profitability its implementation. The discount rate *E,* which takes into account these risks, is calculated according to the Capital Assets Prices Model (CAPM):

$$E = Eo + \beta\,(R - Eo), \qquad (1)$$

where *Eo* is return on risk-free investment; *R* is average market return in the industry in the region at the time of calculation; β is a ratio that reflects the relative riskiness of this project compared to investing in the average market stake. Usually $0 = <\beta = <2$.

The main task at this stage is to determine the β-coefficient. Such methods can be divided into computational, statistical and expert. Given the specificity of calculation and statistical methods, as well as a number of limiting factors, it is worth paying attention to the expert method, as it allows you to take into account all the specific risks of projects. The method of calculating the β - coefficient by experts is given in the table below (Table 1):

Table 1. Method of calculating the β-coefficient by experts

	Total	Rick level								
Risk factor		1. low			2. middle			3. high		
Value of β		*0,00*	*0,25*	*0,50*	*0,75*	*1,00*	*1,25*	*1,50*	*1,75*	*2,00*
GENERAL ECONOMIC FACTORS										
Socio-political risk								X		
Domestic economic risk							X			
Foreign economic risk						X				
INDUSTRIAL FACTORS										
Cyclic factor					X					
Stage of development			X							
Competition							X			
Regulation								X		
Barrier to market entry							X			
RISK FACTORS AT THE LEVEL OF THE ENTERPRISE										
Liquidity								X		
Income stability							X			
Financial lever								X		
Operating lever						X				
Market share						X				
Clientele diversification										X
Product diversification							X			
Diversification by territory										X
Technological level						X				
RISK OF INCOMPATIBILITY OF INTERESTS										
The possibility of conducting a policy to the detriment of the interests of holders of securities of the enterprise									X	
TOTAL NUMBER OF OBSERVATIONS	18	0	1	0	1	4	5	4	1	2
CALCULATION OF WEIGHED AVERAGE VALUE β	23	0	0,25	0'	0,75	4	6,25	6	1,75	4

The scale of the degree of risk is set expertly, each degree of risk is assigned a corresponding value of the β-coefficient. The list of project risks is determined and for each item of the list the subordination of the project to the corresponding risk is revealed. Next, the weighed average value of the β-coefficient is calculated mathematically. In this case, $\beta = 23/18 = 1{,}28$.

For innovative projects, it is possible to apply the modified risk rate proposed by Jensen:

$$Ei = Eo + \beta\,(R - Eo) + V; \quad Ei = E + V, \quad V = \beta v\,(R - Eo), \qquad (2)$$

where V is the part of the risk premium that depends on the rating, reputation of the enterprise and the part of the risk premium that is not due to general market trends and reflects variational non-systematic risk (this includes innovation risk).

In essence, V can be included in the composition of $\beta\ (R - Eo)$, but to determine the innovative component, it is more correct to allocate it, as done in the above formula. When calculating the discount rate for IIP together with the classic, it is advisable to use a compound formula:

$$D_v = \frac{1}{((1+E)(1+V))^i}. \qquad (3)$$

Thus, when $Ei = E + V$, where V is the rate of innovation risk, following the law of economic feasibility, additional benefits (P) in the innovation project should always be > 0 і $> Ve$, де Ve , where Ve is the average value of V for the duration of the innovation project. Thus, if $P < Ve$; $P < 0$, investing in innovation is not economically feasible, it is more profitable to invest in similar traditional investment projects. The reason why it is not possible to compare P with V, but it is necessary to calculate Ve in advance, lies in determining the risk premium. The risk premium in this case is the static potential additional return for the innovative component of the project, unchanged at any point of the project. Innovation *risk (V)* in turn affects project performance in a dynamic way through the project discount rate, which depends on the time. Therefore, it is necessary to bring V into the appropriate P form, namely: to calculate such Ve at a time-constant discount

rate, at which the project indicators will be equal to the indicators obtained through the classical discount rate and *V*. The formula *Ve* is defined as follows:

Let x be a conditional income equal in all periods of the post-investment phase of the project. For the purity of the calculation in the formula *Ev = (E + V)*, *E* can be equated to 0, so, in our case, the risk rate will be formed only by innovation risk (*Ev = V)* => the discount rate will take the following form:

$$D_v = \frac{1}{(1+V)^i} \quad (4)$$

where *Dv* is the discount rate; *V* is the risk rate of the innovative component of the IIP of the territory, and *i* is the discount period;

Then

$$\frac{x}{(1+V)^i} + \frac{x}{(1+V)^{i+1}} + \cdots + \frac{x}{(1+V)^n} = \frac{(n-i+1)x}{(1+Ve)};$$

$$Ve = \frac{(n-i+1)}{\sum_{i=t}^{n} \frac{1}{(1+V)^i}} - 1, \quad (5)$$

where *t* is the first period of income withdrawal from the project, $t \in [0 \ldots n)$;

$(n - i + 1)$ is the number of periods of withdrawal of income from the project.

Ve (2.4) takes into account the duration of development and investment of innovation, which is a very important factor when considering project risks.

When calculating the discount rate for IIP, it is impractical to use the formula:

$D_v = \frac{1}{(1+Ev)^i}$, where *Dv* is the discount rate of the IIP, *Ev* is the risk rate for the IIP, and *i* is the discount period;

The formula below better reflects the innovative nature of the project, and also allows you to compare the risk components of IIP and IP-analogues. This is achieved due to the fact that the discount rate for IIP is based on the discount rate of the IP-analogue:

$$D_v = \frac{1}{((1+E)(1+V))^i}, \quad (6)$$

where E is the risk rate for the investment project-analogue; V is risk rate of the innovation component.

The economic meaning of this formula is as follows: the discounted values of the income of the IP-analogue are additionally discounted by the amount of innovation risk, this value reflects the risk difference between the IP-analogue and the IIP.

The calculation of the value of the risk premium should also reflect the advantages that arise in innovative products over existing products. The following formula allows you to take into account this aspect:

$$P = \frac{IM}{AM} - 1 \tag{7}$$

where P is the risk premium, expressed in shares or percentages; IM is absolute profitability of innovative products, AM is absolute profitability of analog products.

In turn, the principle of calculating IM and AM is given below:

$$\begin{aligned} IM &= \frac{I_c - I_{cc}}{I_{cc}} M_i \\ AM &= \frac{A - A_{cc}}{A_{cc}} M_a, \end{aligned} \tag{8}$$

where I_c is the market value of innovative products (determined on the basis of marketing and statistical research), I_{cc} is the cost of production, M_i is demand (attractiveness) for innovative products (in shares), A_c is market value of analogue products, A_{cc} is production cost analogue products, M_a is demand (attractiveness) for analogue products (in shares).

In the case of energy-saving innovations in the development of territories, when commercial efficiency can not be calculated, but there is economic efficiency, which is expressed in reducing production costs and sales rate per unit of heat, you can determine P by comparing the energy density (ED) of the innovative energy supply scheme indicators, or with indicators of analogues:

$$P = 1 - \frac{\mathrm{ED}_i \cdot \mathrm{CC}_i}{\mathrm{ED}_a \cdot \mathrm{CC}_a};\ P = 1 - \frac{\mathrm{ED}_i \cdot \mathrm{CC}_i}{\mathrm{ED}_n \cdot \mathrm{CC}_n}, \quad (9)$$

where CC_i is specific cost / cost of 1 kW of energy in the case of an innovative solution, taking into account additional capital investment in energy-saving innovations; CC_a is specific cost / production cost of 1 kW of energy for the analogue of the innovation scheme; CC_n is the average unit cost of production of 1 kW of energy in the region. ED_i is an indicator of the energy density of the building in the case of an innovative solution; ED_a is an indicator of energy density of building of the territory in case of analog; ED_n is an indicator of the energy density of the built-up area, which reflects the current standards of energy consumption in buildings.

(P) obtained by this formula reflects the economic benefits of the final consumer and producer of electricity in the form of savings by reducing the amount of energy consumed and its cost compared to the analogue of the innovative solution.

In general, the formula for determining the advantage (P) is a set of formulas (8) and (9):

$$\begin{cases} P_1 = \dfrac{IM}{AM} - 1 \\ P_2 = 1 - \dfrac{\mathrm{ED}_i \cdot \mathrm{CC}_i}{\mathrm{EB}_a \cdot \mathrm{CC}_a} \end{cases}, \quad (10)$$

P_1 reflects the advantage obtained by increasing the profitable part (commercial efficiency), with the condition under which IIP is considered commercially effective $\begin{bmatrix} P_1 > 0 \\ P_2 > Ve \end{bmatrix}$; P_2 is the advantage obtained through savings in energy production (economic efficiency), with the condition under which the project is considered cost-effective – $P_2 > 0$.

Thus, Ve, P_1, and P_2 allow:

• assess the feasibility of investing in innovation;

• assess the impact of innovation on the basic individual development of the territory;

• assess the additional risks of innovation that arise in connection with the implementation of the FE in the development of the territory;

• evaluate the premium for the risk of innovation in the individual development of the territory, expressed in additional profitability, which reflects the relative commercial and economic efficiency.

In this case, *Ve* і P_1, in addition to rapid analysis of the project, can be used in the search for such classic indicators as *IRR* and *NPV*. They will allow to adjust these indicators for the innovation component:

$$NVP_{\text{IIP}} = \frac{1 + P_1}{1 + Ve} \cdot NVP_{\text{IIP}}, \qquad (11)$$

NPV_{IIP} net discounted income of IIP of territory development; P_1 is risk premium, expressed in additional profitability of IIP; *Ve* is the average risk rate for this IIP; NPV_{IP} is net discounted income of the IP proprietorship of the territory.

Thus, *Ve*, P_1 and P_2 have the following properties and advantages:

• they allow to make the express analysis of an innovative part of the investment project;

• they ake into account the specific properties of innovative projects, namely: additional risks and benefits;

• they take into account the time factor of project implementation as a factor that increases its risks;

• they introduce an innovative amendment to the basic calculations of the investment project, i.e. can be used to search for classic performance indicators, such as *IRR* and *NPV*.

Among the significant shortcomings of the existing methods of evaluation of the effectiveness of innovations of construction companies, in particular from the standpoint of energy-saving innovations in development of territories, the following ones are highlighted: they do not take into account the specifics of investment projects for development of territories; relativity of efficiency assessment; these models allow to compare alternative projects, but it is impossible to estimate the real irrelevant economic efficiency with their help; lack of consideration of risks / benefits; the models do not assume the assessment of risk / prevailing factors of the innovation project, which significantly affects the

reliability of the evaluation of economic efficiency; impossibility of classical evaluation of economic efficiency of innovation and investment projects, using these methods; to calculate such indicators as net discount income and internal rate of return, it is necessary to make a separate complicated calculation, which will not be able to take into account the specifics of energy-saving innovations in the development of territories to the full extent.

It is proposed to use the discount rate method to assess additional risks in relation to innovation development of territories projects, taking into account its following advantages: flexibility and versatility of the method; the possibility of its use in evaluation of the risks of almost any investment project, including innovation - investment projects; taking into account the time factor; ease of calculation and application. The dissertation analyzes the possibility of risk assessment using insurance premiums and identifies the unsuitability of such an assessment in relation to the developed methodology.

Demand for innovation products and analogue products for innovations used in development of territories is determined, by the expert way on the basis of known methods BREEAM or LEED. In this case, the impact of time in estimation demand is not taken into account due to the fact that the risk premium indicator for real estate does not depend on the age of the object, but is directly related to such spontaneous and unpredictable parameters as : demographic situation, geopolitical factor, economic and ecological situation in the region / country, etc.

The following properties and advantages of commercial and economic efficiency are singled out: the possibility of carrying out the express analysis of an innovation part of the investment project from the point of view of commercial and economic efficiency taking into account the indicators of energy density of the construction; taking into consideration the specific properties of innovation projects, namely: additional risks and benefits; taking into account the time factor of project implementation as a factor that increases its risks; introduction of an innovative amendment to the basic calculations of the investment project, i.e. can be used to search for efficiency indicators such as net discount income and internal rate of return.

Development of project documentation for spatial planning is carried out by achieving standardized construction indicators, such as energy consumption and construction density. Thus, it is recommended to assess the energy efficiency of

buildings already at this stage using the indicator of ES of construction by comparing the calculated indicators of ES of construction with the indicators of ES on the basis of target indicators of energy consumption.

Developed and substantiated innovation management mechanism to stimulate the housing market, including a set of projects and specific measures, allows to achieve the following results: the increase of sales in construction organizations, reduction of operating costs of buildings and infrastructure; creation of conditions and definite mechanisms of stimulation and motivation of introduction of innovation processes and energy saving technologies at all stages: from the beginning of designing to the end of construction and operation; creating an attractive investment climate and conditions for developers through the provision of additional subsidies and benefits for the development of innovative construction, as well as the creation of clear, accessible and transparent procedures for approval and obtaining the necessary documentation; ensuring reduction of energy consumption in the medium and long term, including that through the introduction of energy efficient, environmentally friendly technologies and materials.

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ANALYSIS OF THE FINANCIAL STABILITY OF INDUSTRIAL ENTERPRISES AS A PREREQUISITE FOR SUCCESSFUL OPERATION IN AN UNSTABLE MARKET ENVIRONMENT

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DOI: 10.31891/monograph/2021-10-6

Along with the study of operating activities, there is a need to analyze the financial position of industrial enterprises. Assessment of financial condition will determine the effectiveness of activities; identify problems, shortcomings and ways to improve efficiency. In addition, the study of financial stability will establish the level of independence of the enterprise from borrowed resources, the ratio of equity and debt capital, the presence of financial risk, the degree of business insurance, the efficiency of working assets and fixed assets. Moreover, industrial enterprises are constantly negatively influenced by the external environment, threats, crises, which affect the efficiency of their work, the level of financial stability. Therefore, it is also advisable to determine the type of financial stability of enterprises, which will define the adequacy of their own working capital, the level of inventory coverage, the efficiency of using financial resources, the state of solvency. According to the results of the assessment of financial stability, we can talk about the state of operating, financial, investment activities, financial capabilities of industrial enterprises.

It should also be noted that the results of the investigation of financial stability can identify opportunities, advantages of industrial enterprises to expand or determine problems that need immediate solution. Thus, the successful operation of enterprises depends on their financial stability and each enterprise should strive to improve its financial condition in order to reduce dependence on borrowed funds, the probability of bankruptcy, successful development, and increase competitiveness.

For research of the financial stability, determination of the type of financial constancy of industrial enterprises should use the indicators that are given in the textbook of the authors Yu.M. Tiutiunyk, L.O. Dorohan-Pysarenko, S.V. Tiutiunyk [6, p. 110-124].

Let's start with a study of the financial stability of PJSC "Berdyansk harvesters", which was conducted in 2015-2019 (Table 1). The first group of

indicators, i.e. the indicators of the structure of sources of capital formation in 2019 compared to 2018, shows the following dynamics: the coefficient of financial autonomy increased by 9%, but the value is lower than the norm and should further increase independence from borrowed funds; the debt capital concentration coefficient has decreased by 5%, but it does not meet the regulatory value and the share of borrowed resources should be reduced; the financial risk ratio diminished by 13%, but does not match the normative value and the level of risk increases; the coefficient of financial stability elevated by 15% and indicates the dependence of the enterprise on external sources of financing; the coefficients of business insurance, equity insurance and insurance of registered (share) capital in 2015-2019 are absent, which indicates that the company does not carry out business insurance and have no reserve capital. The following group of indicators of current assets also shows variable dynamics and in 2019 compared to 2018 the following changes took place: the maneuverability ratio of equity decreased by 24%, is higher than the normative value, but reflects a reduction in the share of equity to finance current assets; the coefficient of provision of current assets with own working capital corresponds to the normative value, but there was a diminution by 10%; the ratio of provision of inventories with working capital increased by 68% and reflects a sufficient amount of inventories; the coefficient of maneuverability of working capital remained unchanged in 2017-2019, which represents the low level of maneuverability. The latter is a group of indicators of the state of fixed capital and in 2019 compared to 2018 there is a reduction in the coefficient of property for industrial purposes by 35% and indicates a decrease in production capacity; increase the real value of fixed assets by 29%, which demonstrates an increase in the share of fixed assets. Thus, in 2019 there is a slight decrease in financial stability.

We can proceed to determine the type of financial stability of PJSC "Berdyansk harvesters" (Table 2). Summarizing the data, it can be noted that in 2015-2019 the company formed a financial crisis because of lack of working capital for inventory, deficiency of working capital and long-term bank loans for inventory, shortage of total sources of inventory. Therefore, in the analyzed period there is no coverage of stocks by sources of their formation. Therefore, there is a need to assess the probability of bankruptcy and to determine the threat of closure.

Table 1. Indicators of financial stability of the enterprise PJSC "Berdyansk harvesters" in 2015-2019

Indicators	2015	2016	2017	2018	2019	Normative value
Indicators of the structure of sources of capital formation						
Coefficient of financial autonomy	0,47	0,42	0,35	0,37	0,40	≥ 0,5
Coefficient of debt capital concentration	0,53	0,58	0,65	0,63	0,60	< 0,5
Coefficient of financial risk	1,11	1,37	1,86	1,73	1,51	< 1
Coefficient of financial stability	0,90	0,73	0,54	0,58	0,66	≥ 1
Coefficient of business insurance	0,00	0,00	0,00	0,00	0,00	Increase
Coefficient of equity insurance	0,00	0,00	0,00	0,00	0,00	Increase
Coefficient of insurance of registered (share) capital	0,00	0,00	0,00	0,00	0,00	Increase
Indicators of current assets						
Coefficient of equity maneuverability	0,55	0,70	0,74	0,69	0,52	> 0,1
Coefficient of provision of current assets with own working capital	0,33	0,34	0,45	0,29	0,26	≥ 0,1
Coefficient of provision of inventories with working capital	0,59	0,61	0,50	0,58	0,98	≥ 0,5
Coefficient of maneuverability of working capital	0,02	0,02	0,07	0,07	0,07	Increase
Fixed capital indicators						
Coefficient of industrial property	0,65	0,61	0,60	0,55	0,36	Increase
Coefficient of the real value of fixed assets	0,21	0,12	0,09	0,11	0,14	Increase

Note: calculated by the author based on [2]

Table 2. Determining the type of financial stability of the enterprise PJSC "Berdyansk harvesters" in 2015-2019

Indicators	2015	2016	2017	2018	2019
Own working capital	47660	83646	110284	120049	103148
Long-term bank credits	0	0	0	0	0
Short-term bank credits	0	50000	40900	44000	0
Stocks and current biological assets	80127	136078	218850	206476	105644
Availability of working capital and long-term loans of banks for the formation of stocks (i.1 + i.2)	47660	83646	110284	120049	103148
The total value of sources of stock formation (i.1 + i.2 + i.3)	47660	133646	151184	164049	103148
Excess (+), lack (-) of working capital for the formation of stocks (i.1 – i.4)	-32467	-52432	-108566	-86427	-2496
Excess (+), shortage (-) of working capital and long-term loans of banks for the formation of stocks (i.5 – i.4)	-32467	-52432	-108566	-86427	-2496
Excess (+), lack (-) of the total value of sources of stock formation (i.6 –i.4)	-32467	-2432	-67666	-42427	-2496
Type of financial stability	Crisis financial situation				

Note: calculated by the author based on [2]

Let's examine the indicators of financial stability of the enterprise PJSC "Zaporizhzhia Electric Locomotive Repair Plant" (Table 3). Analyzing the group of indicators of the structure of sources of capital formation, it can be noted that in

2019 compared to 2018 there are the following changes: the coefficient of financial autonomy decreased by 31%, does not meet the normative value, i.e. there are financial risks, reduced efficiency of financial activity; the debt capital concentration coefficient increased by 16%, does not match the regulatory value and confirms the growth of financial risks; the financial risk coefficient elevated by 68%, exceeds the normative value and indicates a decline in financial stability, dependence on borrowed capital; the coefficient of financial stability has diminished by 41%, is below the regulatory value and the company cannot perform its obligations on time, there is a risk of bankruptcy; the business insurance coefficient did not change in 2015-2019; the coefficient of equity insurance increased by 50%; the insurance coefficient of registered (share) capital in 2015-2019 also remained unchanged. After the investigation of the group indicators of current assets and in 2019 compared to 2018 the following dynamics is observed: the coefficient of the maneuverability of equity in 2019 was negative, below the norm, i.e. the equity is fully used to finance non-current assets; the coefficient of provision of current assets to own working capital in 2019 was also negative, below the normative value, the company cannot finance its current assets with equity and depends on borrowed capital; the coefficient of provision of inventories with own working capital in 2019 is negative, below the normative value; the coefficient of maneuverability of working capital in 2019 reached a negative value.

In the third group of fixed capital indicators in 2019 compared to 2018 there was a reduction in the coefficient of property for production purposes by 16%, i.e. production potential of the enterprise diminished, and the real value of fixed assets decreased by 7% too, indicating a decline in share fixed assets. Thus, the financial position of the company in 2019 deteriorated compared to 2018.

Next, we determine necessarily the type of financial stability of PJSC "Zaporizhzhia Electric Locomotive Repair Plant" in 2015-2019 (Table 4). At the enterprise in 2015-2018 there is a lack of working capital for the formation of stocks, shortage of working capital and long-term bank loans for the formation of stocks, deficiency of total sources of formation of stocks and, accordingly, a crisis financial state is formed.

Table 3. Indicators of financial stability of the enterprise PJSC "Zaporizhzhia Electric Locomotive Repair Plant" in 2015-2019

Indicators	2015	2016	2017	2018	2019	Normative value

Indicators of the structure of sources of capital formation						
Coefficient of financial autonomy	0,56	0,54	0,35	0,33	0,23	≥ 0,5
Coefficient of debt capital concentration	0,44	0,46	0,65	0,67	0,77	< 0,5
Coefficient of financial risk	0,77	0,85	1,83	1,99	3,34	< 1
Coefficient of financial stability	1,29	1,17	0,55	0,50	0,30	≥ 1
Coefficient of business insurance	0,01	0,01	0,01	0,01	0,01	Increase
Coefficient of equity insurance	0,02	0,02	0,03	0,03	0,04	Increase
Coefficient of insurance of registered (share) capital	0,05	0,05	0,05	0,05	0,05	Increase
Indicators of current assets						
Coefficient of equity maneuverability	0,22	0,20	0,02	0,04	-0,27	> 0,1
Coefficient of provision of current assets with own working capital	0,22	0,19	0,02	0,02	-0,09	≥ 0,1
Coefficient of provision of inventories with working capital	0,42	0,35	0,02	0,03	-0,17	≥ 0,5
Coefficient of maneuverability of working capital	0,77	0,20	5,00	0,30	-3,61	Increase
Fixed capital indicators						
Coefficient of industrial property	0,67	0,67	0,73	0,71	0,60	Increase
Coefficient of the real value of fixed assets	0,36	0,35	0,29	0,27	0,25	Increase

Note: calculated by the author based on [3]

Table 4. Determining the type of financial stability of the enterprise PJSC "Zaporizhzhia Electric Locomotive Repair Plant" in 2015-2019

Indicators	2015	2016	2017	2018	2019
Own working capital	38523	34005	3156	5626	-23987
Long-term bank credits	0	0	0	0	0
Short-term bank credits	0	0	0	0	0
Stocks and current biological assets	92432	97279	166977	179417	138171
Availability of working capital and long-term loans of banks for the formation of stocks (i.1 + i.2)	38523	34005	3156	5626	-23987
The total value of sources of stock formation (i.1 + i.2 + i.3)	38523	34005	3156	5626	-23987
Excess (+), lack (-) of working capital for the formation of stocks (i.1 – i.4)	-53909	-63274	-163821	-173791	114184
Excess (+), shortage (-) of working capital and long-term loans of banks for the formation of stocks (i.5 – i.4)	-53909	-63274	-163821	-173791	114184
Excess (+), lack (-) of the total value of sources of stock formation (i.6 –i.4)	-53909	-63274	-163821	-173791	114184
Type of financial stability	Crisis financial situation				Absolute financial stability

Note: calculated by the author based on [3]

However, in 2019 there is a surplus of the above indicators, i.e. the absolute financial stability is typical. This situation is explained by the fact that in 2015-2017 the company was unprofitable and in 2018-2019 made a profit.

It is also necessary to dwell on the study of the financial stability of the enterprise PJSC "Zaporizhzhia Abrasive Plant" (Table 5). According to the group indicators of the structure of sources of capital formation in 2019 against 2018, the following dynamics took place: the coefficient of financial autonomy increased by 38%, meets the normative value and allows us to note that the company can finance 68% of its assets with equity, has a normal level of resilience, low level of risks, but in 2019 there was a loss; the debt capital concentration coefficient decreased by 37% and indicates a low level of financial risks, the feasibility of further increasing the share of borrowed capital; the financial risk coefficient reduced by 55%, corresponds to the normative value and also confirms the diminution of business risk; significant growth has a coefficient of financial stability, which is 1.21 times, i.e. the enterprise has a high level of efficiency of its activity; the coefficient of business insurance, the coefficient of equity insurance have unchanged value in 2015-2019, i.e. the enterprise carries out activity insurance; there was a reduction in the coefficient of the insurance of registered (share) capital by 64%.

The next is a group of indicators of current assets and in 2019 compared to 2018 there were the following changes: the maneuverability coefficient of equity increased by 5%, i.e. meets the regulatory value and the use of equity improves; the coefficient of provision of current assets to own working capital elevated by 61%, corresponds to the normative value; the coefficient of provision of inventories with own working capital raised by 21% and reflects a sufficient level of inventories; the maneuverability coefficient of own working capital increased by 30%, i.e. there is an efficient use of own funds. According to the third group, the indicators of the state of fixed capital, during 2019 compared to 2018 there were changes: the coefficient of property for production increased by 15% and reflects the rise in production capacity, the coefficient of real value of fixed assets increased by 5%. In general, the indicators of financial stability show improvement and resumption of the enterprise.

Table 5 Indicators of financial stability of the enterprise PJSC "Zaporizhzhia Abrasive Plant" in 2015-2019

Indicators	2015	2016	2017	2018	2019	Normative value
Indicators of the structure of sources of capital formation						
Coefficient of financial autonomy	0,45	0,51	0,48	0,49	0,68	≥ 0,5
Coefficient of debt capital concentration	0,55	0,49	0,52	0,51	0,32	< 0,5
Coefficient of financial risk	1,21	0,94	1,07	1,02	0,46	< 1
Coefficient of financial stability	0,82	1,06	0,94	0,98	2,16	≥ 1
Coefficient of business insurance	0,01	0,01	0,01	0,01	0,01	Increase
Coefficient of equity insurance	0,02	0,02	0,02	0,02	0,02	Increase
Coefficient of insurance of registered (share) capital	2,95	3,01	3,70	5,27	1,92	Increase
Indicators of current assets						
Coefficient of equity maneuverability	0,42	0,44	0,21	0,51	0,53	> 0,1
Coefficient of provision of current assets with own working capital	0,26	0,32	0,18	0,33	0,54	≥ 0,1
Coefficient of provision of inventories with working capital	0,47	0,58	0,41	0,74	0,90	≥ 0,5
Coefficient of maneuverability of working capital	0,12	0,22	0,94	0,24	0,31	Increase
Fixed capital indicators						
Coefficient of industrial property	0,65	0,66	0,47	0,50	0,57	Increase
Coefficient of the real value of fixed assets	0,24	0,27	0,22	0,16	0,17	Increase

Note: calculated by the author based on [4]

It is also necessary to determine the type of financial stability of PJSC "Zaporizhzhia Abrasive Plant" (Table 6).

Table 6. Determining the type of financial stability of the enterprise PJSC "Zaporizhzhia Abrasive Plant" in 2015-2019

Indicators	2015	2016	2017	2018	2019
Own working capital	99965	116668	65454	194287	310009
Long-term bank credits	0	0	0	0	0
Short-term bank credits	159639	104256	58941	66464	43114
Stocks and current biological assets	213917	201517	158785	261142	343739
Availability of working capital and long-term loans of banks for the formation of stocks (i.1 + i.2)	99965	116668	65454	194287	310009
The total value of sources of stock formation (i.1 + i.2 + i.3)	259604	220924	124395	260751	353123
Excess (+), lack (-) of working capital for the formation of stocks (i.1 – i.4)	-113952	-84849	-93331	-66855	-33730
Excess (+), shortage (-) of working capital and long-term loans of banks for the formation of stocks (i.5 – i.4)	-113952	-84849	-93331	-66855	-33730
Excess (+), lack (-) of the total value of sources of stock formation (i.6 –i.4)	45687	19407	-34390	-391	9384
Type of financial stability	Unstable financial condition	Unstable financial condition	Crisis financial condition	Crisis financial condition	Unstable financial condition

Note: calculated by the author based on [4]

During 2015-2019 there is a variable dynamics and in 2018 there was a financial crisis, in 2019 - an unstable financial situation. In 2019, there is a shortage of working capital for the formation of stocks, lack of working capital and long-term bank loans for the formation of stocks, the excess of the total amount of sources of stocks. Unstable financial condition in 2019 is also because of the loss and it is advisable to attract long-term bank credits, to increase the share of working capital.

Consider the level of financial stability of JSC "Motor Sich" (Table 7). According to the first group of indicators of the structure of sources of capital formation in 2019 compared to 2018, the following changes took place: the coefficient of financial autonomy increased by 11%, corresponds to the regulatory value, which indicates a decrease in the level of financial risk; the coefficient of concentration of borrowed capital decreased by 21%, correlates with the normative value and allows to note the decline in dependence on borrowed funds; the financial risk coefficient reduced by 29%, which shows a low risk for investing in the company; the coefficient of financial stability elevated by 40%, which reflects the low level of financial risks, the ability of the company to perform its obligations in a timely manner; the business insurance coefficient remained unchanged in 2018-2019; the equity insurance coefficient was low during 2015-2019, which indicates a low level of business insurance; the insurance coefficient of the registered (share) capital in 2015-2019 was unchanged.

The next group is the indicators of current assets and in 2019 relative to 2018 there is a dynamic: the coefficient of maneuverability of equity increased by 0.35%, which demonstrates a sufficient amount of financial resources; the coefficient of provision of current assets to own working capital increased by 15%; the coefficient of provision of inventories to own working capital decreased by 5%, which testifies a sufficient amount of inventories; the coefficient of maneuverability of working capital was low in 2018-2019. Regarding the third group of fixed capital, in 2019 compared to 2018 there was a rise in the coefficient of property for production purposes by 12%, i.e. increasing production capacity, reducing the coefficient of real value of fixed assets by 2%, which indicates a decline in the share of fixed assets. Thus, at the enterprise indicators of financial stability in 2019 are at a low level [7, p. 109-112].

Table 7. Indicators of financial stability of JSC "Motor Sich" in 2015-2019

Indicators	2015	2016	2017	2018	2019	Normative value
Indicators of the structure of sources of capital formation						
Coefficient of financial autonomy	0,69	0,63	0,67	0,67	0,74	≥ 0,5
Coefficient of debt capital concentration	0,31	0,37	0,33	0,33	0,26	< 0,5
Coefficient of financial risk	0,46	0,58	0,50	0,50	0,35	< 1
Coefficient of financial stability	2,18	1,72	2,01	2,02	2,83	≥ 1
Coefficient of business insurance	0,003	0,003	0,003	0,002	0,002	Increase
Coefficient of equity insurance	0,01	0,004	0,004	0,004	0,003	Increase
Coefficient of insurance of registered (share) capital	0,25	0,25	0,25	0,25	0,25	Increase
Indicators of current assets						
Coefficient of equity maneuverability	0,58	0,61	0,61	0,60	0,61	> 0,1
Coefficient of provision of current assets with own working capital	0,56	0,51	0,59	0,55	0,63	≥ 0,1
Coefficient of provision of inventories with working capital	0,78	0,75	0,78	0,79	0,75	≥ 0,5
Coefficient of maneuverability of working capital	0,08	0,10	0,06	0,0009	0,0008	Increase
Fixed capital indicators						
Coefficient of industrial property	0,79	0,75	0,77	0,76	0,85	Increase
Coefficient of the real value of fixed assets	0,28	0,24	0,25	0,25	0,24	Increase

Note: calculated by the author based on [1]

Next, it is necessary to consider the type of financial stability of JSC "Motor Sich" (Table 8). At the enterprise in 2015-2019 there is a lack of working capital for the formation of stocks, deficit of working capital and long-term bank credits for the formation of stocks, shortage of total sources of stocks, i.e. financial crisis is characterized for it. In addition, in 2019 the company suffered a loss and it is advisable to further determine the probability of bankruptcy.

Table 8. Determining the type of financial stability of the company JSC "Motor Sich" in 2015-2019

Indicators	2015	2016	2017	2018	2019
Own working capital	8190425	9765789	10753535	12005324	12799878
Long-term bank credits	17878	347225	410294	329700	168120
Short-term bank credits	601461	849409	717452	682787	641896
Stocks and current biological assets	10533410	12941091	13775965	15142329	16979957
Availability of working capital and long-term loans of banks for the formation of stocks (i.1 + i.2)	8208303	10113014	11163829	12335024	12967998
The total value of sources of stock formation (i.1 + i.2 + i.3)	8809764	10962423	11881281	13017811	13609894
Excess (+), lack (-) of working capital for the formation of stocks (i.1 – i.4)	-2342985	-3175302	-3022430	-3137005	-4180079
Excess (+), shortage (-) of working capital and long-term loans of banks for the formation of stocks (i.5 – i.4)	-2325107	-2828077	-2612136	-2807305	-4011959
Excess (+), lack (-) of the total value of sources of stock formation (i.6 –i.4)	-1723646	-1978668	-1894684	-2124518	-3370063
Type of financial stability	Crisis financial situation				

Note: calculated by the author based on [1]

Taking into account the indicators of operating activity, we will investigate the financial stability of the enterprise of PJSC "Zaporizhtransformator" (Table 9). According to the group indicators of the structure of sources of capital formation in 2018 compared to 2017, the following changes took place: the coefficient of financial autonomy in 2016-2018 was negative, which is explained by the negative value of equity and confirms the need to restore financial stability, the possibility of bankruptcy; the coefficient of the debt capital concentration increased by 12%, which indicates a high level of financial risks in the enterprise; the financial risk coefficient in 2016-2018 was negative, below the normative value, i.e. a high level of risk activity; the financial stability coefficient was also below zero, does not meet the normative value, which proves the possibility of bankruptcy and rapid cessation of activities; the coefficients of business insurance, of equity insurance, insurance and of registered (share) capital are absent, because the company has no reserve capital, i.e. no business insurance and in case of financial crisis there are no reserve funds. It should be noted that the group indicators of current assets in 2018 compared to the previous period there are changes: the coefficient of maneuverability of equity increased by 8%; the coefficient of provision of current assets to own working capital in 2016-2018 was negative because of the negative value of equity, which shows the lack of funds in the enterprise for the formation of working capital, the existence of dependence on borrowed capital; the coefficient of provision of inventories with own working capital and the coefficient of maneuverability of own working capital in 2016-2018 were negative. Considering the data on the group of indicators of the state of fixed capital, it can be discovered that in 2018 compared to 2017, the coefficient of property for industrial purposes increased by 0.25%, the coefficient of real value of fixed assets - by 6%. A significant decline in the financial stability of the enterprise is observed in 2016-2018.

Table 9. Indicators of financial stability of the enterprise PJSC "Zaporizhtransformator" in 2014-2018

Indicators	2014	2015	2016	2017	2018	Normative value
Indicators of the structure of sources of capital formation						
Coefficient of financial autonomy	0,47	1,18	-1,30	-1,21	-1,48	≥ 0,5
Coefficient of debt capital concentration	1,47	2,18	2,30	2,21	2,48	< 0,5
Coefficient of financial risk	3,13	1,85	-1,77	-1,83	-1,68	< 1

Coefficient of financial stability	0,32	0,54	-0,57	-0,55	-0,60	≥ 1
Coefficient of business insurance	0,00	0,00	0,00	0,00	0,00	Increase
Coefficient of equity insurance	0,00	0,00	0,00	0,00	0,00	Increase
Coefficient of insurance of registered (share) capital	0,00	0,00	0,00	0,00	0,00	Increase
Indicators of current assets						
Coefficient of equity maneuverability	-0,40	0,47	0,58	0,57	0,61	> 0,1
Coefficient of provision of current assets with own working capital	-0,55	1,48	-1,67	-1,44	-2,11	≥ 0,1
Coefficient of provision of inventories with working capital	-2,89	8,64	-4,23	-3,44	-4,93	≥ 0,5
Coefficient of maneuverability of working capital	-0,14	0,05	-0,17	-0,23	-0,09	Increase
Fixed capital indicators						
Coefficient of industrial property	0,35	0,32	0,40	0,47	0,47	Increase
Coefficient of the real value of fixed assets	0,28	0,26	0,22	0,27	0,28	Increase

Note: calculated by the author based on [5]

Consider the type of financial stability of PJSC "Zaporizhtransformator", which is defined for 2014-2018 (Table 10). In 2014, the company has a lack of working capital for the formation of stocks, deficit of working capital and long-term bank credits for the formation of stocks, the excess of the total amount of sources of stocks, which reflects the unstable financial situation; in 2015, a surplus was formed in all indicators and is characterized by absolute financial stability; in 2016-2018 there is a shortage of all indicators and is characterized by a financial crisis. During 2014-2018, the company suffered a loss and it is advisable to study the probability of a financial crisis.

Table 10. Determining the type of financial stability of the enterprise PJSC "Zaporizhtransformator" in 2014-2018

Indicators	2014 p.	2015 p.	2016 p.	2017 p.	2018 p.
Own working capital	-678932	2034474	-7551273	-8033718	-8455726
Long-term bank credits	0	0	0	3591082	0
Short-term bank credits	3429649	5609341	7989001	5162975	8866716
Stocks and current biological assets	235248	235482	727158	923377	757345
Availability of working capital and long-term loans of banks for the formation of stocks (i.1 + i.2)	-678932	2034474	-7551273	-4442636	-8455726
The total value of sources of stock formation (i.1 + i.2 + i.3)	2750717	7643815	437728	720339	410990
Excess (+), lack (-) of working capital for the formation of stocks (i.1 – i.4)	-443684	1798992	-6824115	-7110341	-7698381
Excess (+), shortage (-) of working capital and long-term loans of banks for the formation of stocks (i.5 – i.4)	-443684	1798992	-6824115	-3519259	-7698381
Excess (+), lack (-) of the total value of sources of stock formation (i.6 –i.4)	2515469	7408333	-289430	-203038	-346355
Type of financial stability	Unstable financial condition	Absolute financial stability	Crisis financial situation		

Note: calculated by the author based on [5]

Based on the results of the investigation, it should be generalized that PJSC "Berdyansk harvesters" in 2015-2019 formed a financial crisis and there is a need to assess the probability of bankruptcy. Regarding the indicators of financial stability, there is a slight decrease and it is advisable to take measures to reduce dependence on the use of borrowed capital, increase the efficiency of financial resources usage, business insurance, diminish financial risks. Concerning the enterprise PJSC "Zaporizhzhia Electric Locomotive Repair Plant", it should be noted that in 2019 it has absolute financial stability, but there is a slight deterioration in financial stability indicators. In order to increase financial activity, it is advisable to improve the use of equity, borrowed capital, working capital, reduce financial risk, insure business, and improve production activity [8].

At PJSC "Zaporizhzhia Abrasive Plant" in 2019, the financial situation is unstable and the probability of bankruptcy should also be analyzed, but financial stability is acceptable. In terms of financial stability, there has been a slight increase and it is advisable to attract long-term bank credits, perfect the use of working capital, and improve operating activities. Note that the financial crisis in 2019 is observed at the company JSC "Motor Sich" and to determine the possibility of a financial crisis should analyze the probability of bankruptcy. According to the indicators of financial stability, it is necessary to increase the level of business insurance, the rational use of working capital, as well as to cover losses. The worst situation is noticed at the enterprise of PJSC "Zaporizhtransformator", as in 2016-2018 a financial crisis was established, during 2014-2018 a loss was received. Along with this, there is an urgent need to quickly restore financial stability, obtain a positive value of equity, reduce dependence on borrowed funds, the implementation of business insurance, the rational use of resources.

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ANALYSIS OF THE LNG MARKET AS AN ESSENTIAL PART OF THE STRATEGY FOR TRANSFORMING WORLD ECONOMIES AND AN ENVIRONMENTALLY FRIENDLY ECONOMY

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DOI: 10.31891/monograph/2021-10-7

Purpose and research method

The aim of the article is to identify and present the main trends in the development of the LNG market in terms of supply and demand, using the market analysis method.

Introduction

In 2020, the demand for LNG exceeded 410 million tons, experts estimate. Global demand for LNG increased by 12.5% to 359 million tonnes in 2019. Its supply in 2019 increased by the record production of 40 million tons - as estimated by Shell experts in the Global LNG Outlook 2021 report.

An additional supply of liquefied gas was possible because, in 2018/2019, most of the gas liquefaction installations from the 2014/2015 investment wave were put into operation.

On the other hand, 2020 turned out to be poor in new installations, and the only major project was undertaken in 2020 was the Sempra Energy LNG plant in Costa Azul, Mexico. It is currently the only new LNG installation project intended for export in the world. The reduced investment activity in this sector is attributed to the impact of the COVID-19 pandemic. However, perhaps the more important factor was the significant drop in energy commodity prices at the beginning of 2020.

Demand for LNG 2019-2050

In 2019, another year of growth in demand for LNG, its global import increased by 13%. The FSRU (floating gas terminals) market is developing dynamically, contributing to the more accessible collection of liquefied gas.

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Of the 37 existing LNG import markets, 19 imported LNG via FSRU's floating terminals in 2020 and six used land terminals. The construction of such a terminal is planned in Gdańsk. Its launch would be a great complement to the activity of the Northern Port.

Shell analysts forecast that the global demand for LNG will reach 700 million tons by 2040. The expectations are based especially on the observation of the Asian market. The demand for natural gas in Asia continues to grow strongly and is gaining importance in supplying sectors that are difficult to electrify. Therefore, it is assumed that further significant supply investments will be needed to avoid the estimated supply gap in the middle of this decade.



Fig. 1. Global LNG Exporters Map 2020

Source: World LNG Report 1.

Demand for LNG will systematically grow until 2037, and then it will decrease - according to the February McKinsey Global Gas Outlook report to 2050. In 2035, LNG supply will reach 4,333 cbm (bcm), while in 2020, it amounted to 3,787 cbm. 2020 was not a particularly good year for LNG exporters. Many of them suspended exports during the pandemic. For example, more than 100 US shipments were stopped per month and canceled in June and July. The spot price in the Asian and European markets did not cover the costs of gas supplies to the USA, its liquefaction, and shipping. Despite these low prices, many US LNG deliveries have been sustained through long-term contracts.

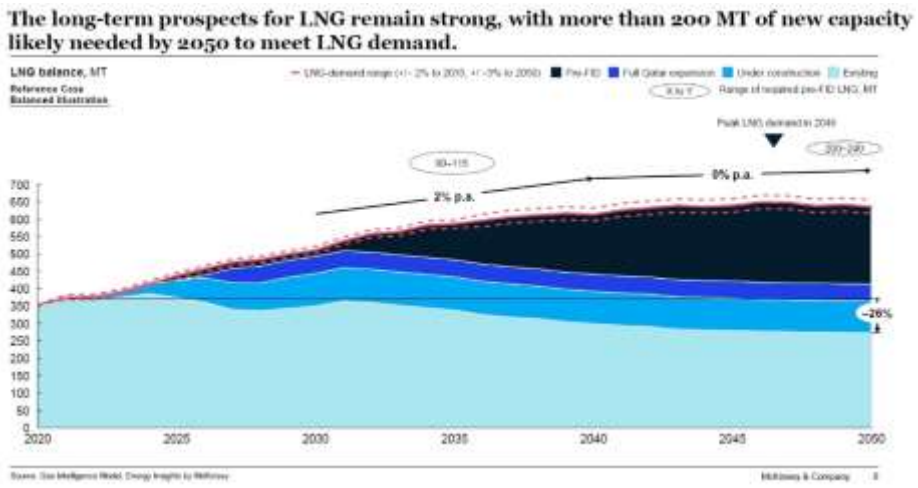


Fig. 2. LNG demand for 2050

Source: McKinsey Report, Feb 2021.

Natural gas demand is forecast to increase by over 1,200 bcm over the next 20 years. It is estimated that approximately 65% of this growth will be generated by sectors other than energy, Shell experts believe. The consumption of gas will increase industry, housing, and trade as well as transport. The energy transformation and transition to environmentally friendly technologies in these sectors will increase the demand for gas for many years to come. Switching from coal to gas in smelters could cut CO2 emissions by 36% in the next ten years.

NZE strategy - zero net emissions

These are the effects of the active zero-emission policy of many countries. All over the world, governments are increasingly focusing on reducing the emissions of harmful compounds related to coal combustion in industry and households. The policy of net zero emissions (NZE) will be manifested in developing low-emission energy systems. Notably, the Paris Agreement was accepted with understanding by the vast majority of countries. And it is in the midst of the global COVID-19 pandemic in 2020. Three of the ten countries with the highest CO2 emissions must join the promotion and implementation of the zero-emission policy agenda. China has announced it will become carbon neutral by 2060. In contrast, Japan and South Korea are aiming for net zero CO2 emissions by 2050. It means that almost 50% of the world's gross domestic product and about 50% of global carbon dioxide emissions are now subject to net zero commitments, the researchers calculated.

Asia - LNG market

Asia and the Pacific region are the main markets creating demand for LNG. This region in total absorbs almost 70% of global LNG imports and is still growing dynamically. In Asia, the LNG market in 2020 was a critical year. Before the pandemic outbreak, this region promised to be an area of numerous infrastructure investments and the construction of new LNG installations. In 2019, it was forecast to be a paradise for investors, as the region's demand for electricity from gas-fired power plants was growing dynamically. Investors targeted countries such as Pakistan and Bangladesh, Burma, Vietnam, Indonesia, and the Philippines.

"However, a significant number of international players withdrew from these and other regasification projects over the course of the year. Projects that were continued suffered from the paralysis of key ministries related to COVID-19, which made it difficult to build consensus "- explain market changes Norton Rose Fulbright analysts in the latest Global LNG Outlook 2021. Japan is a leading importer of LNG with terminals and installations that receive 77 million tonnes of liquefied gas annually. South Korea discharges 40 million tons of LNG annually in its ports.

Table 1. Main LNG importers in 2018 and 2019

Country	2018 [mln t]	Market share	2019 [mln t]	Market share
Japan	83,2	25,4%	76,9	22%
China	54,8	16,7%	61,7	17%
South Korea	44,5	13,6%	40,1	11%
India	23,3	7,1%	24	7%
China Taipei	17,1	5,2%	16,7	5%

Source: International Gas Union.

China and India - increase in demand for LNG by 111%

China and India were particularly active on the LNG market after the outbreak of the pandemic. They caused a significant pull on the demand side for LNG; both countries increased LNG imports by over 11%. China increased in last month. Liquefied natural gas imports by almost 12% to 67.6 million tonnes -

Upstream analysts have found. Chinese traders took advantage of the low price of this raw material and focused on increasing inventories.

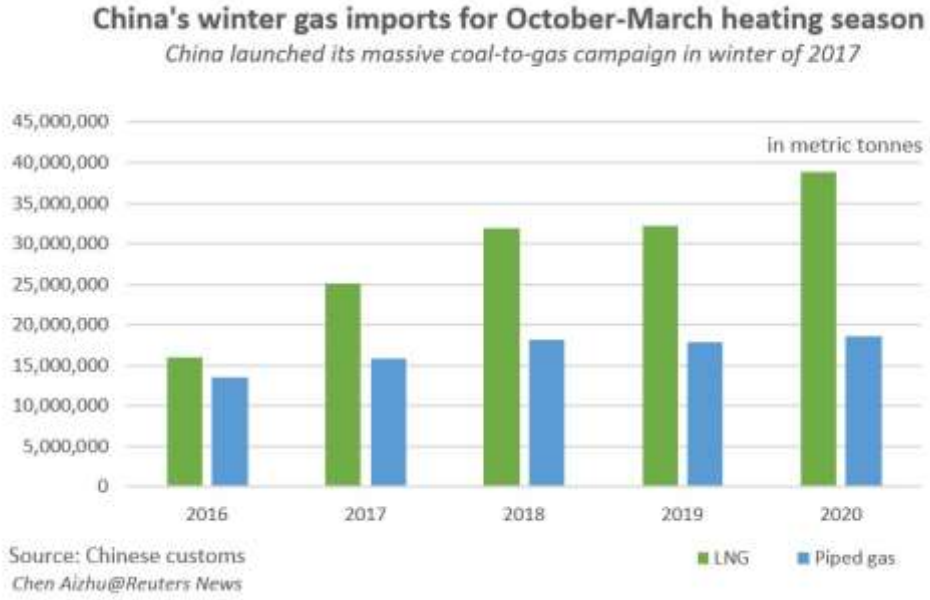


Fig.3. China - gas imports in winter in 2016-2020

Source: Chen Aizhu and Jessica Jaganathan, China's LNG import surge to cool in winter as high prices bite, https://www.reuters.com/business/energy/chinas-lng-import-surge-cool-winter-high-prices-bite-2021-08-25/ [2021-09-11].

In 2018, China imported over 53 million tonnes of liquefied natural gas. At that time, a 43% increase was achieved compared to 2017, and 60% of the world's marine natural gas supplies reached Chinese ports. In 2018, over 230 million metric tons of LNG were imported. This year, China has become an important player in the maritime LNG market. Although China filled its tanks with gas during low prices time, experts assume that the country will increase its imports by another 10% in 2021.

India imported around 38 billion m3 in 2020, while only about 22 billion m3 had been unloaded at the subcontinent's gas terminals five years earlier. Platts Analytics predicts that India will exceed the 40 bcm of LNG threshold in 2021. In June 2020, the Indian Gas Exchange was launched. It provides an efficient gas trading platform on one of the fastest-growing gas markets in the region. It is believed that as the share of gas in India's energy mix increases, more and more players will enter the Indian market.

American expansion[2]

The American EIA is trying to predict changes in the LNG market, but it is stipulated that everything will depend on the stability of supply sources. The US Energy Information Administration (EIA) has recently published its Annual Energy Outlook 2020, which assumes a steady increase in natural gas production until 2050. Production will be mainly directed to foreign markets. Poland is one of the important contractors of American LNG producers.

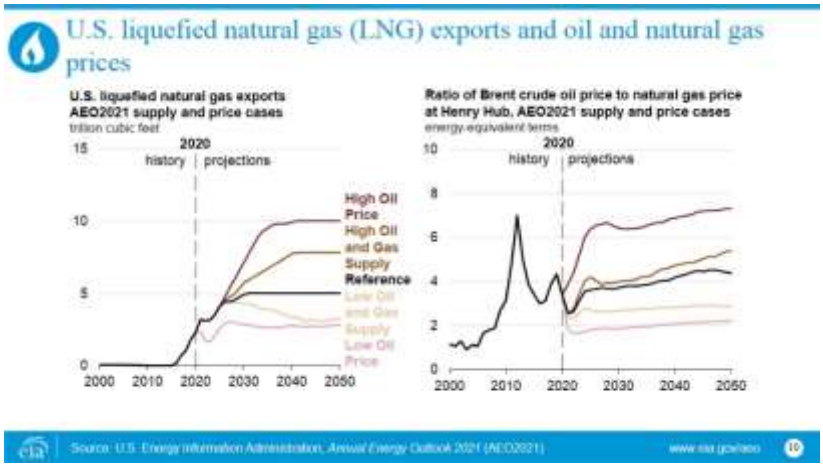


Fig. 4. US gas export 2050

Source: EIA US gas export 2050.

Since 2017, the United States has been a net exporter of natural gas, including to Poland. Production significantly exceeds domestic demand. The United States consumes the most of this raw material than any other country. They are also the world's leading gas producer. The EIA expects US domestic natural gas production to reach 94.16 bcfd (billion cubic feet per day) this year. That's over 20 bcfd more than five years ago when the 74.1 bcf was produced in 2015.

The supply and prices of LNG are created by Kuwait and Australia

Kuwait and Australia dominate the exporters market, the United States maintains a 10% share in the global LNG market. They overtook Malaysia in 2019. Today, they are the third-largest LNG exporter in the world. In 2019, they exported 13.1 million tons of LNG by the sea—the US exports over 20 million tons of gas via pipelines to Canada and Mexico. The investment processes have been delayed and are likely to be finalized in 2021 or even later. The impact of the

Cowid-19 pandemic on the LNG market is visible both on the supply and demand sides.

Table 2. Main LNG exporters in 2018 and 2019.

Country	2018 [mln t]	Market share [%] 2018	2019 [mln t]	Market share [%]2019
Quatar	78,7	24,9%	77,8	22%
Australia	68,6	21,7%	75,4	21%
Malaysia	24,5	7,7%	26,2	7%
U S A	21,1	6,7%	33,8	10%
Nigeria	20,5	6,5%	20,8	6%
Russia			29,3	8%

Source: International Gas Union.

In the US, natural gas production in 2018 reached an all-time high of 30 Tcf (trillion cubic feet), and net gas exports reached 3.3 Bcf / d (billion cubic feet per day). According to information from EIA, gas exports amounted to 14 Bcf / d in 2020. The EIA announces that exports will increase in the coming decades and will reach around 28 Bcf / d in 2050. The increased production will, in large part, be directed to foreign recipients, including Poland. US LNG exports will exceed 15 Bcf / d. "With energy production rising and consumption relatively low, the United States became a net exporter of energy in 2020 and will continue to be a net exporter of energy," said Linda Capuano, director of the EIA, as we discussed the Annual Energy Outlook in Washington.

Polish LNG market

In 2020, PGNiG (Polish Oil and Gas Company) imported approximately 3.76 bcm of LNG via the terminal in Świnoujście. It was 9.7% more than in 2019. The entire structure of LNG imports had a share of 25.4% - we read in the PGNiG press release. For comparison, imports from the eastern direction in 2020 amounted to 9 bcm (8.95 bcm in 2019). The share of Russian gas accounts for 60% of the total natural gas imported by PGNiG. The total gas imports by PGNiG in

2020 amounted to approximately 14.79 bcm. In 2020, 2.78 million tonnes of LNG (around 3.83 billion m3) were imported via the terminal in Świnoujście. Compared to 2019, this is an increase of approximately 0.26 million tonnes of LNG. During five years of operation, the LNG terminal in Świnoujście accepted 130 gas deliveries. We imported 24 million m3 by sea, which corresponds to 13 billion Nm m3 of gas. In Świnoujście, approximately 10.6 million tonnes of liquefied gas ordered by PGNiG were pumped for five years, corresponding to almost 15 billion m3 of natural gas after regasification.

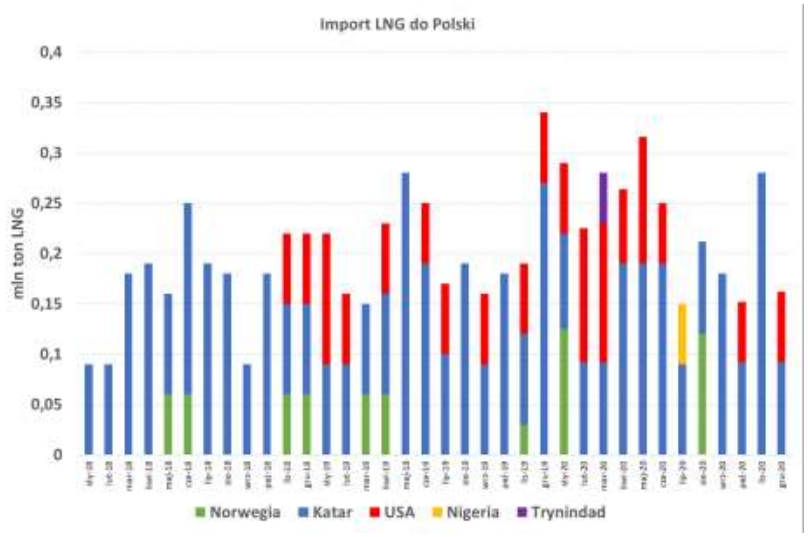


Fig. 5. Gas reloading at the LNG Terminal Świnoujście

Source: A*naliza Instytut Studiów Energetycznych na podstawie publicznie dostępnych danych*, za: Polskie LNG - podsumowanie 2020 roku, https://www.cire.pl/artykuly/opinie/178677-polskie-lng-podsumowanie-2020-roku [2020--12-30]

The construction of the LNG terminal in Świnoujście was an excellent entry with an innovative investment in the constantly growing market. Currently, the Polish LNG terminal uses Norwegian and American supplies as well as installations from Qatar. Following the full implementation of the last agreements signed, from 2023, PGNiG will have at its disposal at least 7.45 million tonnes of liquefied gas, which is over 10 billion m³ of natural gas after regasification.

Poland is one of the beneficiaries of the US export policy. As for Polskie Górnictwo Naftowe i Gazownictwo SA (Polish Oil and Gas Mining JSC), in December 2018, an agreement was signed with partners from the USA for the supply of LNG to Poland. On the American side, partners were Port Arthur LNG

and the subsidiary Sempra Energy. Two years ago, PGNiG contracted the supply of 2 million tonnes of LNG per year for 20 years (approximately 2.7 billion m³ after regasification). The cargo pickup was to begin in 2023 from the Port Arthur LNG terminal, which will be built in Jefferson County, Texas. As a result of the pandemic, Port Arthur LNG delayed the delivery of the terminal, and PGNiG terminated the contract for gas supplies from this terminal. The Polish concern has signed an agreement with Venture Global to annex the contracts. It was established that from 2023 when the purchase of gas from the Yamal contract with Gazprom will be suspended, Venture Global would secure about one-third of the current gas demand in Poland.

Table 3. Use of the LNG terminal in Świnoujście

Year	LNG Terminal Świnoujście Usage in %
2016	**33%**
2017	**30%**
2018	**55%**
2019	**70%**
2020	**76%**
2021	**85%**

Source: opracowanie Instytutu Studiów Energetycznych, Prognoza ISE dotyczy 2021 r.

Poland is active in the LNG market. For now, as an importer. It may act as a re-exporter in the future. Several years ago, it was announced that by 2025 the FSRU unit could be installed in Gdańsk at the Northern Port. It was reported in 2019 by Piotr Naimski, the government's plenipotentiary for strategic energy infrastructure, when signing the contract for the expansion of the LNG terminal in Świnoujście in April this year. As a result, in 2025, we could import up to 7.5 billion m3 per year via Świnoujście and install the FSRU vessel in Gdańsk up to 3 billion m3. Poland consumes about 17 billion m3 of gas annually. Based on the extended agreement between Venture Global and PGNiG, 3.5 million tons of LNG per year from the American market will reach Poland from the American market

from installations located in Louisiana. Deliveries may begin in 2022, i.e., when the Yamal contract expires. If all plans are implemented on time, in 2025, we will be able to import as much gas by sea as we currently import from Russia annually.

Development of LNG imports

Until 2000, the number of countries interested in LNG import did not exceed 15, and sea transport by LNG tankers did not exceed 100 MTPA (million tons per year). In 2010, the number of importers exceeded 25 countries, and the demand for LNG increased to around 200 MPTA. In 2018, more than 35 countries already had LNG import terminals, and the demand significantly exceeded 300 MPTA. Based on the analysis of the energy security strategies announced by LNG importers, it is expected that in 2019 the demand for sea LNG transport will increase by at least 10%.

Ten years ago, only 23 countries had access to LNG. Costly import terminals that took years to build and inflexible supply contracts made it difficult to import gas by sea. Concerns about the risk of dependence on LNG also inhibited the growth in demand for LNG delivered by tankers. from existing importers, even if few other delivery options were available. In 2020, 43 countries decided to import LNG. Growing competition between suppliers made freight so low that it often did not cover gas production and liquefaction. The development of technology for the construction and use of floating storage and regasification units (FSRU) made the construction of terminals for customers cheaper. At the same time, importers can react more flexibly to changes in gas demand and supply. In practice, if a country or region decides to develop gas imports by sea, FSRU allows you to build an efficient installation in less than two years. In this way, the country can become an import gas from an alternative source in a short time.

Summary

The LNG maritime transport market will grow. The authors of "Global Gas Outlook to 2050" believe 2020 was a critical year for the gas and LNG markets. Global demand for gas fell by 3%. Demand for LNG has resisted the slowing economies and managed to grow by 1%. However, it was not a quiet time for the carriers. In 2020, jumps in demand for LNG maritime transport were recorded. However, these fluctuations do not affect long-term forecasts. The demand for gas

will grow. It will be the fastest-growing market. McKinsey predicts that demand for this fossil fuel will grow by 0.9% annually from 2020 to 2035, while in 2037, demand for gas will slow down, and in the period 2035 to 2050, it will decrease by 0.4%. Such a moderate decrease in demand will result from gas consumption in the chemical industry and other industrial sectors.

The demand for gas will grow in the longer term. It is the result of the policy of rapid carbon neutrality adopted by many countries. The trend is set by the world's four largest LNG markets: China, the European Union, Japan, and South Korea. Research conducted by McKinsey as part of the LNG Buyers Survey shows that 33% of respondents assume that in commercial contracts concluded between companies, more and more attention is paid to clauses regarding emissions reduction. The environmentally friendly approach is becoming more and more common. And this, in the long term, will drive the demand for gas, including LNG and LPG.

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JUVENILE DELINQUENCY IN POLAND - A STUDY OF CRIMINAL LAW AND CRIMINOLOGY

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DOI: 10.31891/monograph/2021-10-8

Crime among juniors is one of the most significant legal and criminological problems. The dynamically developing world poses more and more challenges to modern youth. Because of their diversity, juniors often cannot meet the growing expectations; they display demoralization or commit criminal acts. In such cases, appropriate preventive measures are taken. Responsibility for upbringing requires cooperation, information exchange, system solutions, and the creation of legal regulations and preventive programs[2].

Committing crimes by minors requires a distinction between those committed by girls and those committed by boys. In the applicable legal provisions, the legislator treats the indicated groups without a distinction based on sex, using the collective term - minors. Nevertheless, the fundamental difference between underage girls and boys is related to the externalized manifestations of demoralization and methods and frequency of committing acts by each group and their type. However, specifying the legal-criminal and criminological aspects of juvenile delinquency requires first to indicate general legal aspects of bringing minors to justice and defining the criminological determinants of its occurrence.

Legal regulations concerning the rights of minors have already been indicated in the Constitution of the Republic of Poland, as well as in separate legal acts, e.g., in the acts on juvenile delinquency proceedings, the Ombudsman for Children[3], the Penal Code, the Code of Criminal Procedure, the Code of Civil Procedure and others.

The primary source of regulations on the principles of dealing with minors, but containing only indications concerning the prevention and combating of demoralization and crime [4], is the Act of October 26, 1982, on proceedings in juvenile cases[5].

[2] M. Stefański, *Analiza niedostosowania przestępczego wśród nieletnich*, [w:] A. Jaworska (red.), *Kryminologia i kara kryminalna*, , Oficyna Wydawnicza Impuls, Kraków 2008, s. 11.
[3] Tekst jedn. Dz. U. z 2020 r. poz. 141.
[4] A. Grześkowiak, *Prawo nieletnich,* Wydawnictwo C.H. Beck, Warszawa 2020.
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An essential part of it is the preamble. Preamble formulates two goals: prevention (i.e., striving for a counteroffensive of crime) and demoralization of minors. The preamble formulates resocialization, which is understood as striving to create conditions for the return to proper functioning in the society of children involved in a conflict with the law. Preamble covers optimization of upbringing in the natural environment of minors, which is manifested in the desire to strengthen the care and educational function and the sense of family responsibility for educating minors as participants of a society who are aware of their duties[6].

According to the statutory assumption, minors included in Art. 1§1 points 1-3 of the AJDP, there is a person:

- who are under the age of 18 - in the field of preventing and combating demoralization,
- who has committed a criminal offense after the age of 13 but under the age of 17,
- until the age of 21, in relation to which educational or corrective measures are carried out[7].

The indicated groups of people have been recognized as minors under the Act. Therefore, if a minor shows signs of demoralization or commits a punishable, the action is taken, as described in the Act[8].

Under the assumption of art. 4 of the Act on juvenile delinquency proceedings, one of the manifestations of juvenile demoralization is committing a punishable act [9]. Suppose it was committed before the age of 13. In that case, such behavior is treated by the court as a manifestation of the minor's demoralization, and the response measures provided for in the provisions of the AJDP apply.

If a minor commits a criminal act between the age of 13 and 17, the provisions of the AJP generally apply. However, if the Act was committed after the age of 15, and it bears the features of a prohibited act specified in the provisions of Art. 10 §2 of the Penal Code[10], then the legislator provided for the

[6] R. Waluś, *Instrumenty prawne stosowane w przypadkach przestępczości nieletnich*, „Zeszyty Naukowe Wyższej Szkoły Humanitas. Pedagogika" 2015, nr 10, s. 69.
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[9] A. Grześkowiak, op. cit., s. 58.
[10] Tekst jedn. Dz. U. z 2020 r. poz. 1444.

possibility of applying to him the principles of liability provided for in the Penal Code [11].

In the case of perpetrators committing a prohibited act between 17 and 18 years of age, the provisions of the Penal Code are assumed to be applied. However, in exceptional circumstances, it is possible to order a minor - instead of a penalty - of therapeutic, educational, or corrective measures, especially when the Act is a misdemeanor, and the circumstances of the case, the degree of development of the perpetrator, his properties, and personal conditions speak for it[12].

Under Art. 94 of the AJDP: "If a minor who has been ordered to be placed in a correctional facility has reached 18 years of age before the commencement of the enforcement of the judgment, the family court decides whether to execute the adjudicated measure or to withdraw from it and impose a penalty on the perpetrator. When imposing a penalty, the court applies its extraordinary leniency. In particularly justified cases, they may refrain from imposing a penalty, especially when there has been a significant improvement in the perpetrator's behavior. In the event of imposing a penalty of deprivation of liberty or restriction of liberty, its duration may not exceed the period remaining until the perpetrator completes the age of 21."[13]

The Act provides for some possible measures, methods, and tools that contribute to the reduction of the level of demoralization of minors and the consequences of their application to result in their rehabilitation and minimize the risk of returning to committing criminal offenses. In practice, however, it is not always possible. However, it should be emphasized that the AJDP is not the only legal instrument used in the case of juvenile delinquency proceedings.

In addition to the Act, criminal law plays an essential role by specifying the principles of dealing with minors[14]. Subsequent Polish penal codes (from 1932, 1969) maintained the limit of 17 as the age[15], at which a person reaches mental maturity, allowing him to bear responsibility for his actions[16].

[11] Ibidem.
[12] M. Bojarski, J. Giezek, Z. Sienkiewicz, *Prawo karne materialne. Część ogólna i szczególna*, Wydawnictwo Wolters Kluwer, Warszawa 2020, s. 115.
[13] Tekst jedn. Dz. U. z 2018 r. poz. 969.
[14] Ibidem, s. 113-114.
[15] V. Konarska-Wrzosek, op. cit., s. 43.
[16] G. Rejman, *Zasady odpowiedzialności karnej. Art. 8-31 Kodeks karny. Komentarz*, Wydawnictwo C. H. Beck, Warszawa 2009, s. 144-146.

In art. 10 § 1 of the 1997 Criminal Code, 17 was indicated as the limit of criminal legal age[17]. On the other hand, the exceptional responsibility of minors has been modified; because the age limit has been lowered from 16 to 15 years[18]. The legislator also changed the way of defining crimes for which a juvenile may be held criminally responsible, indicating specific articles, i.e., differently from the previous penal codes[19].

The Criminal Code introduced the principle of guilt as a premise of criminal liability. The consequence of its adoption is marking the age limit for the capacity to incur criminal liability [20]. Therefore, the perpetrator is responsible for the committed Act only to the extent that it can be charged [21].

Reaching the age of criminal responsibility by the perpetrator of the prohibited Act means the possibility of imposing sanctions against him under the criminal law. According to the Polish legislator, the perpetrator of an act who has not yet reached the age of 17 is treated as a minor[22]. However, the statutory age limit allows to take into account the individual characteristics of the juvenile's personal development, introducing exceptions from the adopted age limit in justified cases, thus allowing him to bear responsibility[23].

Based on the provision of art. 10 of the Penal Code, detailed premises for the criminal liability of minors can be distinguished. These are:

- at least 15 years of age at the time of committing a prohibited act,
- the alleged offense must meet the criteria of one of the listed in Art. 10 § 2 crimes,
- the circumstances of the case and the degree of development of the perpetrator support prosecution,
- art. 10 § 2 may be applied when the conditions specified therein are met jointly,

[17] Tekst jedn. Dz. U. z 2020 r. poz. 1444.
[18] *Ustawa z dnia 19 kwietnia 1969 r. Kodeksu karny* (Dz. U. z 1969 r. Nr 13, poz. 94 ze zm.) przewidywała bowiem, że nieletni po ukończeniu 16 roku życia w określonych sytuacjach mógł ponieść odpowiedzialność.
[19] P. Kobes, *Węzłowe problemy modelu postępowania z nieletnimi w Polsce*, [w:] G. Kudlak (red.), *Instytucjonalna resocjalizacja nieletnich. Wyzwania i perspektywy rozwoju*, Wydawnictwo Difin, Warszawa 2016, s. 20-21.
[20] A. Zoll, *Zasady odpowiedzialności karnej*, [w:] W. Wróbel, A. Zoll (red.), *Kodeks karny część ogólna. Tom 1. Komentarz do art. 1-52*, wyd. 5, Wydawnictwo Wolters Kluwer, Warszawa 2016, s. 171.

[21] T. Grzegorczyk, R. Olszewski, *Verba volant, scripta manent. Proces karny, prawo karne skarbowe i prawo wykroczeń po zmianach z lat 2015-2016. Księga pamiątkowa poświęcona Profesor Monice Zbrojewskiej,* Wydawnictwo Wolters Kluwer, Warszawa 2017, s. 145.
[22] Tekst jedn. Dz. U. z 2020 r. poz. 1444.
[23] J. Warylewski, *Prawo karne. Część ogólna*, Wydawnictwo Lexis Nexis, Warszawa 2015, s. 179-180.

– the educational and corrective measures applied so far have turned out to be ineffective - however, this is not a prerequisite for holding a minor responsible under Art. 10 § 2 of the Criminal Code[24].

For a minor perpetrator of an act to be held criminally responsible, the circumstances of the Act must indicate its demoralization[25].

An essential premise of the juvenile's responsibility is the degree of development of the perpetrator. When assessing it, the level of mental development and its adequacy to age should be taken into account. Likewise, the personal characteristics of the perpetrator are his features, which speak "for" or "against" the application of Art. 10 § 2 of the Criminal Code. They can be both a reduction in intellectual performance and a tendency to react with aggression or to submit to others[26].

Under Art. 10 § 2 of the Penal Code, a minor has reached the age of 15 and has committed the prohibited Act specified in Art. 134 of the Penal Code, Art. 148 § 1, 2, or 3 of the Penal Code, art. 156 § 1 or 3 of the Penal Code, Art. 163 § 1 or 3 of the Penal Code, Art. 166 of the Penal Code, Art. 173 § 1 or 3 of the Penal Code, Art. 197 § 3 or 4 of the Penal Code, Art. 223 § 2 of the Penal Code, Art. 252 § 1 or 2 of the Penal Code and in Art. 280 of the Penal Code may be held liable under the principles set out in the Penal Code if the circumstances of the case and the degree of development of the perpetrator, his properties, and personal conditions support it. Also, in a situation where the previous educational or corrective measures turned out to be ineffective[27].

For many years, there have been discussions on raising the age of criminal liability to the age of 18. This view seems correct due to the unification of the age of maturity in the light of other branches of law. Family and guardianship (Article 10 of the Code of Criminal Procedure), and civil law (Article 10 § 1 of the Civil Code), labor law (Art. 190 § 1 of the Labor Code), or constitutional law (Art. 62, 70 section 1 of the Constitution of the Republic of Poland).

In addition, in the light of research in psychology, it seems right to raise the age of criminal liability to the age of 18. There is no scientific basis for considering persons under the age of 18 to be immature for independent living,

[24] T. Bojarski, *Zasady odpowiedzialności karnej*, [w:] T. Bojarski (red.), *Kodeks karny. Komentarz*, Wydawnictwo Wolters Kluwer, wyd. 7, Warszawa 2016, s. 79-81.
[25] A. Zoll, op. cit., s. 181.
[26] Ibidem, s. 182.
[27] Ibidem, s. 120.

make decisions about themselves or take up paid work, and recognize she is fully criminally responsible for her behavior from the age of 17[28].

Over the years, the penal repression against minors has been becoming more severe. It is particularly evident in the application of the principle of exceptional criminal liability of minors[29].

Under Art. 10 § 3 of the Penal Code, the penalty imposed on a minor who has committed an act meeting the conditions specified in Art. 10 § 2 of the Penal Code is two-thirds of the upper limit of the statutory sentence assigned to this act[30].

However, this solution is criticized because it means that even in the case of the most demoralized minors committing offenses with the use of exceptional cruelty, the sentence of life imprisonment cannot be applied, and the sentence of 25 years imprisonment seems doubtful[31].

The above doubts were dispelled by the judgment of the Supreme Court of September 22, 1999, where it was stated that: "Contained in Art. 54 § 2 of the Penal Code, the prohibition of imposing a life sentence on a perpetrator who at the time of committing the crime was under 18 years of age does not exclude the possibility of imposing on a minor who responds under the conditions of Art. 10 § 2 of the Penal Code for a crime punishable by such a penalty - 25 years imprisonment (...). Therefore, the prescribed obligation to impose a penalty not exceeding two-thirds of the statutory risk on a minor should be applied to the penalty of life imprisonment, and not to the penalty of 25 years imprisonment"[32].

Life imprisonment cannot be imposed on perpetrators under the age of 18, because as a rule, their socialization process is still incomplete [33]. According to Art. 54 § 1 of the Penal Code, the court, when punishing a minor, should be guided by the upbringing of the perpetrator. The penalty of 25 years imprisonment is not educational but only protective concerning society, which is protected against a minor perpetrator[34].

A different type of regulation is included in the Act on Juvenile Proceedings[35]. It stipulates that a special kind of exceptions in the application of

[28] Ibidem, s. 171.
[29] P. Kobes, op. cit., s. 20.
[30] M. Bojarski, J. Giezek, Z. Sienkiewicz, op. cit., s. 115.
[31] A. Zoll, op. cit., s. 184.
[32] Wyrok SN z dnia 22.09.1999 r., III KKN 195/99, OSNKW 1999, Nr 11-12, poz. 73.
[33] A. Zoll, op. cit., s. 185.
[34] Ibidem.
[35] Tekst jedn. Dz. U. z 2018 r. poz. 969.

penalties may be applied to a minor, consisting in the obligatory occurrence of conditions which constitute an accident provided for by law (a penalty may be imposed only in cases ruled by law), or the finality of the situation, as provided for in Art. 5 AJDP[36]. This provision indicates the general principle of preventing and combating demoralization and juvenile delinquency, which should be carried out by applying educational and corrective measures to them and, if necessary, placing them in a correctional facility[37].

The basis for initiating proceedings before a family court is a situation "when a minor shows signs of demoralization"[38] or commits a criminal act. The most severe correction measure is placing a minor in a correctional facility. The measure, as mentioned earlier, is applicable when "other educational measures have proved ineffective or do not predict the juvenile's rehabilitation."[39]. The legislator, because of the diversity of acts committed by minors, as well as the diversity of groups committing criminal acts, established separate correctional facilities for boys and girls.

W To define the crime of juvenile girls in Poland, apart from the analysis of criminal law provisions, it is necessary to point out the criminological determinants of demoralization, the occurrence of which, independently or together with the commission of a criminal act, determines taking actions aimed at preventing the occurrence of similar events in the future.

From the theories explaining the importance of etiology, i.e., behavioral disorders leading to juvenile delinquency, it should be noted that the family environment plays an important role.[40]. The research results indicate a relationship between the crime in the minor's family and its deviant behavior[41].

According to W. B. Anders, the theory of crime should explain and consider two problems:

- the first, which deals with crime patterns as well as the frequency of occurrence,

[36] Ibidem.
[37] J. Kurdelek, *Postępowania szczególne w procesie karnym. Postępowanie w sprawach nieletnich*, Wydawnictwo Wyższej Szkoły Policji w Szczytnie, Szczytno 2009, s. 116-117.
[38] Tekst jedn. Dz. U. z 2018 r. poz. 969.
[39] Ibidem.
[40] V. Konarska-Wrzosek, *op. cit.*, s. 43.
[41] A. Nowak, E. Wysocka, *Problemy i zagrożenia społeczne we współczesnym świecie*, Wydawnictwo Śląsk, Katowice 2001, s. 123.

- the second, describing the motivational processes of minors who adopt criminal patterns[42].

Juvenile delinquency is recognized as a social problem with considerable potential for danger. A conflict with the law leaves the minor's personality with permanent deformities that are difficult to repair in adulthood. This process begins with 'minor' and 'insignificant' behaviors that are viewed negatively by society[43]. Criminal acts committed by minors are considered a significant social problem.

According to his research, L. Hewitt distinguishes three and describes in detail two types of juvenile delinquents:

- aggressive, unsocialized type, the main feature of which is cruelty, aggressiveness, aggressiveness, rebellion towards everyone, malice and lack of guilt,
- the socialized type, i.e., participation in thefts, both in a group and secretly, being in bad company, systematic truancy, late returns and spending longer outside the home during the day,

over inhibited type [44].

Various forms and types of acts performed and the degree of characterological disorders of minors can be distinguished. The criminal acts committed by them result from the pressure of demoralized peers or groups with anti-social features. They are often the result of experiences from the past - occurring in the period of growing up in the family home or the lack of it[45].

The reasons for committing punishable acts by minors can also be found in disturbed interpersonal relations, traumatic experiences, accumulated frustration, and powerlessness for the situation. For a young person, a crime is a specific reaction, response, and reaction to anger and stress.

An essential criterion to determine the causes and manifestations of psychosocial disorders occurring in juvenile girls in the form of social maladjustment is the frequency and circumstances of committing punishable acts, as well as motivational and situational determinants[46].

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[42] B. Urban, *Zachowania dewiacyjne młodzieży*, Wydawnictwo Uniwersytetu Jagiellońskiego, Kraków 2001, s. 21.
[43] J. Papież, A. Płukis, *Przemoc dzieci i młodzieży w perspektywie polskiej transformacji ustrojowej*, Wydawnictwo Adam Marszałek, Toruń 2000, s. 308.
[44] E. Żabczyńska, *Przestępczość dzieci a szkoła i dom*, Wydawnictwo Szkolne i Pedagogiczne, Warszawa 1974, s. 124.
[45] B. Hołyst, *Kryminologia*, Wydawnictwo Naukowe PWN, Warszawa 2016, s. 617.
[46] A. Makowski, *Niedostosowanie społeczne młodzieży i jej resocjalizacja*, Wydawnictwo Naukowe PWN, Warszawa 1994, s. 67.

Nowadays, when analyzing the phenomenon of crime, various factors are taken into account, dividing them into:

- endogenous - related to a minor, the so-called somatic (external appearance, physical health), mental (mental state, mental properties, and disorders),
- exogenous - related to the influence of the external environment (social, natural) and situational influence, such as suggestive, facilitating, or provoking[47].

When investigating crime, the first thing to do is specify its types, which allows you to determine the actual extent of the problem. When analyzing the issue of juvenile delinquency, it should be noted that the estimation of the number of criminal offenses committed by minors is challenging and covers the so-called "Big, dark number.[48].

To increase the possibility of disclosing criminal offenses committed by minors, authorized institutions keep criminal statistics, which allow estimating the likelihood of juvenile delinquency while providing a qualitative and quantitative description of the possibilities of preventing them. The source of information on juvenile delinquency is research covering the functioning and effectiveness of legal norms and measures implemented by authorized bodies[49].

An equally important task from the point of view of criminology is to determine the structure and dynamics of crime, which allows for the analysis of data relevant from the judiciary's point of view regarding the diversity of factors that influenced the commission of a criminal act by minors[50]. It allows for the simultaneous identification of factors related to the types of criminal behavior, the specific gravity of the committed Act, and their individual perpetrators' distinguishing features. The structure of crime allows for identifying persons potentially at risk of committing criminal offenses, using the principle of distinguishing similar and different characteristics for a given type of offense. As

[47] A. Nowak, E. Wysocka, op. cit., s. 121.
[48] B. Hołyst, op. cit., s. 619.
[49] *Informacja dotycząca stanu zagrożenia przestępczością nieletnich w Polsce w roku 2020*, Biuro Prewencji KGP, file:///C:/Users/DELL/Downloads/Przestepczos___nieletnich_w_2020_r_.pdf, [dostęp: 13.03.2021 r.]
[50] M. Noszczyk-Bernasiewicz, *Demoralizacja i czyny karalne wśród nieletnich – dynamika i rozmiary*, „Resocjalizacja Polska" 2016, nr 11, s. 145-146.

part of the structure of crime, analyses can be carried out to determine the sex and age of perpetrators of criminal acts and the place of their commission[51].

Criminological reasons for committing crimes are increasingly often conditioned by intense socio-economic changes. The pace and direction of changes taking place in the field of juvenile delinquency are referred to as the dynamics of crime. Juvenile delinquency is developmental, and there is considerable variability in the ways and methods of committing criminal offenses by minors[52].

An important diagnostic tool for criminology is the geography of crime. However, it should be emphasized that in the case of juvenile delinquency, it is not possible to determine the degree of risk and the number of variants that would allow for the precise determination of places where criminal acts may be committed by minors[53].

The causes of juvenile delinquency can be searched for in the natural environment from which the juvenile comes, and the connections between minors and the criminal world and their participation in the functioning of organized crime can be indicated[54]. To define juvenile delinquency as a socially harmful phenomenon, it is essential to evaluate the perpetrators of offenses by minors. Phenomenology gives researchers a wide range of diagnostic tools, which appropriately allows to reduce the manifestations of demoralization of minors and take preventive measures before the effects occur[55].

Child development disorders are not accidental; they are often preceded by earlier signals, contributing to the minor's entering a criminal path. Prevention plays a crucial role in counteracting juvenile delinquency by taking actions at the initial stage of the phenomenon, such as learning failures or educational difficulties that are not yet severe.

To reduce the criminogenic acts committed by minors, intensive preventive measures are carried out. B. Hołyst defines crime prevention as a set of measures and methods to make it difficult or impossible to commit a crime[56].

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[51] B. Hołyst, op. cit., s. 618-620.
[52] K. Biel, *Przestępczość dziewcząt – rodzaje, uwarunkowania, Wydawnictwo* Wyższej Szkoły Filozoficzno-Pedagogiczna Ignatianum, Kraków 2008, s. 31-34.
[53] Ibidem.
[54] K. Stępień, *Przestępczość nieletnich dziewcząt objętych procesem resocjalizacji w zakładach poprawczych. Studium kryminologiczne*. *Część 1*, Wydawnictwo Wyższej Szkoły Policji w Szczytnie, Szczytno 2020.
[55] A. Grześkowiak, op. cit., s. 76-77.
[56] B. Hołyst, op. cit., s. 56.

One of the forms of influencing juveniles referred to a correctional facility showing symptoms of social maladjustment is the use of mediation. As an alternative measure, it is used in many European countries, especially in cases where the mediation procedure foresees that it will end positively. The purpose of mediation is to arouse the minor's sense of responsibility for the criminal Act committed and make the minor aware of the consequences and effects of its proceedings.

Another form of influencing minors who show symptoms of social maladjustment is the work of school tutors, often supported by therapists, volunteers, family educators, and psychologists. The task of the family educator is to cooperate with the "most difficult" parents. His work aims, above all, to improve the child's current situation in which they find themselves, indicate prospects, help them survive a crisis, show the possibility of satisfying their needs in a legal manner, and teach conflict resolution. The educator works for the good and in the child's interest, but most of all, he is a mediator, organizer of help, and diagnostician[57].

Both violence among young people and aggressive behavior, the lack of constructive behavior, wrong authorities, and the desire to impress and exist among peers can result from threats, both in educational institutions and for minors themselves. One of the most critical preventive measures undertaken is their identification, treatment, and elimination[58].

It should be noted how important the early localization of disturbing signals related to minors' behavior and prevention is applied to counteract juvenile delinquency and prevent the development of the process of demoralization among the youngest group of society.

Pointing to the above, not only the school or the family should be involved in preventive actions on the youngest, but also some other institutions responsible for interfering with the correct process of educating minors.

The analysis of the phenomenon of demoralization and its impact on the commission of criminal acts by minors allowed drawing the following conclusions:

- the age limit of perpetrators of criminal acts is gradually decreasing,
- the risk of social maladjustment among young people is increasing,

[57] W. Kołak, *Nasz sposób na brutalne dzieci*, „Nasz Animator” 1997, nr 1 (13).
[58] Ibidem.

- the behavior of young people shows more and more signs of demoralization and is characterized by an increasing degree of brutality,
- there is an increase in criminal behavior and demoralization among young people, which is becoming a growing social problem,
- the intensification of negative behaviors has a significant impact on the rise in pathological phenomena in the immediate environment of minors.

It should be pointed out that the catalog of educational and corrective measures applied to minors is so extensive that it facilitates an individual approach to each perpetrator of the Act. Considering the Act committed by the young man, his age and personality, as well as the conditions in which he grows up and the degree of his demoralization, the court selects and adjusts a given educational measure to bring the most significant educational benefits to the minor.

Juvenile delinquency is a dynamic, changeable phenomenon, dependent on many interdependent factors. Only its proper detection, identification, and judgment will increase the possibilities of preventive influence of authorized institutions, reducing the dynamics of the development of this socially harmful phenomenon.

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RESOURCE POTENTIAL MANAGEMENT AS A COMPONENT OF THE SYSTEM FOR ENSURING ENTERPRISES' ECONOMIC SECURITY

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DOI: 10.31891/monograph/2021-10-9

Introduction

Current conditions for the functioning of economic systems, both globally and at the level of national economies, cause many unpredictable dangers and threats to enterprises' existence and economic activity. The reasons for this are the high dynamism of the external environment, the growth of competition in the world and domestic markets, the destabilizing impact of integration and globalization transformations. In 2019, society faced another global challenge related to the Covid-19 pandemic, which caused threats to the viability of both national economies and the global economic system as a whole [1]. It led to the deepest global recession in decades, despite the extraordinary efforts of governments to counter the recession with financial and monetary policies. According to the World Bank [2], the reduction in world GDP during 2020 was 5.2%, which exceeded even the effects of the financial crisis of 2008-2009. Countries suffered the most from below-average incomes, which significantly reduced jobs [3].

The consequences of the pandemic have significantly affected the activities of domestic business entities, leading to a significant shortage of financial resources for doing business, deteriorating financial condition of enterprises, the closure of a substantial proportion of small businesses. Under such conditions, companies abandoned the implementation of strategic plans to ensure the timely solution of current problems and resorted to finding internal resources and opportunities for their further use. Providing the conditions for the effective development of the enterprise is crucial today. It is based on the security of its economic activity at all levels: the state, region, industry, the separate entity.

Security is an integral feature of the functioning of the economic system, which ensures its viability, stable development, and resistance to external disturbances [4]. Concerning the activities of business units, it is advisable to consider the category of economic security, which characterizes its security and resilience under the influence of changes in the external and internal environment,

does not allow threatening deviations in its development. It is a complex and multifaceted category. The actual content covers almost all aspects of the enterprise through its constituent parts – financial, material, technological, political, legal, intellectual, personnel, information, market, environmental, power, and involved resource.

Therefore, designing a system of economic security and creating conditions for its provision is one of the essential management areas. A fundamental basis for its successful operation is to ensure effective management of the resource potential of business entities.

Problem description

Resource potential is a category that establishes the ability to manage resources at certain stages of their development. In the most general form, the essence of management is defined as a purposeful, systematic influence on a particular system, carried out by various methods to maintain it in a specific stable state or transition to a new (desired) shape following the objectives of the enterprise. It reflects the totality of stocks and is primarily related to the characteristics of resource sources

Resource potential exists outside the production sphere and can participate in it to a certain extent. It is formed from the total availability of resources in specific combinations that meet the needs of the future production process. We agree with the opinion of S.V. Filippova and A.S. Dashkovskyy [5] that four main criteria can characterize the resource potential of the enterprise:

– real opportunities of the enterprise in this or that sphere of activity (including unrealized opportunities);

– the volume of resources both involved and only prepared for use in production;

– the ability of personnel (managers) to use resources, the ability to manage the help of the enterprise;

– form of entrepreneurship and the corresponding organizational structure of entrepreneurship.

As a micro-level production system, the enterprise inevitably becomes involved in relations with the participants of the markets of means of production, which determine the use of a particular set of resources, which causes the corresponding costs. Given the market saturation, purchases made by the company

can significantly affect the growth of its profits. At the same time, the expenses incurred in supply and distribution are also quite significant and comparable to the costs in the production field. That is why the task of economic security of the enterprise is to neutralize the threats that arise in the struggle for a limited amount of material resources within the living space of the enterprise.

Threats can be limited to full or partial access to a particular type of resource and the impossibility of its replacement, so the issue of resource provision of the economic security management system will involve the development, implementation, and evaluation of their ways to find, attract and use different types of resources, that are needed for the protection of the interests of the enterprise from external and internal disturbances.

At the same time, during the formation of economic security of the enterprise, it is necessary to consider that the enterprise's direct relations with suppliers and consumers cause a particular type of risk associated with production and economic activity. However, the operation of the enterprise can lead to threats to the level of security of its counterparties, which causes them a natural response and further reduction of the overall level of enterprise's security [6].

Results of investigation

The presence of security is a fundamental prerequisite for ensuring the stable development of socio-economic systems in space and time, which creates opportunities for building their capacity, improving efficiency, and timely achievement of selected strategic, tactical, and operational goals, taking into account the available resource base.

The strategic potential of the enterprise has the maximum ability to adapt to changing production conditions due to the periodic need for technical re-equipment and reconstruction, restoration or improvement of staff skills, changes in strategic areas of management or type of activity, and more. Thus, the economic security management system should be based on a resource approach. The quality of governance will depend on the availability of resources and the ability to change them throughout the life cycle of the enterprise following changing operational and strategic goals.

Management of resource potential of the enterprise in the context of ensuring its economic security should be carried out under the strategy of development of the enterprise, which determines the general purpose of managing

the resource potential, identification of strategic guidelines with further strategic analysis, determination of the type of strategy and development of its components, formation of the mechanism for managing the enterprise resource potential under defined goals and ensuring the required level of economic security.

Among the main tasks that need to be addressed to ensure this level is:

– assistance in achieving the goal of functioning of the economic system;

– ensuring the economic system stability;

– validity and rationality of the choice of strategy and tactics of gradual and stable development of both the system as a whole and its subsystems;

– hierarchy of relationships and interdependencies of subsystems of the economic system;

– modeling the behavior of the economic security system;

– assessment of the state of the economic security system by calculating a set of defining characteristics (indicators) and preventing them from going beyond the established limits.

Given that the main task of the management system is to ensure efficiency by achieving goals with minimal resource costs, the main goals of resource management should include its rational use, development, and improvement of efficiency, reproduction of resource potential, which is detailed in the following tasks:

– identification of factors influencing the resource potential of the enterprise;

– determining the optimal structure for managing the resource potential of the enterprise,

– determination of directions of development of resource potential, increase of efficiency of production, achievement by the enterprise of necessary volumes and quality of the made production;

– monitoring of the available resource potential of the industrial enterprise and the level of its use;

– determining the directions of developing the resource potential in accordance with the strategic and tactical goals of the industrial enterprise;

– identification of the main external and internal factors that affect the resource potential of the industrial enterprise in the process of its formation, distribution, use, and restoration;

– determination of the management structure of the resource potential of the industrial enterprise, which will optimize the process of its formation, distribution, use, and restoration.

Given the directions of increasing the scientific level of validity of management decisions based on the assessment of economic efficiency of production and use of resource potential, it is advisable to take into account such components of these processes as unity and interaction of enterprise resources in the production process; optimal management of indicators that determine the level of use and reproduction of resource potential, based on both local tasks and tasks of enterprise development; variability in improving the efficiency of enterprises, based on possible diversity; management of indicators of efficiency of use of resource potential from the point of view of search of an optimum level of intensity of use of particular types of resources.

The management system of enterprise resource potential, in turn, is also provided with resources: first of all, investment, financial, logistical, organizational, information, legal, intellectual, personnel. For the latter component, special attention should be paid to the formation of consciousness of management, which is manifested in the moral responsibility for economic activity results. It is also vital to create the necessary motivational incentives for management to rational behavior, their direct interest in the system's effective functioning. It makes grounds for further steps to develop a system of resource potential of the enterprise [7].

The enterprise management can reach the planned level of economic security at rational use of all available resources only on condition of formation and use of the corresponding organizational and administrative mechanism.

Among the types of organizational and economic mechanisms can be distinguished the following groups:

– organizational and structural, which exercise managerial influence through the formation of organizational structures and their restructuring;

– organizational and technical, which have an impact on technical and technological factors to ensure the appropriate level of economic security;

– organizational and economical, which affect the financial and economic parameters of production and economic activities;

– executive and administrative, concerning the activities of staff.

A key element of resource management in the system of economic security is the organizational and economic management mechanism, which is a complex category of management necessary to implement management decisions aimed at achieving specific goals of the object of surveillance by influencing specific factors using resource potential. The leading role is performed by the economic mechanism, which significantly affects the formation and functioning of the components of the organizational mechanism. On the other hand, organizational aims to achieve the goals of economic security and includes organizational levers and management tools.

Organizational levers are the requirements of a specific form. The maximum effect is achieved when using the tools: regulations, rules, instructions, powers, orders, directives, directive requirements, others. Organizational tools have an impact on staff motivation and, consequently, on productive work.

Thus, the primary purpose of forming an organizational and economic mechanism for managing resource potential in the system of economic security is to create favorable administrative and economic conditions to achieve the required security level.

Conclusions

The study results allow us to conclude that in current conditions of economic activity is especially important to create a system of formation and economic security of the enterprise. The concept of forming the system of economic security of the enterprise involves the most efficient use of resource potential of the enterprise, the creation of adequate organizational structures, development of appropriate mechanisms and responses that would ensure stable operation of the enterprise at the present stage and sustainable development in the future. The organizational and economic mechanism for resource potential management in the management system of economic security of the enterprise is established. Varieties of mechanisms and features of their functioning are considered.

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COMPENSATION TOOLS IN PROACTIVE ENTERPRISE MANAGEMENT

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Obecny poziom rozwoju gospodarczego Ukrainy i nowoczesne zarządzanie przedsiębiorstwem charakteryzuje szereg cech. Dzięki obecności na rynku ukraińskim firm zagranicznych, inwestorów zagranicznych oraz banków z kapitałem zagranicznym, ukraiński sektor biznesowy ma możliwość zdobycia zagranicznego doświadczenia w zakresie zarządzania procesami biznesowymi i ryzykiem przy wykorzystaniu zaawansowanych globalnych technologii zarządzania ryzykiem z uwzględnieniem aktualnego rynku globalnego trendy. Dziś ważne miejsce w kierunku kontroli procesów biznesowych w przedsiębiorstwie zajmują te ryzyka, które są trudne do skwantyfikowania i oceny, ale ze swej natury stanowią poważne zagrożenie dla firm w obliczu zwiększonej konkurencji i globalizacji gospodarki międzynarodowej . Takie bieżące ryzyka obejmują ryzyko operacyjne, ryzyko utraty reputacji i wizerunku biznesowego, ryzyko natury politycznej i prawnej, ryzyko strategiczne, ryzyko wpływu sankcji i embarg międzynarodowych, ryzyko geograficzne itp. Jednak liczba takich czynników ryzyka stale rośnie, a czołowe światowe instytucje i organizacje opracowują nowe podejścia i adaptacyjne metody zarządzania przedsiębiorstwem.

Mówiąc o nowych podejściach do zarządzania ryzykiem, należy zidentyfikować nowy obszar kontroli, jakim jest compliance. Compliance przetłumaczone z języka angielskiego (compliance) - oznacza zgodność, zgodę, podążanie, zgodność. Termin „zgodność" powstaje od czasownika „przestrzegać", który tłumaczy się jako przestrzegać, przestrzegać. Oxford Dictionary of English podaje następującą definicję tego terminu:

„Zgodność" – czynność, która spełnia ustalone wymagania lub wytyczne.

Dziś na Ukrainie pojęcie „compliance" jest w dużej mierze utożsamiane z kierunkiem walki z korupcją, tj. przestrzeganiem przepisów antykorupcyjnych lub walką z praniem pieniędzy, oszustwami i tak dalej. Jednak na poziomie międzynarodowym kontrola zgodności jest ważnym elementem istnienia firmy, ponieważ obejmuje i wpływa na tak ważne elementy aspektów biznesowych, jak wdrażanie i kontrola procedur i polityk wewnętrznych, oparta na interakcji

wszystkich pionów, współpracy lokalnej i międzynarodowej z partnerami biznesowymi, dostawcami, konkurentami, tworzenie kodeksu relacji biznesowych z uwzględnieniem specyfiki firmy, w tym przepisów i regulacji, nawiązuje wzajemną współpracę między pracownikami, wdraża kodeks etyki korporacyjnej, ustala poziomy ryzyka w działalności biznesowej przy podejmowaniu odpowiedzialne decyzje, tworzy podstawę do odróżnienia ryzyka od akceptowalnego do wysokiego; zapewnia ważny przegląd działalności firmy poprzez analizy i raporty itp. Ogólnie rzecz biorąc, znaczenie zgodności nabiera tempa. Wraz z rozwojem globalizacji na arenie światowej pojawiają się nowi uczestnicy rynku międzynarodowego, powstają nowe rynki współpracy międzynarodowej, co również prowadzi do pojawienia się nowych zagrożeń, które mają charakter kompleksowy i mogą bezpośrednio wpływać na działalność firmy, choćby pośrednio. Dlatego nowe warunki i okoliczności wymagają szybkiego dostosowania się do zmodernizowanych przepisów międzynarodowych i szybkiego dostosowania się do wprowadzenia zagranicznej działalności gospodarczej.

Globalne czynniki ryzyka o dużej skali, takie jak korupcja i łapówkarstwo, nieuczciwa konkurencja i monopole, niebezpieczne tendencje ze strony grup agresorów zagrażających społeczeństwu globalnemu, niestabilna sytuacja ze strony krajów trzeciego świata, stworzyły potrzebę kształtowania lokalnych i międzynarodowych organizacje przeciwdziałające czynnikom ryzyka oraz tworzenie bezpiecznego środowiska dla międzynarodowych stosunków gospodarczych. Skorzystanie z zagranicznych doświadczeń we wdrażaniu programów compliance w zarządzaniu przedsiębiorstwem wiąże się przynajmniej z dynamicznymi trendami globalnego rozwoju gospodarczego i integracją globalnego systemu finansowego. Geneza prawa obcego i standardów compliance w zarządzaniu procesami biznesowymi na wszystkich szczeblach przedsiębiorstwa na ryzyko stawia przed uczestnikami rynku wymagania i konieczność przestrzegania międzynarodowych praktyk, zwłaszcza w dzisiejszej integracji europejskiej. Współdziałanie krajowych i międzynarodowych regulatorów stwarza nowe warunki do prowadzenia biznesu, celem tej współpracy jest stworzenie wiarygodnego gospodarczo-finansowego globalnego rynku, opartego na wprowadzaniu standardów biznesowych minimalizujących ryzyko w zakresie integracji.

System kontroli zgodności to kompleksowy system zarządzania ryzykiem braku zgodności na poziomie zarządzania przedsiębiorstwem, który pozwala na identyfikację tego rodzaju ryzyka i prowadzenie jego systematycznego monitorowania, zapewniającego ciągłość procesu biznesowego oraz ograniczanie poziomu zagrożeń, które mogą mieć zarówno lokalne, jak i międzynarodowe uderzenie.

Program Compliance zapewnia efektywne zarządzanie korporacyjnymi procesami biznesowymi, biorąc pod uwagę, że w ostatnich latach na Ukrainie nastąpiły znaczące zmiany w dziedzinie biznesu i rozszerzenie współpracy między Ukrainą a zagranicą. Wiele zmian wpłynęło również na standardy prowadzenia biznesu, gdzie w tej chwili duży nacisk kładzie się na aktywną walkę z korupcją, praniem pieniędzy, oszustwami i tak dalej. Ustawodawstwo jest również wymagane przez prawo. Na przykład Ustawa Ukrainy „O zapobieganiu korupcji", „O zamówieniach publicznych", „Przeciwdziałanie praniu pieniędzy i finansowaniu terroryzmu". istnieją takie aktualne zagadnienia, jak walka z korupcją, etyka biznesu i inne czynniki ryzyka. Należy zauważyć, że naruszenie ustalonych zasad i reguł może prowadzić do nałożenia znaczących sankcji cywilnych i karnych, będzie miało negatywne konsekwencje dla reputacji firmy, a być może nawet pociągnie urzędników do odpowiedzialności.

Ogólnie, typowa polityka zgodności powinna zawierać następujące elementy:

1. Zdefiniowanie zgodności jako priorytetu na wszystkich poziomach organizacji. Obejmuje to również identyfikację konfliktów interesów, w przypadku których zainteresowanie niektórymi projektami biznesowymi może spowodować druzgocące szkody dla przedsiębiorstwa oraz spowodować szkody dla reputacji i finansów.

2. Identyfikacja i ocena istniejących zagrożeń; prognozowanie ryzyka z uwzględnieniem specyfiki przedsiębiorstwa i strategicznego kierunku rozwoju.

3. Opracowanie polityki compliance zgodnie z potrzebami firmy z uwzględnieniem czynników ryzyka; stworzenie procedury identyfikacji i eliminacji ryzyk biznesowych, sposobów zapobiegania i minimalizowania kosztów finansowych, upadłości, sankcji, embarg i innych ograniczeń mogących mieć negatywny wpływ na przedsiębiorstwo.

4. Stworzenie i wykorzystanie Macierzy Ryzyka, która obejmuje definicję ryzyka od niskiego, średniego, wysokiego i niedopuszczalnie wysokiego, budowę macierzy ryzyka dla niektórych działań przedsiębiorstwa;

5. Opracowanie algorytmu działań mających na celu identyfikację i eliminację zgodności ze zdarzeniem, tworzenie raportów dla wyższej kadry kierowniczej, prowadzenie dochodzeń i stosowanie środków zapobiegających podobnym przypadkom.

6. Współdziałanie Departamentu Zgodności z innymi działami przedsiębiorstwa, z innymi instytucjami, przede wszystkim z instytucjami bankowymi obsługującymi kalkulacje przedsiębiorstwa; interakcja z personelem współpracującym z kontrahentami, stronami trzecimi, instytucjami bankowymi, konkurentami itp.; stałe szkolenia, konsultacje, pobudzenie do efektywnej współpracy.

Każda kontrola zgodności obejmuje następujące kroki:

→ Identyfikacja kroków zgodności i innych słabości wymagających weryfikacji zgodności z procedurą zgodności

→ Wdrożenie procesu weryfikacji. Pozyskiwanie dodatkowych zasobów, współpraca ze wszystki3333mi działami

→ Na podstawie uzyskanych informacji oceń dane i zidentyfikuj główne kryteria ryzyka, które negatywnie wpływają na proces i wynik

→ Opracowanie i wdrożenie algorytmu redukcji ryzyka

→ Zarządzanie zidentyfikowanymi ryzykami w przyszłości z uwzględnieniem otoczenia wewnętrznego i zewnętrznego.

W efekcie powstaje macierz ryzyka dla konkretnego zdarzenia, którą można wykorzystać w przyszłości. Również ten algorytm działań ułatwia szybką reakcję na potencjalną lub rzeczywistą zgodność z incydentem.

Poniżej znajdują się również ogólnie praktyczne rozwiązania, które można wykorzystać do efektywnego wykorzystania funkcji i możliwości firmy do ograniczenia wpływu czynników ryzyka (Tabel 1). [1]

Ogólnie, ryzyka braku zgodności można podzielić na następujące grupy. [2]

- Komercyjne
- Korporacyjny
- Administracyjny
- Regulacyjne
- Finanse
- Reputacja

Tabel 1. Rodzaje rozwiązań, które można wykorzystać podczas korzystania z funkcji i możliwości complins

Przegląd problemu, który wymaga odpowiedniej decyzji w sprawie zgodności.	↔	Tworzenie i wykorzystanie macierzy ryzyka.
Zaangażowanie i wsparcie najwyższego kierownictwa organizacji oraz wzmocnienie znaczenia decyzji zarządczych.	↔	Ma charakter średnio- i długoterminowych polityk i procedur compliance w celu konsolidacji i stosowania ustalonych zasad.
Osiągnięcie i wykazanie doskonalenia umiejętności praktycznych rozwiązań compliance oraz prezentacja pozytywnego wpływu.	↔	Poprawa klimatu wewnętrznego organizacji, wzmocnienie jej pozycji w pewnej niszy rynkowej.
Nakreślenie jasnej wizji kluczowych kroków i kroków.	↔	Definiowanie algorytmu i terminów dla środków zgodności.
Promowanie zdolności i możliwości pracowników organizacji poprzez różne aspekty zarządzania.	↔	Prowadzenie na bieżąco edukacji i szkoleń, trwale podnoszące świadomość pracowników i zachęcające do rozwoju.
Akceptacja compliance jako ważne ogniwo w funkcjonowaniu organizacji.	↔	Skup się na wsparciu ekspertów na wszystkich poziomach.

Każdą grupę charakteryzują określone zasady compliance oraz środki compliance, które mają na celu minimalizację czynników ryzyka oraz przeciwdziałanie negatywnym skutkom środowiska wewnętrznego i zewnętrznego. W przypadku nieprzestrzegania ustalonych zasad, każda grupa ponosi określone ryzyko dla organizacji, co przedstawia poniższa tabela 2.

Tym samym rola compliance staje się strategicznym elementem zarządzania ryzykiem w organizacji, która nastawiona jest na rozwój nie tylko na rynku lokalnym, ale również na arenie światowej.

Jednym z głównych celów strategicznych współczesnego przedsiębiorstwa jest zorganizowanie efektywnego systemu zarządzania przedsiębiorstwem w zakresie ryzyk zewnętrznych i wewnętrznych w oparciu o podejście compliance. Wśród głównych obszarów są następujące:

• Konsolidacja i koordynacja wysiłków w procesie badania i wdrażania najlepszych praktyk w zakresie zarządzania przedsiębiorstwem i stosowania zarządzania zgodnością, łączenie wysiłków na rzecz zwalczania korupcji na wszystkich szczeblach biznesu, przeciwdziałania praniu pieniędzy, a także wykrywania nadużyć finansowych i innych możliwych naruszeń w proces działalności przedsiębiorstwa.

Tabel 2. Środki zgodności w celu zminimalizowania czynników ryzyka

Ryzyka handlowe					
Zawieszenie działalności gospodarczej z powodu zawieszenia płatności	Zawieszenie operacji na rachunkach	Blokowanie transakcji walutowych przez kontrolę walutową	Odmowa usługi w instytucji bankowej	Blokowanie środków na koncie bankowym	Definiowanie umów jako nieważnych
Ryzyka korporacyjne					
Struktura własnościowa, brak przejrzystości nie jest jasno określony	Definiowanie kontrolerów nie jest w stanie plateau	Blokowanie części nieruchomości	Stwierdzenie bezprawności operacji z kapitałem autoryzowanym	Blokowanie pracy działów wykonawczych organizacji	Blokowanie wypłaty dywidend i innych zobowiązań organizacji
Ryzyko administracyjne					
Nieplanowane kontrole państwowych organów regulacyjnych	Oddzielenie urzędników i kierownictwa od kierownictwa	Sankcje finansowe i blokowanie aktywów	Kary administracyjne i procesy sądowe	Ryzyko karne	Ryzyko prawne
Ryzyko regulacyjne					
Rozwiązanie organizacji	Cofnięcie zezwoleń i koncesji na prowadzenie działalności gospodarczej	Blokowanie inwestycji i innych projektów finansowych	Ustalenie niezdolności organizacji do regulowania zobowiązań	Likwidacja organizacji	Bankructwo
Ryzyka finansowe					
Utrata potencjalnych projektów i kontraktów	Utrata partnerów biznesowych	Pogorszenie historii kredytowej	Utrata inwestycji	Utrata klientów i rynków	Wykluczenie z rynku
Ryzyko reputacji					
Utrata zaufania ze strony banków	Utrata zaufania ze strony kontrahentów	Utrata zaufania klientów	Utrata zaufania inwestorów i wierzycieli	Utrata zaufania organów regulacyjnych	Wykluczenie z rynku

• Rozwój nowoczesnego podejścia do zarządzania przedsiębiorstwem, którego celem jest rozwój współpracy międzynarodowej, która prowadzi regularną i efektywną ocenę ryzyka w procesie interakcji, wprowadza doświadczenia globalnych TNK i instytucji finansowych.

• Zorientowanie przedsiębiorstwa na zachowanie reputacji biznesowej na rynku lokalnym i międzynarodowym, współdziałanie z wiodącymi firmami w zakresie rozwoju zarządzania i adaptacyjnego wykorzystania wszystkich możliwych funkcji na minimalizację czynników ryzyka mogących mieć negatywny wpływ na działalność przedsiębiorstwa.

• Opracowanie podstaw metodologicznych efektywnej technologii compliance jako nowoczesnego innowacyjnego podejścia do zarządzania przedsiębiorstwem w zakresie ryzyka.

• Właściwa ocena rosnącej roli nowego podejścia do zarządzania zgodnością, nie tylko w prowadzeniu biznesu na rynku lokalnym, ale przede wszystkim w poszerzaniu biznesowego kręgu współpracy i dostępie do rynków międzynarodowych w kontekście globalizacji.

Wraz z rozprzestrzenianiem się światowych trendów w rozwoju compliance jako najnowocześniejszego podejścia do zarządzania przedsiębiorstwem, wzmocnienie kontroli organów ścigania w zakresie zgodności z ustawodawstwem antykorupcyjnym, do tego obiecującego trendu dołącza coraz więcej firm na Ukrainie, szczególnie skupiony na handlu zagranicznym.[3]

Na Ukrainie coraz więcej uwagi poświęca się zagranicznym doświadczeniom w prowadzeniu biznesu, ponieważ zagraniczne stosunki gospodarcze między Ukrainą a innymi krajami rozwijają się. Perspektywy wprowadzenia międzynarodowych doświadczeń w procesie prowadzenia ukraińskiego biznesu dadzą szansę na zwiększenie konkurencyjności ukraińskich przedsiębiorstw na poziomie etyki biznesowej i sprostania współczesnym globalnym wymogom współpracy międzynarodowej. Zdaniem kierownictwa przedsiębiorstwa w warunkach ryzyka w obecnych trendach globalizacji rynków również zmieni się i dostosuje do współczesnych wymagań. Tym samym rozwój zarządzania ryzykiem compliance jest obiecującym kierunkiem w innowacyjnym procesie zarządzania przedsiębiorstwem i wymaga dalszej analizy.

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KAPITAŁ INTELEKTUALNY I SMART-TECHNOLOGIE W ZARZĄDZANIU NOWOCZESNYM PRZEDSIĘBIORSTWEM

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DOI: 10.31891/monograph/2021-10-11

Przejście społeczeństwa do ery postindustrialnej, wykorzystanie technologii intensywnie wykorzystujących naukę, intelektualizacja i informatyzacja biznesu, rozwój systemów i technologii informatycznych mają globalny wpływ na wszystkie obszary otoczenia biznesu. Zmieniają się standardy, formy, zasady działania przedsiębiorstw, zmieniają się formy komunikacji z partnerami biznesowymi. Niezbędnym elementem efektywnego zarządzania przedsiębiorstwem jest rozwój kapitału intelektualnego, a także systematyczne wykorzystywanie systemów i technologii informatycznych w celu uzyskania przewagi konkurencyjnej i zwiększenia konkurencyjności podmiotów gospodarczych.

Od końca XX wieku kraje rozwinięte rozpoczęły przechodzenie na zorientowane na naukę modele rozwoju gospodarczego. Rozwój ten realizowany jest w oparciu o szerokie wykorzystanie kapitału intelektualnego [1, 2, 3]. Kluczowym celem konkurencji staje się kapitał intelektualny. Jego dostępność w przedsiębiorstwach i efektywne zarządzanie jego realizacją są gwarancją powodzenia funkcjonowania zarówno danego przedsiębiorstwa, jak i całej gospodarki. Kapitał intelektualny pozwala firmom zwiększać rentowność, zapewniać konkurencyjność i osiągać strategiczne cele rozwoju. Dlatego celowe jest odróżnienie kapitału intelektualnego od innych kapitałów, zbadanie jego istotnych cech, struktury, uzasadnienie możliwych dróg rozwoju [4, 5, 6].

Badanie publikacji naukowych pozwala nam zidentyfikować system zróżnicowanych kategorii, które odzwierciedlają różne cechy ludzkich zdolności do pracy i konsumpcji. Jako takie kategorie naukowcy często wyróżniają: „zasoby niematerialne”, „kapitał ludzki”, „intelektualny potencjał ludzki”, „zasoby intelektualne”, „potencjał pracy”, „potencjał innowacyjny”, „kapitał społeczny” [5, 6, 7] i inne.

Zgodnie z wynikami [12] przeprowadzonych badań dochodzimy do wniosku, że zasoby niematerialne należy rozumieć jako zbiór wiedzy przedstawionej w określonej formie, który posiada podmiot gospodarczy, dający mu organizacyjne i prawne możliwości dalszego stabilnego rozwoju, tworzenia i

utrzymywania wysokiej konkurencyjności. przewagi konkurencyjne związane z dostępnością wykwalifikowanej kadry, patentami, wprowadzeniem nowoczesnego zarządzania, wykorzystaniem nowoczesnych technologii cyfrowych, utrzymywaniem długotrwałych relacji z konsumentami, dobrą opinią itp. Kapitał intelektualny przedsiębiorstwa determinuje i kształtuje jego zdolności i potencjał innowacyjny [8]. Potencjał innowacyjny należy rozumieć jako zbiór wszystkich dostępnych aktywów materialnych i niematerialnych przedsiębiorstwa, wykorzystywanych w procesie działalności gospodarczej i ich zdolności do realizacji szans w przyszłości.

Niezbędnym warunkiem zwiększenia potencjału innowacyjnego przedsiębiorstwa jest naszym zdaniem przyciągnięcie kapitału intelektualnego i identyfikacja jego elementów. Z drugiej strony realizacja potencjału innowacyjnego zapewnia rozwój kapitału intelektualnego.

Biorąc pod uwagę specyfikę działalności przedsiębiorczej, proponujemy alokację elementów składowych kapitału intelektualnego przedsiębiorstwa zgodnie z podejściem funkcjonalnym i klasyfikacją procesów biznesowych. Do prowadzenia badań i uzasadniania rekomendacji dotyczących zwiększania kapitału intelektualnego na rzecz rozwoju przedsiębiorczości, właściwe jest wykorzystanie strukturyzacji, która znajduje odzwierciedlenie w standardach IFAC 2000 (Międzynarodowa Federacja Księgowych). Zgodnie z tą strukturą kapitał intelektualny dzieli się na ludzki, konsumencki i organizacyjny [6]. Kapitał ludzki odzwierciedla zatem cechy osobowe (zarówno nabyte w procesie kształcenia i szkolenia, jak i wrodzone), które determinują zdolność personelu do pełnienia funkcji zawodowych i obowiązków związanych z pracownikiem i które realizowane są z odpowiednią motywacją.

Strategiczna rola kapitału intelektualnego w rozwoju przedsiębiorczości wynika z jego cech: kreatywności i innowacyjności, zdolności adaptacyjnych do zmian; umiejętność rozwoju, ciągłego zdobywania wiedzy. To innowacyjność kapitału intelektualnego zapewnia rozwój społeczeństwa. Przedsiębiorca wybiera rodzaj działalności, określa strategię i zasady prowadzenia biznesu, którego powodzenie zależy od poziomu ukształtowania kapitału intelektualnego i potencjału oraz determinuje konkurencyjność.

Według badania Światowego Forum Ekonomicznego (WEF), według Global Competitiveness Index 2014-2019, liderami rankingu są kraje: Singapur,

USA, Hongkong, Holandia, Szwajcaria, Japonia itd. Wśród Ukrainy najbliżsi sąsiedzi, najwyższa ocena Wskaźnik konkurencyjności Ukrainy nie podlegał znacznym wahaniom i nie zmienił się znacząco w ostatnich latach. Najbardziej pozytywny pod względem ilościowym wskaźnik - 76. miejsce Ukraina w 2014 r. Pogorszenie oceny Ukrainy w latach 2015-2019 do 85 pozycji, naukowcy wyjaśnić [9, 10] skutki interwencji wojskowej na wschodzie kraju oraz kryzysu społeczno-gospodarczego, który negatywnie wpływa na skuteczność oceny kraju (tabela 1).

Tabela 1. Pozycja Ukrainy i krajów sąsiednich w rankingu Global Competitiveness Index (GCI) *

Stanowiska Ukrainy i niektóre kraje na całym świecie według Globalnego Indeksu Konkurencyjności	2013 (ze 148 krajów)	2014 (ze 144 krajów)	2015 (ze 140 krajów)	2016 (ze 138 krajów)	2017 (ze 137 krajów)	2018 (ze 140 krajów)	2019 (ze 141 krajów)
Ukraina	***84***	***76***	***79***	***85***	***81***	***83***	***85***
Polska	42	43	41	36	39	37	37
Indyk	44	45	51	55	53	61	61
Gruzja	72	69	66	59	67	66	74
Rosja	64	53	45	43	38	43	43

** Źródło: pogrupowane według autorów według [9, 10, 11]*

Z drugiej strony w nowoczesnych warunkach wspomaganie informacyjne działań zarządczych od strony pomocniczej, drugorzędnej stało się decydującym czynnikiem sukcesu nowoczesnego przedsiębiorstwa. Stale rosnące potrzeby struktur biznesowych w zakresie jakościowego wsparcia informacji wiążą się z koniecznością pracy kierownictwa z dużą ilością informacji, doboru niezbędnych, weryfikacji ich wiarygodności, zapewnienia wydajności i niezawodności, systematyzowania, przetwarzania i przechowywania, terminowości i skuteczne decyzje zarządcze.

W kontekście cyfryzacji procesów społeczno-gospodarczych, tworzenie wsparcia informacyjnego dla działalności biznesowej pozwala na wykorzystanie Smart-technologii. Przekształceniu ulega cały system zarządzania przedsiębiorstwem. Przedsiębiorczość na początku XXI wieku charakteryzuje się tym, że firmy nie decydują się już o możliwości wdrażania systemów informatycznych czy technologii do optymalizacji procesów biznesowych. Istnieje potrzeba wybrania konkretnego systemu informacyjnego lub zestawu narzędzi.

Istniejące wsparcie informacyjne systemów zarządzania w dużej części przedsiębiorstw przemysłowych jest niedoskonałe. Analiza publikacji naukowych na ten temat oraz informacji o praktycznych zasadach korzystania z systemów i technologii informatycznych pozwala stwierdzić, że systemy informatyczne zarządzania przedsiębiorstwem są zwykle wykorzystywane jedynie jako automatyzacja niektórych zadań lokalnych, co nie w pełni realizuje możliwości biznesowe i strategię rozwoju przedsiębiorstwa . Często niską wydajność systemów informatycznych i technologii działających w ukraińskich przedsiębiorstwach tłumaczy się nieuporządkowanym obiegiem dokumentów, równoległą księgowością, powielaniem obliczeń w różnych działach, tworzeniem dokumentów, które nie zawsze są wykorzystywane w zarządzaniu i tak dalej.

Innowacyjny rozwój światowych gospodarek jest oceniany przez coroczny indeks Bloomberg Innovation Index. Podsumowuje dziesiątki kryteriów z różnych obszarów za pomocą siedmiu wskaźników, w tym kosztów badań i rozwoju, zdolności produkcyjnych i koncentracji przedsiębiorstw państwowych high-tech. W zakresie: działalności patentowej; koncentracja kadry naukowej; Wyższa edukacja; gęstość firm technologicznych; wydajność; struktura dochodu narodowego; działalność innowacyjna i inwestycyjna. Należy wzmocnić pozycję Ukrainy w rankingu innowacyjnych technologii (tabela 2).

Tabela 2. Pozycja Ukrainy i krajów sąsiednich w rankingu Innowacyjnych Technologii Bloomberg w latach 2019-2020. *

Stanowiska Ukrainy i niektórych krajów świata w ranking Innowacyjnych Technologii Bloomberg	2019	2020	
	Miejsce	Miejsce	Wartość
Ukraina	***53***	***56***	***48,24***
Niemcy	2	1	88,21
Polska	22	25	69,98
Indyk	33	35	63,84
Rosja	27	26	68,63

** Źródło: [11, 13]*

W celu wyeliminowania problemów nowoczesne systemy informatyczne powinny być stosowane wyłącznie w koordynacji z systemem zarządzania procesami biznesowymi, a podstawą rozwoju cyfryzacji i podstawą wyboru Smart-

technologies powinien być uogólniony system procesów biznesowych: od etapu pozyskiwania klientów na produkty i usługi, powiązania, badania rynku, uzasadnienie pozyskiwania inwestorów, organizacja procesów gospodarczych i wykorzystanie mocy produkcyjnych, synchronizacja dostaw surowców i komponentów, procesy związane ze sprzedażą produktów, wysyłką do klienta, rozliczeniami i serwis pogwarancyjny. Cechy te określają wymagania stawiane systemom i technologiom informatycznym w procesie przygotowywania i uzasadniania decyzji zarządczych.

Ponadto ważną rolę wsparcia informacyjnego w kierunku ochrony zasobów. Biorąc pod uwagę ograniczone i kosztowne zasoby materiałowe, pracownicze i finansowe, ważnym narzędziem sukcesu biznesowego jest promowanie podejmowanych na czas i świadomych decyzji kierowniczych dotyczących wykorzystania potencjału zasobów, promowanie możliwości wysokiej wydajności i efektywności wykorzystania zasobów. To aktualne i aktualne informacje, które pozwalają dokładnie określić, na czym należy skoncentrować zasoby, aby zrealizować priorytety firmy. Inteligentne technologie poszerzają możliwości profesjonalistów i pozwalają firmie działać szybciej, wydajniej, ekonomiczniej, a w konsekwencji wydajniej.

Według badań możemy zidentyfikować etapy rewolucji przemysłowych i powstawania branż:

- 1780, etap mechanizacji - przemysł 1.0: produkcja przemysłowa na maszynach wodnych i parowych;

- 1870, etap elektryfikacji - przemysł 2.0: produkcja masowa na liniach technologicznych;

- 1970, etap automatyzacji - przemysł 3.0: automatyzacja z wykorzystaniem elektroniki i komputerów;

- 1980, etap globalizacji - przemysł 3.5: organizacja produkcji na zasadach ekonomicznych (technologie zasobooszczędne, przyciąganie taniej siły roboczej, oszczędność energii itp.);

- nowoczesność, faza cyfryzacji - przemysł 4.0: informatyzacja, wprowadzenie elektronicznych urządzeń do analizy danych i technologii sztucznej inteligencji dla dalszej automatyzacji procesów produkcyjnych i zarządczych;

- przyszłość, etap personalizacji - Piąta rewolucja przemysłowa, czyli Przemysł 5.0: nacisk na współpracę człowieka i maszyny; inteligencja ludzka

działa w harmonii z obliczeniami poznawczymi; szersze zaangażowanie ludzi w produkcję przemysłową przy pomocy robotów; zaawansowane szkolenie i samokształcenie personelu w celu wykorzystania innowacyjnych technik; wzrost wartości dodanej produkcji; zwalnianie towarów zindywidualizowanych [14].

Na każdym etapie informacja jest kluczowym czynnikiem sukcesu firmy. Rosnące na obecnym etapie znaczenie zasobów informacyjnych i rosnące wymagania co do ich jakości, wymuszają zaangażowanie technologii Smart w procesy zarządzania i działalności biznesowej przedsiębiorstw. Posiadanie sprawnie działającego systemu informatycznego upraszcza proces zarządzania, pozwala szybko zbierać, sortować, przetwarzać informacje i szybko podejmować decyzje.

Zgodnie z wynikami przeprowadzonej przez Gartnera oceny otoczenia biznesowego w 2020 r. zidentyfikowano 10 kluczowych trendów cyfrowych: 1) hiperautomatyzacja; 2) wszechstronną wiedzę i wieloaspektowe doświadczenie kadry; 3) demokratyzacja technologii; 4) budowanie potencjału ludzkiego; 5) przejrzystość wyboru i stosowania; 6) zwiększać możliwości; 7) publiczną dostępność serwerów w chmurze; 8) robotyka; 9) blockchain procesów biznesowych; 10) troska o bezpieczeństwo obiektów sztucznej inteligencji.

Należy jednak wziąć pod uwagę złożoność struktury i różnorodność informacji: informacja – ważny czynnik produkcji, specyficzny zasób systemów gospodarczych; produkcja informacji – rodzaj działalności gospodarczej; informacja - towary; niektóre informacje - zasób publiczny; informacja wpływa na definicję optymalnych i równowagowych warunków na rynkach, tj. jest częścią mechanizmu rynkowego; informacja jest kluczowym czynnikiem zapewniającym konkurencyjność przedsiębiorstwa.

W kontekście badania roli Smart-technologii w zarządzaniu przedsiębiorstwem, warto rozważyć różnicę pomiędzy kategoriami „systemów informacyjnych” i „technologii informacyjnych”. Obie kategorie są ściśle powiązane z pojęciami zarządzania informacją i kapitałem intelektualnym.

Ponadto specjaliści z różnych krajów nadają systemom tego typu różne nazwy: Systemy Informacji Gospodarczej (EIS), Zautomatyzowane Systemy Zarządzania Przedsiębiorstwem (ASMS), Systemy Informacyjne Zarządzania Przedsiębiorstwem (ISMS), Systemy Informacji Korporacyjnej (CIS), Wewnętrzne Systemy Informacyjne Zarządzania (IMS).), Systemy Planowania Zasobów

Przedsiębiorstwa są znane jako System Planowania Zasobów Przedsiębiorstwa (ERP), Systemy Planowania Zapotrzebowań Materiałowych są znane jako systemy MRP i inne [39; 40]. Główną przyczyną takiej sytuacji jest brak standardów w tym zakresie.

Aby lepiej zrozumieć kategorię systemów informatycznych i technologii inteligentnych, konieczne jest rozważenie etapów ich zastosowania w przedsiębiorstwach w procesie ewolucji. Tak, inteligentne technologie są stosowane w biznesie od dawna. Nie zawsze są identyfikowane. Tak, komputery, kamery monitorujące, mapy elektroniczne, nawigacje GPS to elementy „inteligentnych" technologii, czyli technologii inteligentnych, które naprawdę przynoszą korzyści i upraszczają wiele procesów. Jednak początkową kategorią jest system informacyjny. Jako jego elementy zaangażowane są inteligentne technologie. Aby lepiej zrozumieć kategorię systemów informatycznych, należy wziąć pod uwagę etapy ich powstawania i powstawania (tab. 3). W ten sposób pierwsze systemy informatyczne przedsiębiorstw zaczęły kształtować się na początku lat 50. ubiegłego wieku. Następnie służyły do uciążliwych obliczeń cyfrowych i wynagrodzeń pracowników, a wykonywano je za pomocą maszyn księgowych. Taka innowacja w tamtym czasie pomogła obniżyć koszty finansowe i czasowe przygotowania dokumentacji.

Nowoczesne systemy zaczęły pojawiać się na początku lat 90-tych. W tym okresie liderzy biznesu szukali sposobów na skrócenie cyklu produkcyjnego i w rezultacie wpadli na pomysł wdrożenia systemów informatycznych w zarządzaniu. Obecnie systemy informatyczne wykonują szeroki zakres zadań. Ich funkcjonalność pozwala grupować i przechowywać informacje, przetwarzać je i efektywnie wykorzystywać. Systemy informatyczne zapewniają swobodny dostęp do zasobów informacyjnych kadrze zarządzającej, a jednocześnie zapewniają ochronę danych przedsiębiorstw. Systemy informatyczne różnią się rodzajem i zakresem zadań, przedmiotem zastosowania i przeznaczeniem.

Aby scharakteryzować systemy informatyczne przedsiębiorstwa, ważne jest określenie ich rodzaju. Naszym zdaniem głównymi cechami klasyfikacji systemów informatycznych powinny być: sposób i czas przetwarzania informacji,

stopień automatyzacji, stopień integracji, zakres, charakter wykorzystania informacji, ustrukturyzowane zadania i (jeśli to konieczne) inne.

Tabela 3. Etapy rozwoju systemów informatycznych przedsiębiorstwa *

Okres, lata	Pojęcie wykorzystania informacji	Rodzaje systemów informatycznych przedsiębiorstw	Przeznaczenie
1950-1960	Papierowy obieg dokumentów księgowych	Systemy informatyczne do przetwarzania dokumentów księgowych na elektromechanicznych maszynach księgowych	Zwiększenie szybkości przetwarzania dokumentów. Uproszczenie procedury przetwarzania raportów i naliczania wynagrodzeń
1960-1970	Podstawowa pomoc w przygotowaniu raportów	Systemy informatyczne zarządzania kierunkiem produkcji	Przyspiesz proces raportowania
1970-1980	Kontrola zarządcza sprzedaży	Systemy Wspomagania Decyzji	Szukaj najbardziej racjonalnych rozwiązań
1980 – 2000	Informacja to strategiczny zasób, który zapewnia przewagę konkurencyjną	Systemy dla wyższej kadry zarządzającej Strategiczne systemy informacyjne	Utrzymanie pozycji firmy i rozwój jej przewag konkurencyjnych
2000-2013	Informacja jest podstawą do zapewnienia działalności gospodarczej	Zautomatyzowane biura Zintegrowane systemy informatyczne	Zależność przedsiębiorstw od działalności IP

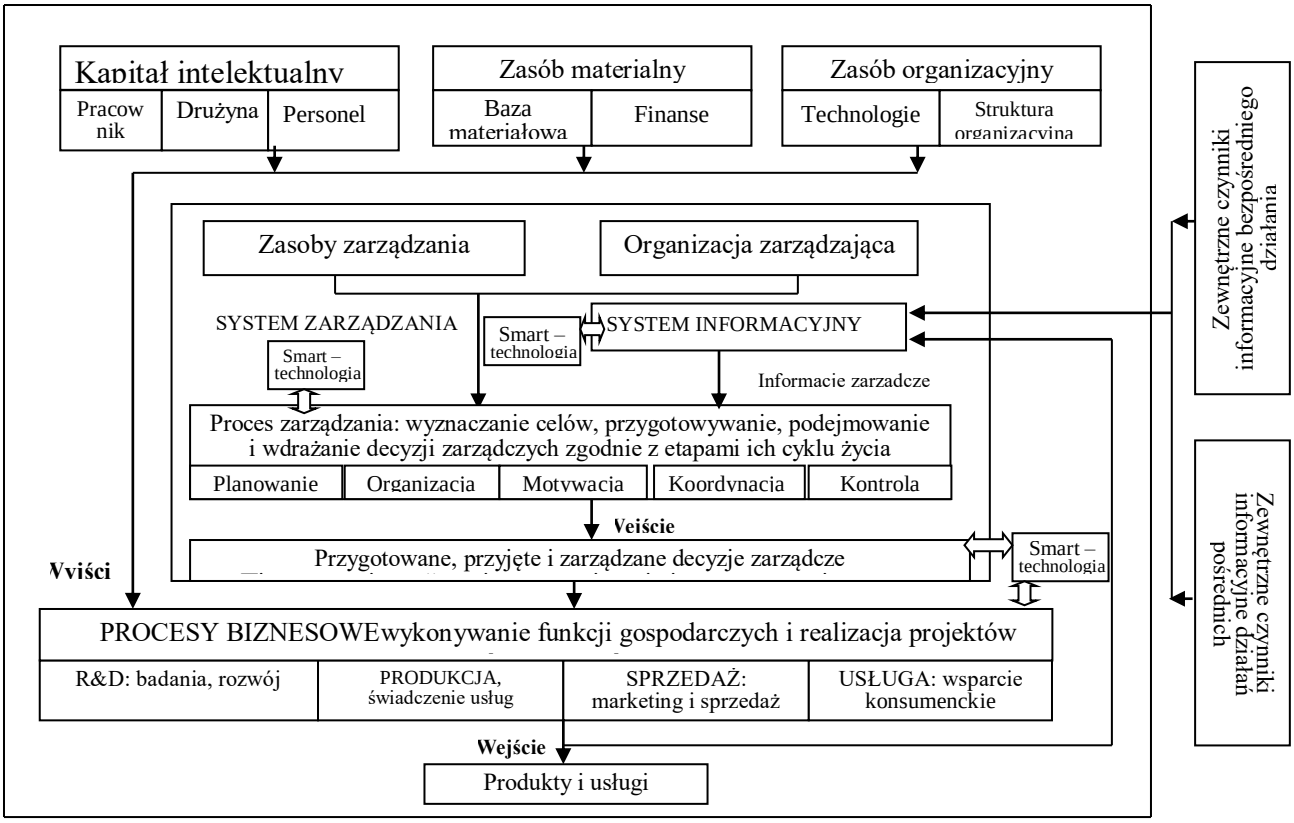
** Utworzony przez autora [9, 10, 12, 14]*

W wyniku analizy kategorii systemów informatycznych przedsiębiorstw, procesu rozwoju i obszarów ich zastosowania naukowcy określają istotę pojęcia systemu informacyjnego. Uważamy, że najbardziej udane podejście: system informacyjny przedsiębiorstwa to infrastruktura, która jest zaangażowana w proces zarządzania wszystkimi przepływami informacji w przedsiębiorstwie i zawiera informacje, instrukcje i zasady pracy z nim, personel zaangażowany w utrzymanie i rozwój systemu oraz niezbędne narzędzia informatyczne, które zapewniają funkcjonowanie mechanizmu jako całości.

System informatyczny przedsiębiorstwa przeznaczony jest do realizacji bieżących zadań w przedsiębiorstwie: planowania, kontroli i regulacji na różnych

poziomach procesu zarządzania, a także opracowywania prognoz i uzasadniania obiecujących decyzji strategicznych oraz celów i zadań (rys. 1).

Zatem podstawą tworzenia i funkcjonowania systemu zarządzania przedsiębiorstwem, jak każdej innej struktury biznesowej, jest kapitał intelektualny. Realizacja procesów biznesowych i komunikacji jest możliwa dzięki wykorzystaniu systemów informatycznych. Głównym składnikiem systemów informatycznych jest bezpośrednio technologia informacyjna. Efektem zastosowania technologii informatycznych jest informacja o określonej formie, która jest następnie wykorzystywana w zarządzaniu. W związku z tym potrzeba wykorzystania technologii Smart powstała w momencie postrzegania informacji jako realnego zasobu materialnego, a potrzeba jej przetwarzania i przekształcania jest motorem rozwoju technologii.



Rys.1 – Kapitał intelektualny i Smart-technologie w systemie zarządzania przedsiębiorstwem * [własny rozwój] [12]

Podsumowując, należy zauważyć, że informatyka jest ogólnie definiowana jako proces zarządzania informacją i jest wykonywana jako sekwencja znormalizowanych procedur przetwarzania informacji przy użyciu określonych

narzędzi: produkcji i programowo-technologicznych środków przetwarzania informacji.

Zatem we współczesnych warunkach biznesowych kategorie: „systemy informacyjne", „technologia informatyczna" oraz technologie inteligentne są podstawą zarządzania przedsiębiorstwem, ważnymi czynnikami rozwoju i zależą od kształtowania kapitału intelektualnego. Systemy informacyjne, jako narzędzie zarządzania, służą do tworzenia i realizacji strategii biznesowej, do organizacji działalności biznesowej w celu osiągnięcia celów biznesowych. Dlatego systemy informatyczne mają na celu poprawę efektywności i konkurencyjności, wzmocnienie pozycji rynkowych, identyfikację i zarządzanie ryzykiem rynkowym.

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NARZĘDZIA MARKETINGOWE W ZAPEWNIENIU ROZWOJU INNOWACYJNEGO POTENCJAŁU PRZEDSIĘBIORSTWA I WZROSTU KONKURENCYJNOŚCI

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DOI: 10.31891/monograph/2021-10-12

Transformacja gospodarki Ukrainy, rozwój współpracy międzynarodowej oraz wzmocnienie interakcji mechanizmów rynkowych z procesami społeczno-gospodarczymi intensyfikują innowacyjne metody zarządzania przedsiębiorstwami przemysłowymi. Jednym z ważnych narzędzi dostosowywania przedsiębiorstw do dynamicznych warunków biznesowych, zapewniających ich rentowność i konkurencyjność, głównym narzędziem nowej ideologii relacji z konsumentami produktów i usług, kształtowania i wdrażania potencjału innowacyjnego jest marketing i logistyka.

Organizacja działań marketingowych w kształtowaniu społeczeństwa informacyjnego, przyspieszone wdrażanie postępu naukowo-technicznego wymaga zbudowania takiego systemu wsparcia informacyjnego i zarządzania potencjałem innowacyjnym przedsiębiorstwa, który elastycznie dopasowywałby się do specyfiki informacji ukraińskiej przedsiębiorstwa rynkowe i przemysłowe. Wprowadzenie najnowszych systemów i technologii informatycznych w praktyce marketingu i logistyki oraz rozwiązanie zbioru zagadnień informacyjnego wspomagania ich działalności są szczególnie ważne dla przedsiębiorstw przemysłowych, które stanowią podstawę do wprowadzania naukowo-technicznych w innych branże. Istnieje pilna potrzeba opracowania naukowych i metodologicznych zaleceń, które uzasadnią sposoby wyjścia z kryzysu i promują wzrost gospodarczy.

Zagadnieniu wykorzystania zasobów marketingowych poświęconych jest wiele fundamentalnych, eksploracyjnych i badawczych prac naukowców. Jednak pod wpływem współczesnych zmian w otoczeniu gospodarczym, dynamicznych procesów integracyjnych i globalizacyjnych, pojawiają się nowe problemy, które wymagają rozwiązania w zakresie tworzenia systemu informacyjnego wsparcia marketingu, logistyki i innowacji przedsiębiorstw przemysłowych, zarządzania jego potencjałem.

W szczególności zalecenia naukowo-metodyczne i praktyczne dotyczące kształtowania mechanizmu wprowadzania najnowszych marketingowych systemów informacyjnych, stosowania podejść logistycznych, zintegrowanych baz danych i baz wiedzy, opracowania komponentu intelektualnego, który byłby w stanie przyspieszyć rozwój produkcji i gospodarki procesy przedsiębiorstwa, zwiększenie efektywności formowania, uzasadnienie jego potencjału innowacyjnego oraz funkcjonowanie poprzez optymalizację procesów biznesowych.

Główne komponenty marketingu, naszym zdaniem, są ściśle powiązane z prawami przestrzeni ekonomicznej, co pozwala nam interpretować marketing jako koncepcję działania rynkowego, filozofię biznesu, a także rodzaj zarządzania. W tym zakresie istnieje wiele podejść do określania treści marketingu, podkreślających zakres jego realizacji oraz informacyjny charakter istoty oddziaływań marketingowych. W pracach naukowych naukowców ukształtowały się różne podejścia do rozumienia terminu „marketing". Autorzy ogólnie traktują marketing jako „koncepcję zarządzania", „proces zarządzania", „zintegrowany system", „rodzaj działalności" ukierunkowany na zaspokojenie potrzeb konsumentów i realizację głównych celów firmy. Znany specjalista, autor wielu fundamentalnych prac z zakresu marketingu, prof. F. Kotler uważa, że marketing jest rodzajem działalności ukierunkowanej na zaspokajanie potrzeb konsumentów poprzez wymianę [1, s.22]. U zdecydowanej większości autorów, w szczególności VN Wasiliewa [2], G.Ya. Goldstein [3], P.S. Zavyalova [4] śledzi również rozumienie marketingu z punktu widzenia zaspokajania popytu konsumentów. Z tego punktu widzenia marketing jako proces gospodarczy zapewnia kontakt między producentem a konsumentem, przyczynia się do efektywności ich wymiany. T. Ambler [5], L.V. Balabanova [6], a wielu innych naukowców traktuje marketing jako funkcję zarządzania lub działalność zarządczą, która pozwala dostosować produkcję do warunków środowiskowych, dynamicznych zmian rynkowych, wymagań i popytu grupy docelowej, co w konsekwencji zwiększa konkurencyjność przedsiębiorstwa i jego rentowność. Jednocześnie niektórzy autorzy podkreślają odwrotny wpływ marketingu na rynek, przede wszystkim poprzez produkcję towarów i usług, ich wartość i jakość.

Dlatego powodzenie wymagań rynkowych ma bezpośredni związek z całościową obiektywną oceną i prognozowaniem zachodzących zmian, które z

kolei determinują potrzebę ukierunkowanej, systematycznej organizacji działań marketingowych w celu skutecznego oddziaływania na rynek i istniejący popyt, potrzeby i preferencje zakupowe konsumentów [7, s. 8]. NS. Eriashvili, K. Howard, Yu.A. Tsypkin interpretuje również marketing jako pojęcie dynamiczne, oznaczające rozwój przedsiębiorstwa poprzez aktywną aktywność rynkową [7].

Łysenko O.Yu podkreśla aspekt wiedzy w marketingu. [8] podkreślając istotę marketingu jako systemu wiedzy o istniejącym rynku, a T. Levitt identyfikuje podstawę informacyjną marketingu treści specjalnych, interpretując go jako działanie mające na celu uzyskanie informacji o potrzebach nabywcy, a więc aby firma mogła się rozwijać i oferować niezbędne towary i usługi [7].

Zatem teoretyczne definicje marketingu wskazują, że marketing rozwiązuje się samodzielnie i pomaga rozwiązać wiele problemów pojawiających się w procesie zarządzania przedsiębiorstwem. Wdrażanie marketingu w przedsiębiorstwach różnych sektorów gospodarki przyczynia się do dynamicznego rozwoju relacji rynkowych, postępu naukowo-technicznego, zrównoważonej organizacji produkcji, handlu i konsumpcji.

Zgodnie z wynikami analizy teoretycznej ewolucji koncepcji i podejść marketingowych do zdefiniowania istoty kategorii „marketing", aby zrozumieć rolę marketingu w skutecznym funkcjonowaniu przedsiębiorstwa w otoczeniu rynkowym, ważne jest, aby naszą opinię, uszczegóławiającą zawartość komponentów etap rozwoju społeczeństwa informacyjnego, a głównymi z których naszym zdaniem są: system działań, w tym badanie i prognozowanie popytu, ustalanie cen, organizacja prac badawczo-rozwojowych tworzenie nowych produktów, analiza ich asortymentu; wpływ na organizację produkcji, system promocji rynkowej i inne środki w celu osiągnięcia pożądanych rezultatów działań rynkowych; kształtowanie zachowań pozycyjnych i aktywności na rynku, z normami społeczno-etycznymi i moralnymi nowej filozofii biznesu; identyfikacja wartości konsumenckich i towarów w celu zaspokojenia potrzeb uczestników; kształtowanie efektywnych długo- i krótkoterminowych relacji z partnerami, przewagi konkurencyjne; zapewnienie rozwoju przedsiębiorstwa poprzez aktywną działalność rynkową, tworzenie informacji i wiedzy o rynku

Stąd szybki rozwój nauki i techniki, wzrost produkcji i ekspansja produktów, rosnąca konkurencja na rynkach, marketing i logistyka stanowią kompleksowy

program rozwoju przedsiębiorstwa, który obejmuje wszystkie aspekty jego działalności i podporządkowuje je zidentyfikowanemu rynkowi. wymagania.

Jednocześnie następuje połączenie procesów informacyjnych, intelektualnych, społecznych i zarządczych w systemie nowej ideologii marketingu, co wzmacnia jego rolę w rozwiązywaniu problemów społeczno-gospodarczych i społecznej odpowiedzialności biznesu. Realizacja działań marketingowych jako kompleksowego programu rozwoju przedsiębiorstwa wiąże się z koniecznością zorganizowania ukierunkowanych działań marketingowych przedsiębiorstwa, aby ostatecznie osiągnąć cele taktyczne i strategiczne.

Pomimo tego, że w wielu pracach naukowych zidentyfikowane są kategorie „marketing" i „działania marketingowe", uważamy za właściwe ich rozróżnienie. Tym samym podstawą docelowego kierunku działań marketingowych są naszym zdaniem cele przedsiębiorstwa, które zapewniają jego realizację jako kompleksowego systemu organizacji produkcji i marketingu, nastawionego na zaspokojenie potrzeb konkretnych konsumentów, pozyskanie zaplanowanych - wyniki ekonomiczne w oparciu o badania i prognozy rynkowe, badanie otoczenia wewnętrznego i zewnętrznego przedsiębiorstwa, opracowywanie strategii i taktyk zachowań na rynku w oparciu o programy marketingowe. Programy obejmują działania na rzecz rozwoju naukowo-technicznego, doskonalenie towarów i ich asortymentu, badanie dostawców, nabywców, konkurentów, mechanizmy kształtowania kosztów, doskonalenie polityki cenowej, zdobywanie przewag konkurencyjnych, poszerzanie zakresu usług, innowacyjność. Wskazuje to na bezpośredni związek działań marketingowych i logistycznych przedsiębiorstwa z działalnością zarządczą, produkcyjną, finansową, inwestycyjną, sprzedażową i inną przedsiębiorstwa, a także z procesami zarządzania jego potencjałem.

Całości procesowi działań marketingowych w przedsiębiorstwie towarzyszą decyzje marketingowe. Decyzja podjęta jako marketingowa może być ściśle powiązana z innymi działaniami, tj. w odpowiedzi na każde zadanie, które podlega realizacji głównych celów przedsiębiorstwa. Pod tym względem proces decyzyjny będzie rozumiany jako cały zestaw (sekwencja) procedur, które pod wpływem marketingu prowadzą do rozwiązania problemów produkcyjnych i ekonomicznych. Ponieważ, jak wykazaliśmy wcześniej, działania marketingowe są nieodłącznie związane ze znalezieniem optymalnego rozwiązania w interakcji środowiska wewnętrznego przedsiębiorstwa, a także dostawców, producentów i

konsumentów oraz wpływowych czynników interakcji mechanizmów rynkowych (otoczenia zewnętrznego), zdecydowana większość decyzji marketingowych należy do systemu złożonych decyzji zarządczych.

Zatem wraz z efektem uporządkowanej interakcji wszystkich podmiotów systemu marketingowego, który powstaje w procesie zaspokajania potrzeb konsumentów, pojawia się naszym zdaniem dodatkowy efekt solidnej organizacji działań marketingowych i logistycznych oraz budowania jej systemu wsparcia informacyjnego. , włączenie do mechanizmu zarządzania innowacjami. Efekt ten przejawia się w przyspieszonym osiąganiu celów marketingowych poprzez poprawę poziomu organizacji, podejmowanie świadomych decyzji, planowanie, koordynację i kontrolę wszelkich działań związanych z intensyfikacją polityki marketingowej przedsiębiorstwa, w oparciu o zarządzanie informacją o potencjale innowacyjnym przedsiębiorstwa. przedsiębiorstwo. Marketing jako warunek gospodarki rynkowej zapewnia pełny cykl organizacji procesu produkcyjnego: od badań i rozwoju po sprzedaż i serwis – które podlegają wymogom rynkowym i są pod wpływem szerokiego spektrum ekonomicznego, politycznego, naukowego, technicznego i czynniki społeczne. Dlatego właściwie zorganizowane działania marketingowe są głównym narzędziem osiągania długofalowych i bieżących celów przedsiębiorstwa o najwyższej efektywności ekonomicznej i planowanych wynikach społeczno-gospodarczych. Warunek ten jest jednak możliwy, jeśli firma jest w stanie na bieżąco dostosowywać plany naukowe, techniczne, produkcyjne i sprzedażowe do zmian warunków rynkowych, manewrować własnymi zasobami materialnymi i intelektualnymi, aby zapewnić niezbędną elastyczność w rozwiązywaniu zadań strategicznych i taktycznych, na wyniki działań marketingowych. Marketing jest zatem podstawą wsparcia informacyjnego dla długoterminowego i operacyjnego planowania działalności produkcyjnej i handlowej przedsiębiorstwa, polityki gospodarczej, programów produkcyjnych, organizacji prac naukowo-technicznych, technologicznych, inwestycyjnych i handlowych przedsiębiorstwa, a także zarządzanie wydajnością i całym przedsiębiorstwem.

Dla uzasadnienia składowych i kolejności kształtowania się systemu marketingowego i logistycznego wsparcia rozwoju potencjału innowacyjnego przedsiębiorstw przemysłowych i zwiększenia jego konkurencyjności, konieczna

jest analiza definicji marketingowych systemów informacyjnych i ich wpływu na zarządzanie przedsiębiorstwem w nowoczesnej informacji przestrzeń.

Stąd większość badań naukowców z tej dziedziny, model systemu informacji marketingowej, rozpatrywany na podstawie interakcji podsystemu inteligentnego marketingu i szeregu podstawowych elementów (wewnętrzna informacja marketingowa, aktualny system informacji zewnętrznej, system analityczny), co skutkuje w regularnych informacjach, informacjach na żądanie oraz danych analitycznych określających wpływ kompleksu marketingowego na otoczenie marketingowe, wraz z doborem jego elementów zewnętrznych. Naszym zdaniem koncepcja marketingowego systemu informacyjnego do zarządzania potencjałem innowacyjnym przedsiębiorstwa przemysłowego powinna rozwiązać problem zintegrowanego podejścia do kształtowania zapytań informacyjnych, ustandaryzowanych i technicznych ograniczeń w tworzeniu zasobów informacyjnych, zarządzania innowacjami i potencjałem przedsiębiorstwa oraz może być przedstawiane jako połączenie trzech głównych elementów: gromadzenia, przetwarzania, analizy informacji; bezpośrednio informacje działające w ramach systemu informacji marketingowej; metody i procedury zbierania informacji, przetwarzania, analizy, przygotowania do podejmowania decyzji (rys. 1). Dlatego system zarządzania potencjałem przedsiębiorstwa powinien opierać się na strukturze informacji marketingowej i zawierać podstawowe elementy (podsystemy), elementy otoczenia wewnętrznego i zewnętrznego, rodzaje i kierunki wsparcia informacyjnego.



Rys. 1. System zarządzania potencjałem innowacyjnym przedsiębiorstwa przemysłowego w oparciu o zastosowanie narzędzi marketingowych

Komponenty te mogą składać się z wielu elementów i podsystemów w zależności od zadań przedsiębiorstwa, co jest determinowane warunkami jego funkcjonowania, pozycją rynkową i strategią rozwoju.

Ponieważ jakość badań marketingowych i logistycznych zapewnia wiele elementów, w tym tworzenie planu, programu marketingowego i wymaga uporządkowania przepływów informacji oraz nabiera nowych cech spójności z wykorzystaniem systemu internetowego, możemy stwierdzić, że badania marketingowe są ważnym elementem koordynacji i koordynacji przepływów informacji w zintegrowanej przestrzeni marketingowej, dopasowując je do celu i zastosowania w zarządzaniu przedsiębiorstwem i jego potencjałem.

Naszym zdaniem, marketingowo zintegrowana przestrzeń informacyjna powinna zawierać takie podstawowe elementy, jak zasoby informacyjne, na które składają się dane, informacje i wiedza utrwalona na odpowiednich nośnikach; działy i służby przedsiębiorstwa przemysłowego zapewniające funkcjonowanie i rozwój przestrzeni informacyjnej; środki interakcji informacyjnej użytkowników; oprogramowanie i sprzęt, komunikacja i obsługa oraz kadra zarządzająca i koncentrują się na innowacjach (rysunek 2).



Rysunek 2. Wsparcie marketingowe i logistyczne zarządzania potencjałem przedsiębiorstwa przemysłowego

Tak więc wysokiej jakości wsparcie informacyjne z wykorzystaniem narzędzi marketingowych i logistycznych decyduje o jakości i klarowności wdrażania mechanizmów zarządzania przedsiębiorstwem, innowacyjnością i ogólnym zarządzaniem zdolnością.

Marketing i logistyka są więc podsystemem w systemie zarządzania przedsiębiorstwem i tworzą jednostkę funkcjonalną, która charakteryzuje się jasno określonymi zadaniami, cechami procesu eksploatacji oraz niezależnym mechanizmem zarządzania pozwalającym na uznanie go za obiekt autonomiczny zarządzania, prowadzenia badań marketingowych i potrzeb dalszych badań.

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ZASADY ORGANIZACJI ZAOPATRZENIA ODDZIAŁÓW I ZWIĄZKÓW TAKTYCZNYCH WOJSK UKŁADU WARSZAWSKIEGO W AMUNICJĘ WEDŁUG POGLĄDÓW Z LAT 70. I 80. XX WIEKU

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DOI: 10.31891/monograph/2021-10-13

The issue of logistical support for troops, especially the supply of ammunition in combat operations, has always been an interesting and complicated issue. This activity's planning and organization involve many issues with a very complex structure and nature and high dynamics. Very often, one should consider many factors that are difficult to predict and, therefore, are burdened with a large dose of uncertainty, which may more or less determine its course, contributing or not to the final success. The purpose of the article below is to present the historical views contained in the instructions, regulations, and manuals developed for the training of troops, taking into account the nature and course of the planned conflict.

An essential issue in securing the material of the tactical formation (armored and mechanized divisions) in the attack was to ensure the continuity and timeliness of deliveries of materials to the tactical divisions and the selection and adaptation of the appropriate delivery variant to the situation.

The ammunition was delivered following the applicable rules:

- from the field army ammunition yard to the division ammunition yard - with the army transport;
- from the divisional ammunition depot to regimental ammunition depots (squadrons), and in some cases directly to artillery firing positions - with the division's transport;
- from regimental ammunition depots for battalions and artillery firing positions - by regimental transport[1].

In necessary cases, based on the order of the commander of the army (division) or the order of the quartermaster, the ammunition could be delivered by the army (division) transport from the army (division) ammunition depot directly to the divisions (subunits) to the firing positions of the divisional artillery.

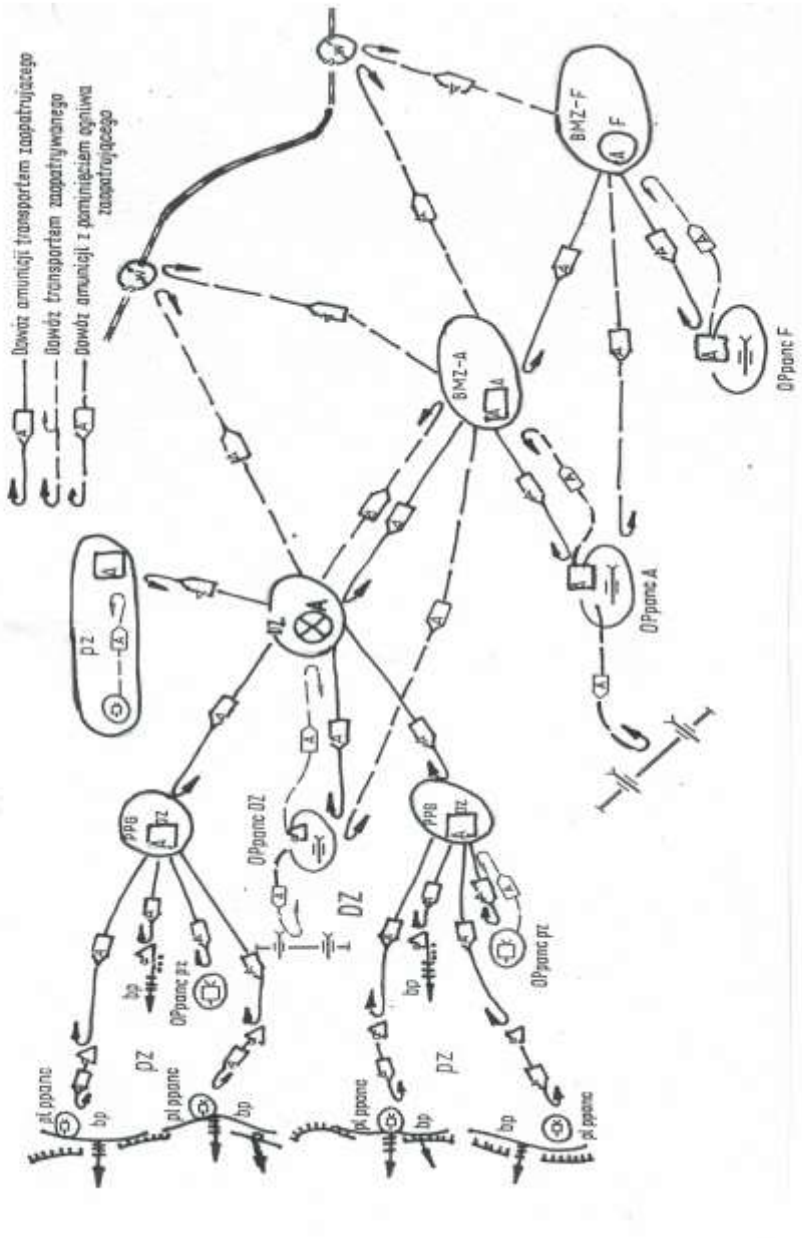


Fig. 1 Variants of the combat group of the anti-tank artillery battery (anti-tank guided missile battery)

Source: The use of anti-tank artillery sub-units and units in combat and operations. Manual, reference number Art. 686/82, ed. MON (Command of the Rocket and Artillery Forces, Warsaw 1984, p. 45.

In some cases, according to the order of the superior, divisional (regimental) car transport could be used to deliver ammunition from the army (division) ammunition depot to the division (regiment) depots.

This method of delivering ammunition could be used when the supplied tactical compound (unit) was in the centering area or the second throw, in the

period of preparation for the attack or defense, as well as in the event of significant losses in the transport of the supplying level.

The ammunition was delivered to the artillery subunits (division) in the tactical connection according to the needs resulting from the expected combat development. The supervisor delivered the ammunition to the designated meeting points, from where it was led to the ammunition depots or directly to the fire detachments. The transport units of the artillery subunit delivered ammunition to the squadrons (batteries).

The delivery was carried out by organized, depending on the level, smaller or larger supply columns. At the division level, the supply columns were arranged in the composition of a platoon or, at most, a transport company. A specific form of delivering supplies to the divisions in the offensive was to organize the rear of the division with columns loaded mainly with ammunition and fuel and moving them behind the rear (or along with them) of the first combat line troops. These materials, constituting the stocks of the rear divisions, were intended to quickly cover the wear and tear of the troops during the attack.

The basis for determining the transport capacity was:

- number and types of trucks;
- length of the delivery arm;
- vehicle mileage;
- the condition of the delivery and evacuation routes;
- weather conditions, season, and day;
- losses (including losses in combat and transport equipment as well as sanitary losses)[2].

For the calculation of the transport capacity of the division, only trucks of the supply battalion intended for the transport of cargo and their one-time transport capacity were taken into account, determined based on the capacity utilization factors established for each type of supply (e.g., fuels and lubricants - 0.9-1.0, ammunition - 0.6-1.0). This transport in the division attack carried out the delivery of materials (in the rear link - divisions) at a distance of 10-50 km. The daily course of transporting the rear of the division in the attack was estimated at an average of 150 km. The mileage could be much lower with the poor condition of the delivery and evacuation routes and unfavorable weather conditions, and the mileage could be much lower[3].

Continuity and timeliness of delivery were ensured by using various measures that prevented longer breaks in delivery. Such breaks may be the result of the activities of sabotage groups on the delivery and evacuation routes, the enemy's destruction of crossings on water obstacles, nuclear weapons strikes on the areas of the second throw of the divisions' rear, etc. the arrangement of the rear, supply columns and communication objects on the delivery and evacuation routes[4].

In addition to the material needs arising from the current consumption of material resources, the division's attack also had to consider those needs that resulted from losses in equipment and materials. These losses could account for quite a significant percentage, especially in the conditions of the enemy's use of weapons of mass destruction[5].

A division advancing in the first operational throw of the army on the enemy's defense prepared in advance during the day of combat without nuclear weapons could suffer losses in tanks of 16-18% and cars - 12-14%. Under the conditions of using nuclear weapons, armored and automotive equipment losses were estimated at a much higher level. Out of generally accepted losses, 35-45% of tanks and 45-55% of cars were to be repaired regularly by 20-30% of tanks and cars - medium repair, with only 25-30% of tanks and 10-15% of cars contributing to losses irretrievable[6].

The supply of ammunition to artillery subunits operating as part of the helicopter tactical landing gear could be carried out by air (helicopters) after being placed in landing packages. However, with the proviso, anti-tank guided missiles could not be dropped on parachutes.

Ammunition depots for artillery divisions were arranged in the areas of distribution (centering). The fire border was occupied by a group of artillery (regimental / division) with a reserve of ammunition necessary to perform the task. At the same time, the anti-tank guided missile launchers had guides loaded, and the remaining missiles were mounted in the combat compartment in special holders. The cannon shells were transported in boxes in the bodies of artillery tractors. If necessary, an additional transport with ammunition could be pulled to the fire line (for anti-tank missiles directed to the launcher loading areas).

At the guns at the firing positions on the fire frontier (while firing straight ahead in the fire preparation of the attack, the number of rounds necessary to perform the envisaged number of fire tasks without the need for replenishing it.

Which was located at the rear or on the wing of the fighting group of anti-tank guided missile batteries. The ammunition not used during the fight was loaded onto the vehicles, and if that was impossible, it was kept under protection until it was removed from the firing position. For the evacuation, empty general-purpose transport returning to the rear was used[7].

When transporting ammunition, the following rules had to be followed:

- the packaging should be undamaged;
- ammunition crates had to be handled carefully. It was strictly forbidden to throw, overturn and hit crates;
- boxes had to be stacked with the lid up. Crates with fallen detonators and fully armed missiles had to be put away and handled further under regulations on unserviceable ammunition;
- if you have mechanical means of loading and unloading, you should use them;
- the ammunition was to be delivered and transported only in a complete condition, sorted by type of projectile and load, and, if possible, by batch number, elaboration years, and specification;
- boxes with ammunition should be carefully fastened to protect them against falling or shifting during transport;
- cartridges and fully armed missiles were required to be placed across the direction of movement to protect them against the arming of fuses in the event of violent strikes;
- transported ammunition should always be under protection;
- persons assigned for loading and unloading works and escorting ammunition transports had to be carefully instructed;
- it was forbidden to light a fire closer than 100 m from the ammunition site;
- when transporting ammunition, the cars should drive in one row; a red flag had to be placed on the front and rear cars; the transport speed should not exceed 30 km / h. Cars should be technically fully operational; each of them should have a fire extinguisher;
- passages through inhabited towns or routes with heavy traffic should be avoided. During a storm, the transport should stop, increasing the

distance between vehicles; it was not allowed to stop transports near trees and tall buildings;

- to rest, you should stop in uninhabited places, away from the road to a distance of 100 m[8].

Table 1. Required artillery and tank ammunition for selected firearms of the LWP mechanized division, including the total fire unit at the ZT level.

* taking into account usage factors.

The name of the fire agent	The number of copies in subunits of a mechanized division (pcs.)	Fire unit (pcs) in a tactical compound *	Total number of cartridges (pcs)	Number of cartridges in the box (pcs)	The gross weight of the box (kg)	Number of boxes (pcs)	The gross weight of boxes (kg)
23 mm cannon plot ZU-23-2	43	2 400	103 200	63	44	1 638	72 076
57 mm cannon plot S-60	24	400	9 600	5	48	1 920	92 160
85 mm cannon ppanc D-44	18	180	3 240	3	65	1 080	70 200
120 mm mortar	54	80	4 320	2	54	2 160	116 540
122 mm hb M-30	54	80	4 320	2	70	2 160	151 200
152 mm ahb MŁ-20	18	60	1 080	1	83	1 080	89 640
Rocket launcher BM-21	12	120	1 440	1	100	1 440	144 000
Tank T-55	201	96	19 296	2	84	9 648	810 432
BWP-1	100	90	9 000	6	60	1 500	90 000
Total						**22 626**	**1 636 248**

Source: own study based on: Standards of fire units for land forces ammunition, ed. Ministry of National Defense (SUiE Headquarters), Warsaw 1987, sign. Arm. 2437/86.

The defense and protection of the transport columns during transport and evacuation were organized and provided by the drivers under the guidelines of their superiors. On the sections of the transport and evacuation routes particularly threatened by the enemy, the forces and resources assigned by the commanders of general military subunits were used to defend and protect the transport columns. If it was necessary for the transport columns to cross-contaminated roads, partial special procedures were carried out by the drivers themselves after traveling sections of contaminated roads or in the destination area before handing over the materials[9].

Table 2. The volume of artillery and tank ammunition for selected firearms of the LWP mechanized division, taking into account the total fire unit at the ZT level.

The name of the fire agent	The number of boxes (pcs.)	Box dimensions (mm)	The volume of the box (m^3)	The volume of all boxes (m^3)
23 mm cannon plot ZU-23-2	1 638	880 x 400 x 190	0,07	114,66
57 mm cannon plot S-60	1 920	640 x 590 x 210	0,08	153,60
85 mm cannob ppanc D-44	1 080	1077 x 460 x 210	0,10	108,00
120 mm mortar	2 160	950 x 350 x 250	0,08	172,8
122 mm hb M-30	2 160	700 x 500 x 200	0,07	151,20
152 mm ahb MŁ-20	1 080	830 x 420 x 240	0,08	86,40
Rocket launcher BM-21	1 440	2810 x 290 x 268	0,22	316,80
Tank T-55	9 648	1200 x 445 x 243	0,13	1 254,24
BWP-1	1 500	1040 x 500 x 270	0,14	210,00
Total				**2 567,7**

Source: own study based on: Standards of fire units for land forces ammunition, ed. Ministry of National Defense (SUiE Headquarters), Warsaw 1987, sign. Arm. 2437/86.

The views presented in the article's content have been developed and updated based on and considering many historical experiences and conclusions from the conducted field exercises. Today it is difficult to state unequivocally whether the developed instructions and guidelines were appropriate and could prove effective and effective in the battlefield of the second half of the 20th century. However, it must be said with certainty that the supply of ammunition in combat conditions was one of the most challenging tasks facing the rear services of any tactical unit.

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MARKETING RESEARCH IN ENTERPRISE POTENTIAL MANAGEMENT IN CONDITIONS OF COMPETITION AND EUROPEAN INTEGRATION

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DOI: 10.31891/monograph/2021-10-14

Before Ukraine as part of a globalized world, appears a range of global issues. The consequence of globalization is the creation of supranational institutions and transfer under their jurisdiction a number of political, economic and social functions which performed previously by national states. This led, on the one hand, to increase the number of national state and legal institutions which focused on the needs of supranational organizations, on the other hand - to elimination of unnecessary government agencies in the new conditions. Further, become the increasing of markets transnationalization (financial, human, energy) and other resources. Ukrainian enterprises are faced with the problem of its products uncompetitive and slowing development.

Various aspects of pay attention next scientists: Bersutskyi A.Y, Voronkova A.E, Oleksiuk O.I Otenko I.P, Repina I.M, Fedonin O.S, Sheleheda N.V, Shulga G.O [1, 2, 4, 5, 8] etc. However, scientific and methodological aspects of the enterprises' potential management, strategies reasoning require clarification with regard to the specific situation. Evaluating the dynamism of the market situation and current business risks, it's important to enterprises right orient the choice of priorities of its economic potential, focus on priority objectives and substantiation phases of formation management strategy.

The globalization, on the one hand, unifies the social space, on the other hand - leading to more precise stratification of the international community. Formed a system which consists of the states: "core" of globalization and of the "periphery" of globalization. Unfortunately, Ukraine is not a subject of globalization and refers in this respect to the peripheral countries. It's because of level of social and economic development, and the place and role of the state in the modern world political "game of events and effects".

This situation complicates the economic activities of enterprises and reduces their opportunities. The role and importance of foreign economic activity of industry enterprises grows, especially its export structure. Realization of the

Ukraine strategy aimed at finding new export markets, requires a successful activities industrial enterprise in comparison with foreign competitors and standing implementation ways of economic development and increase export potential.

Due to this globalization gives for Ukrainian enterprises both positives and some negatives aspects. Positives include the rapidly spreading information technology, more opportunities to find partners around the world, not only among the closest neighbors, improving employee's professionalism and attracting foreign experience. Among the negatives, which brings for Ukraine the European integration, stand out: the strengthening of economic, political and cultural dependence on the superpowers, the gradual loss of national and cultural identity and even national sovereignty through voluntary delegation of a part of state functions such international associations like the UN , European Union, OSCE which negatively impact on the development of the national economy as a whole and individual economic enterprises.

The access to international markets is associated with stiff competition. On the world markets, it has always been heavy, that's why Ukrainian companies have to learn to operate in a global competitive environment.

To successfully integrate into the process of globalization, enterprises must be able to mobilize domestic resources. Due to the globalization trends and Ukrainian entrance into euro area, improving practices of capacity building enterprises' management should be based on thorough analysis and balanced account of the impact factors of external and internal environments. These factors include certain dangers which associated with certain risks as production and business activities in the international markets. On the other hand, with the development of global and integration processes increases the role of environmental factors as real opportunities of expansion of business activities, the ability to provide strategic development of their potential [2, 4, 5, 8]. In this aspect it needs to improve the system of formation and use opportunities. The core of this system is the potential of the enterprise which in the space and time and has effectively and partially adapt to uncertainties and changes.

To determine the approaches to the mechanism of management potential of Ukrainian industrial enterprises formation in terms of European integration was conducted on the example of engineering. Engineering is a leading sector of economic complex. From its condition depends the material basis of other sectors,

the development and implementation of innovative technologies. The business environment factors (PEST-analysis) and the market conditions by building capacity factors of engineering enterprises and the opportunities and threats of the market environment (SWOT-analysis) (Table 1) analyzed.

Table 1. SWOT-analysis of the Ukrainian building industry *

Strengths	Opportunities in the external market environment
1. The presence of some engineering enterprises which produce unique products that have demand in the foreign markets. 2. The presence of specialized research institutes and design that have the qualified experts 3. The traditions and experience of manufacturing engineering products preserved	1. Relatively stable demand in the CIS market. 2. The possibility of recovery of the Ukrainian domestic market. 3. The possibility of the partial development of markets in Asia, Africa and South America. 4. Creating the favorable conditions to euro area entrance accordance with the signed agreement of the Association
Weak sides	Threats of the external market environment
1. Poor quality and therefore products competitiveness. 2. Shortage of working capital. 3. The absence of service system (usually it provides maintenance contract). 4. The absence of brands and weak popularity on the world markets. 5. Exports mainly to CIS countries. 6. Low efficiency of promotion on the foreign markets. 7. Low automation and intellectualization of production and therefore productivity. 8. Insufficient amount of skilled workers, technicians and workers. 9. The high level of wear of the active part of fixed assets. 10. The low innovation activity. 11. The low investment attractiveness. 12. The absence of corporate culture. 13. Owners mostly not focused on investing, but on the quick results. 14. The absence of a portfolio of policy developments of engineering products for introduction into the production.	1. Strengthening the global financial crisis due to the instability European and Asian markets. 2. Competition increased in the markets of CIS not in favor of Ukraine. 3. Activity of key competitors: Europe, China, India, Japan, South-East Asia. 4. The absence or insufficiency of government measures for the development of engineering. 5. The absence of stable funding government programs in timing and volumes. 6. The instability of global currency rates. 7. Rising the products and services prices from natural monopolies. 8. Instability of UAH

* formed by the author [3, 6, 7, 8] and the materials of own research

Thus, SWOT-analysis is a convenient tool for structural description of the strategic characteristics of market environment and enables the identification of prospects industries and helps to create directions for their implementation in the context of globalization and European integration processes.

Realization a SWOT-analysis of Ukrainian Engineering allowed to identify problematic aspects of their activities, such as [5, 8]: the decline in sales of engineering products in the domestic market through the lack of solvency of their clients; reduce innovation of engineering enterprises because of imperfect

mechanism for medium and long-term manufacturers and consumers' lending and high lending rates; the worsening of engineering enterprises' trading activity due to lack of effectiveness mechanism of partial compensation of the equipment's cost and the lack of financial leasing; the discrepancy of engineering in general and machine-building enterprises in the conditions of free competition on the domestic and foreign markets, especially regarding to the ability to quickly create and develop mass production of high-quality, properly standardized, competitive products; the reducing of the technological capabilities of enterprises due to the aging of fixed assets, their low technical level, lack of resource-saving technologies; the deterioration in labor productivity because of poor human resources and its low automation and intellectualization and others.

In the modern conditions of European integration enterprises often faced with uncertainty and risks, unpredictable situations when evolutionary approaches, building the extrapolation forecasts and plans for "incremental" methods can't provide the correct orientation of development in the future, and therefore the survival and the possibility of ensuring the effectiveness of the activity. These problems should be solve by the application the methods of strategic management of enterprises' capabilities as a multifaceted, management process which help to formulate and execute effective strategy of formation and capacity building which aimed at effective balancing the relationship between the enterprise, including its individual parts, and the environment, as well as achieving the goals, developing new features and benefits.

So, the results of the analysis were identified the main factors which influence on the economic potential's formation of both engineering and other enterprises. They should be taken into account in formation the mechanism of management processes of capacity formation and development and taking into account and reduction of risks and uncertainties that characterize modern phase of society development. Procedure about formation the strategy of industrial enterprises' management potential shown in Fig. 1.

Also, we have to consider that on the management of enterprises' potential impact its elemental composition, sources of resources formation and situational factors. All these aspects need to be examined and balanced in the organizational support formation of mechanism for potential enterprises management taking into account the uncertainties and economic risks as a system of interrelated elements.

Their value increases under conditions of European integration.

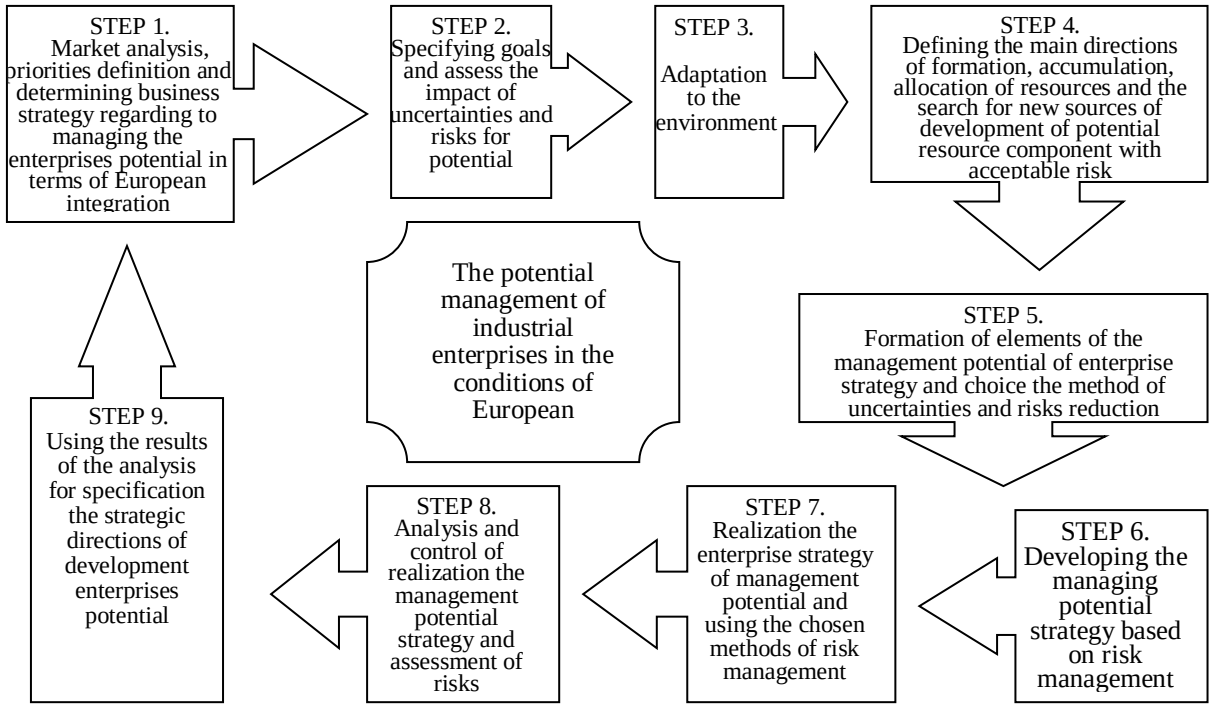


Fig. 1. Formation the strategy of capabilities management of enterprises in the conditions of European integration

Summarizing the information obtained in the conducted during the PEST- and SWOT-analysis of the market situation for engineering industry enterprises by factors of using the potential of the industry and its enterprises we can say that negative factors that have a significant impact on building engineering enterprises' capacity are: reduction in sales of engineering products. This is due to the low effective demand of consumers on the domestic market and because of its low quality and competitiveness in international markets. Engineering and other industrial enterprises have significant financial difficulties that don't allow ensuring the proper recovery of fixed assets, to implement their reconstruction and modernization, implement the advanced scientific and technological achievements. Reducing of the enterprises' innovation activity is due to the imperfection of the legislative and regulatory framework about the businesses encourage to develop and implement new resource-saving technologies. Besides, the industrial enterprises are sensitive to the unfavorable conditions on the international market because of availability of raw materials, limited energy resources.

The basis for practical actions in modern enterprise capacity management, the rationale for its development prospects are theoretical research in the field of

building structuring, identifying its elements and determining the characteristics of their formation. Summarizing the results of modern scholars` scientific research on basis of the enterprise potential structuring, it should be noted that scientists have controversial approaches to its structure defining. Indeed, depending on the industry sector, type of business activity and the specificity of its work the constituents of various entities potential can be modified. However, the basic structure must include a set of elements. The major ones are: information, labour, innovation, investment, financial, organizational and administrative, resource, functional (production) and market potentials [5].

However, this approach is descriptive and only outlines the main elements of enterprise potential structure, as each of these types of potentials is also a structured element. For example, it is believed that technological and resource potentials are parts of production potential, or investment potential is part of the financial one, that is, they are components of a lower order due to the fact that they have common characteristics and reflect the overall activity direction of the enterprise [5].

Surely the logical connection between the production and the resource or technological potentials do exist, and we believe that the construction of the hierarchical structure of a business entity economic potential model is possible provided the availability of certain functional relationships between the components.

Production and functional links between the elements of the economic potential are generated at each enterprise individually, depending on the characteristics of activity and industry sector [5, 8]. To build a potential model adequate to present-day market conditions it is necessary to study the characteristics of its operations and explore the essence and fullness of each of its components.

The most well-known approach to structuring enterprise potential is the one made by Krasnokutskaia N. S. She has suggested a multi-level structural model of enterprise potential formation, which includes production, market and collective potentials [5, 8]. Under the proposed approach, the author considers financial resources a material basis for enterprise potential, which is reflected in its balance. Krasnokutskaia N.S. also notes that the value of the total potential is the result of joint efforts for realization of its elements, and which, depending on the interests of the owners may be expressed or potential profits, remaining at the enterprise disposal, or its cost [5]. However, this approach can be considered somewhat

simplistic. In our opinion, it is impossible to identify the manufacturing and resource potential levels, since not all the available (or affordable) enterprise resources are involved in the enterprise activities or just in productive activities. In addition, the emergence (non-additive) principle of capacity building leads to the deviation (increase) of results from the integration use of resources compared to their effectiveness amount.

Given the above and considering the characteristics of the enterprise potential formation under current market conditions, we think it necessary to carry out the identification of its elements and explore its structure not in three, but four levels, namely: resource; manufacturing; hardware; institutional.

Thus, the level of enterprise resource potential is determined by the available resources and those that can be borrowed and it also characterizes its ability to pursue opportunities for productive potential development, the performance of the functions, achieving the objectives of maximizing positive result and formation of development prospects [5, p. 30]. Functioning of modern enterprises happens under the conditions of highly competitive economy. In the context of development of market, the competitiveness of an enterprise is formed as a combination of efforts of producer, which is aimed at the effectiveness of using resources and stability of its financial state on all stages of business cycle. The success of these efforts depends much on business activity.

Drawing the analogy between the ideas of different authors, we should mention the same approaches to the fact that business activity depends on the effective use of material, labour and financial resources of enterprises. But then it should include together with the indices of effective use of capital assets the indices of effective use of labour resources, which is not defined by all economists. So we should stick to such a thesis, according to which business activity in a broad sense means the whole spectrum of efforts, which are aimed at intensive use of people and financial capital, which directly influence the financial result of some market participant activity.

To the commercial structure of the company, its economic potential had the opportunity to intensification, it is necessary to provide the favorableness of creating, promoting and realization of projects as to designers, participants and managers, substantiating the decrease of uncertainty and riskiness. We believe, that main factor of achieving the success for the organization is self organization, net democracy, its accessibility and absence of center- dictator (hereat, the presence of

a single democratic centre of higher management is obligatory). The management of potential of enterprises under present-day conditions must be based on these principles.

A brief overview of the theory of human capital management gives reasons to believe that among the components of creative control noteworthy rationalization of personnel management. this reason company has to operate an exceptional level of skills, production skills and professional abilities of human resources. However, we note that the set of skills and abilities may not be static because the customers needs are constantly changing, that requires technologically and ergonomically new production. Therefore there is a need to influence the thinking process even of the most qualified employees to continuous updating according to market requirements of a number of their professional qualities.

Formation of a strategy of increasing business activity based on selforganization due to the problems of distribution of powers by the units while reducing the costs and harmonization of interests. The first problem is the rational combination of material and moral incentives, and the part of the latest incomes increases with revenue growth of employees. The difficulty is that when selecting incentives to account individual treats as people, directions of their personality in coordination with the problems of corporate culture and strengthen morale in the team.

Another problem is connected to convergence purposes workers with the tasks of the enterprise in general. Ideal result obviously can not be achieved, but, according to experts, there is a match valid for 60%. That desire to head the opportunity can play an invaluable role in the emergence synergistic effect that will "work" on the company and its prestige.

It should be noted that the degree of adaptability and self-organization of economies systems also (perhaps above all) depends on creative abilities of leaders and managers, their abilities to adequately react. Variability requires such mechanisms that do not always fit to a stable structure. However, without providing some level of stability the descent variability (adaptability) can not be achieved.

There is reason to believe that the paradigm formation is happening today, the main element of which is the quality of interaction of the enterprise with business environment, including quality of corporate culture and the quality of employees. At the same time, a new management of business activity style is forming when within the enterprise created a new team which participates in the process of self-development.

Business activity of the enterprise can be characterized by qualitative and quantitative criteria. Qualitative criteria include breadth of domestic and foreign markets, the company's reputation, competitiveness, availability of stable suppliers and consumers etc. Evaluation of business in the level of quality can be obtained as a result of a comparison of certain company with activities of related companies. Information about the history of the company with suppliers of raw materials and purchasers of finished products gets great importance is also. Using quantitative criteria the efficiency of use of the economic potential of the enterprise can be characterized by two areas: extent of the plan on the basic parameters and provide the specified rates of growth; the efficiency level of enterprise resources.

The development of international cooperation and globalization lead to increasing the competition on the foreign and domestic market. Formation of enterprise potential is a complex dynamic process, focused on maximum interaction with the environment and ensuring high quality of products, and the provision of services. That is why it is important to identify and provide for the development strategy of the enterprise development in the current conditions, which factors determine the development of elements of potential and affect their balance and efficiency of use. It is obvious that the basis for constructing a system of these factors should be based on principle of the potential structuring [8], and spheres of influence on the elements of potential, according to which all the factors can be classified into internal and external in accordance with the formation and development of potential (picture 2).

The external factors include the economic, social, political and legal conditions, the effect of which is determined by the limiting or stimulating measures by various government agencies, banks, investment companies, social groups, political forces etc. Such measures, as a rule, are the tax and interest rates, legal, ethical, social norms, pressures of political forces and others.

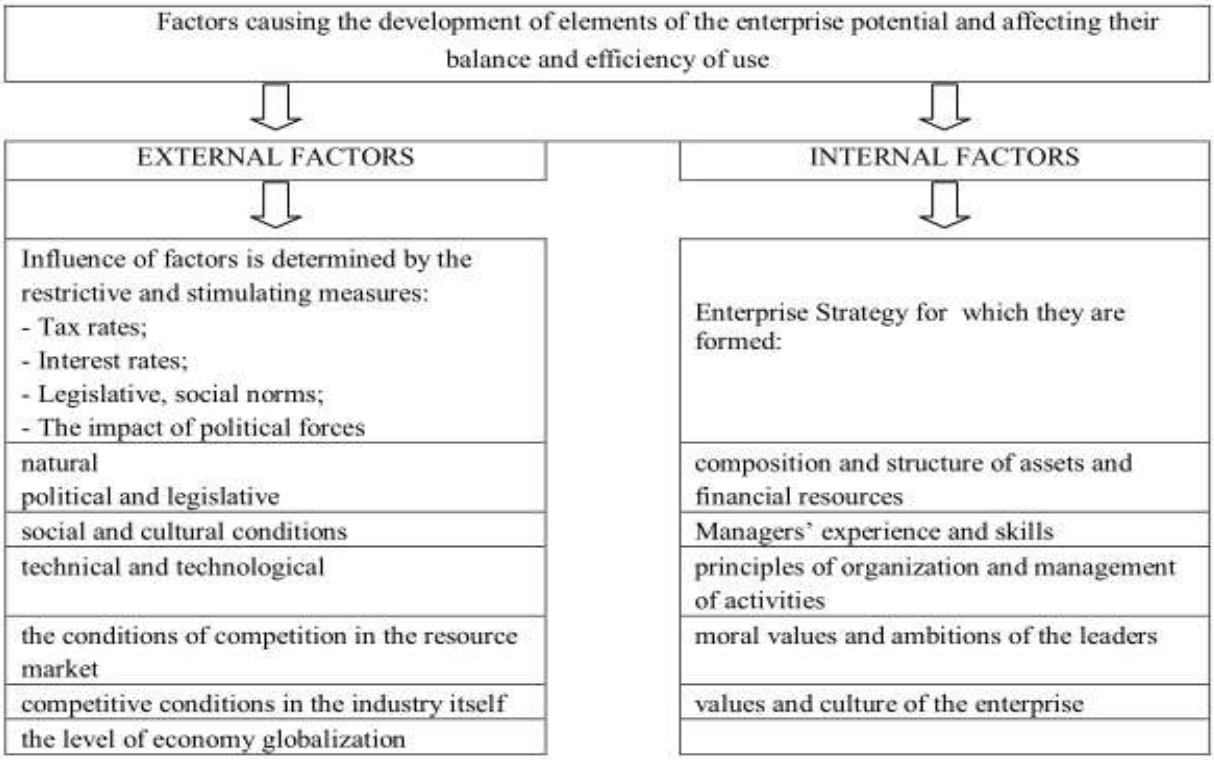


Fig. 2. Effects on the capacity of the enterprise

Besides the important external factor is also the market conditions at the entrance (the conditions of competition in the resource market) and at the exit (competitive conditions directly in the industry). The first factor relates to the cost of providing each element of potential by resources, which is the alternative cost of these resources, that is, the value of those alternatives, which had to be abandoned because of the direction of resources into that and not another element of potential in order to maximize goals achievement.

The second factor means that to win strong market positions, the enterprise potential must comply with the necessary competitive products characteristics, such as price, quality, technical characteristics, service and guarantees). Therefore, in the face of increasing competition, the company should focus its efforts on maximizing the existing potential and creating a new one by means of the timely detection of the weak positions of competitors. Innovations from competitors require, as a rule, an adequate response through the creation and implementation of new opportunities. The internal factors include, first of all, the company strategy, for the implementation of which the potential is formed as well as the experience and skills of managers, which are necessary to implement the plans, principles of organization and business management, which are guided by the company, also

moral values and ambitions of leaders, as well as generally accepted values and culture in the enterprise. Solutions on forming the potential are focused on the future and, therefore, are based on previous conditions of the development of relevant factors, that is, certain circumstances. Of particular importance are the preconditions which are determined by the needs of customers and affect the quality of the products, whose priority in the process of potential building is obvious.

Very important are also the prerequisites associated with competitors, as the resource potential of the enterprise loses its value under their pressure. In addition, internal conditions associated with conventional rules within the enterprise, with the corporate culture and the principles of business need to be taken into account.

The material basis of potential of the enterprise is the financial resources, reflected in its balance sheet, and the value of the total potential is the result of joint efforts for the realization of its elements. The total value can be assessed, depending on the interests of the owners, or the cost of, or potential profit, which remains at the disposal of the enterprise. In other cases, depending on the market share or the ability to generate financial and other results.

Production and financial activity of enterprise begins with the formation of financial resources. They must create the conditions for a stable production process and its continued growth; they also determine the competitiveness of the enterprise on the market.

In its turn, the financial potential is the amount of financial resources of the enterprise, which it can dispose to implement current and future costs. The financial resources of the firm is part of money resources in the form of income and foreign income, used to meet the financial commitments and the implementation of costs to ensure the expanded reproduction [5, p.44]. These resources are generated, usually due to a variety of sources: own, borrowed and attracted. In this case own sources of financing of the enterprise are formed by equity capital, that is part of the capital assets of an entity that remains after the deduction of its liabilities. Borrowed sources of financing of the enterprise are formed mainly due to long- term and short-term bank loans.

Attracted sources of financing of the enterprise are formed by all kinds of accounts payable. All of enumerated sources are involved in the formation of the company's assets, as well as in the implementation of its operational and financial activities to generate income and profits.

The complexity of the analysis of the factors that allow realizing the potential of the company and those, which form it, is caused among other things by the fact that these factors are numerous and it is very important to give the formal description to some of them. In modern conditions, it is impossible to carry out an objective assessment of the level of reliable potential, not taking into account the above factors, and at the same time such assessment has to meet certain requirements, most important of which, in our opinion, are:

1) while evaluating the level of potential of enterprise it is essential to consider all the factors that take part in its formation, or to identify the most significant of them, without which it is impossible to get a reasonable estimation of the potential;

2) the result of the quantitative estimation of the potential must be unique and must be characterized by an acceptable level of accuracy;

3) the assessment of potential of the enterprise must be accompanied by the creation and use of a powerful information database, which would contain information on the activities of the company and its external environment.

Assessment of the potential is methodically complicated by subjectivity of its implementation. Therefore, the criteria to enhance its objectivity should be followed: 1) provide flexible management; the ability to take risks; 2) create a progressive organizational management structure, oriented to work in market conditions; 3) provide a high reputation of the enterprise and its products among consumers and business partners; 4) use enough information on trends in the needs and demands of consumers, the ability to identify and anticipate future needs and demand; 5) good knowledge of the capabilities and potential competitors; 6) the existence of patents for technical solutions and technologies in the chosen field of activity; 7) form the developed labor potential; 8) to ensure high product quality and high production standards; 9) to form a reasonable reserve of resources, etc. [8].

Thus, it should be noted that the overall objective of taking into account results of marketing research, marketing management principles, all influencing factors and management potential of the enterprise, is to enable the company to carry out such activity, which will result in producing innovative competitive products that meet the expectations of the market and are competitive as a whole.

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THE INFLUENCE OF REPRESENTATIVES OF THE POLISH NOBILITY ON THE ART OF PARK BUILDING IN PODILLYA

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DOI: 10.31891/monograph/2021-10-15

Summary: the article analyzes the influence of the cultural life of the nobility of the Podolsk region on the peculiarities of the art of park building in the region in the XVIII-XIX centuries. Some aspects of the problem are considered. Particular attention is paid to the traditional mentality of the nobility of the region. Fashion trends of European cultural life and their interpretation in local conditions are studied. The personal influences of the brightest representatives of the local nobility are noted. The influences of Podolsk landscapes on the general stylistics of park compositions are determined taking into account their interpretation, both by patrons and park builders. Special emphasis is placed on the uniqueness of the art of Podil parks due to their location at the intersection of two vectors of cultural progress: "East - West", "West - East". This is what defined the unique multinational and multicultural space in which the park complexes appeared.

Keywords: cultural segment, compositional solutions, structural components, a landscape park, English style, French style, Podolsk gentry, mentality, palace and park complexes, reformist ideas, world culture trends, authentic features, fashion trends, park semantics, patrons, romantic trends, "eastern frontiers", the dominant height, resources, book collections, family archives, music salons, neo-Gothic, Renaissance, Enlightenment, antiquity, landscape structures, driveways, cultural progress, classical os Itâ, gardening, park sculpture, a dominant influence.

Statement of the problem in general form.

The cultural life of Podillya of the XVIII-XIX centuries is determined by the strong influence of contemporary fashion trends in world culture and art and is characterized by close ties with Western Europe. The political one directly influences the development of the cultural segment, because until 1793 Podillya was a part of the “eastern frontiers” of the Polish-Lithuanian Commonwealth. Due to political events at the end of the 18th century, the Polish-Lithuanian Commonwealth disappeared from the map of Europe, but the "Polish element",

given the ethnonational composition of the region's population, and especially the magnate nobility, had the strongest influence on all spheres of life activities, and continues to operate. Even after the incorporation of Podillya into the Russian Empire, "Russian influence" remained minimal. Western European fashion, artistic and educational trends directly continued to influence the further development of the region's culture.

Contrary to the generally accepted tradition, in which the driving force of cultural progress is the social narrative, we consider it necessary to determine the possibility of developing certain types of arts-based on personal attitude to this process, both creators and patrons. Thus, the confirmation of the value of personal manifestations of an artistic nature and their influence on the general outline of cultural progress can be traced in the art of park building, in particular in Podillya. Characterization of such manifestations and the search for ways of individual influence is a socially significant problem.

Analysis of recent publications. Problems of the influence of cultural life on the art of park building in Podillya were thoroughly studied by L. Tomilovich, N. Ursu, O. Pazhimsky, B. Pazhimsky, L. Kazimirova, V. Chernyak, E. Kolyada, O. Sleptsov, P. Slobodyanyuk and others.

Formulation of the goals of the article. Thus, the purpose of the study is to identify the optimal conditions for the interaction of cultural progress in general and its individualization in the art of parks in Podillya. The following tasks are quite logical:

to characterize the traditions and fashion trends of social development given the art of park construction;

to note the dominant influence of patrons' personalities on the formation of the general outline of the cultural tendency of the art of park building;

to formulate general principles of the genesis of the art of parks of Podillya taking into account authentic features of cultural life.

Presentation of the main material.

The influence of cultural life on the art of park building in Podillya had several components. These are, first of all, quite frequent trips of representatives of noble families throughout Western Europe to get acquainted with world masterpieces of ancient, medieval culture, works of art of the Renaissance and Enlightenment, recovery and new positive impressions and emotions. The results

of the trips were planning and compositional principles of residence construction, impressions, educational and cultural sentiments, "wonderful collections of rare old prints, scientific treatises, sculptures, works of art, etc." [4].

Another aspect of cultural exchange was the hospitality of the Podolsk nobility. The estates became the centers of the cultural life of the region, meeting places of famous musicians, poets, scientists, writers, public figures and more. Such cultural activities of aristocratic life as balls, fishing, and salons deserve special attention. Opportunities for the reception of guests were laid at the stages of planning the territory of the estates. The transport network was arranged at the expense of convenient arrival, exit, and departure of harnesses with a large turning radius. As the presence of a large number of guests necessitated an interesting and varied pastime, the planning of the park parts of the estates provided for walking and attractive compositional solutions. Descriptions of fishing suggest the existence of open spaces suitable for the simultaneous gathering of a large number of people, animals and carts with subsequent organized departure. Thus, the radial construction of driveways, walkways, various compositions, parterres, forest gates, etc. - appear not only as attributes of fashion trends but also the necessary structural components. [7]. According to S. Vasylevsky (1885–1953), the fashion for salons, having received a new impetus with the appearance of grand pianos on estates, contributed to the formation of new and revival of already known cultural centers. In the territory of present-day Vinnytsia, in particular, such centers were Nemyriv (M. Shcherbatova (1893–1918)), Brailiv (N. von Meck (1831–1894)). In the modern lands of Khmelnytsky region - Black Island (Przezdziecki), Makiv (Ratsiborowski), Maliivtsi (Orlovskii). In Samchyky, founded by P. Chechel (1754–1843), the tradition of hospitality was continued by the new owner of the residence, scientist and historian I. Ugrimov (1837–1900). For 34 years (since 1866) of living in the estate, the owner received many prominent figures of politics and culture. Among other estates visited: A. Koni, M. Stasyulevych, I. Yanzhul, V. Spasovych, M. Storozhenko, D. Ushakov, O. Veselovsky, S. Poznanska and a number of other prominent people of that time [3].

An important component of aristocratic life was fashionable educational trends. It was considered a "matter of honor" among the representatives of noble families to provide their descendants with education in the best European universities. Ideas of J.-J. Rousseau (1712–1778), Voltaire (1694–1778), D.

Diderot (1713–1784), and S. Montesquieu (1689–1755) became very popular and did not leave the Podolia nobility indifferent. A striking example of the material embodiment of the concepts of the Enlightenment were the territories belonging to I.-S. Markhotsky (1755–1827). His reforms surprised and shocked the society of that time, and the echoes of reformist ideas influenced the lifestyle of the surrounding world. Possession of I.-S. Markhotsky covered some estates, including the town of Minkivtsi, 27 villages in the Podolsk province of Ushytsya district, one village of Mohyliv district, 9 settlements in the Kherson province, three villages and part of the town of Sokoliv in Sokilets Dominion where a unique private autonomy took place - "Minkovets. In the lands of the "Lordship" in the late XVIII century. self-government, its jury trial, freedom of conscience, and the liberation of peasants from serfdom were introduced. The ruler popularized classical education and art. Among the architectural and landscape structures built on the territory should be noted the arrangement of roads, springs (as in Switzerland), as well as the construction of the "Gothic Belmont Castle" in Minkivtsi, the temples of V. Tel and J.-J. Rousseau, sculptural images of the goddesses of the world, Themis and others. Four residences were arranged, the most luxurious of which was Otrokivska. "Surrounded by a beautiful park, decorated with all sorts of grottoes, columns, statues. Here was, among other things, a pagan temple called "Hermitage" "[2, p. 55–75]. The park complex in Otrokov is the embodiment of the ideas of Enlightenment and romanticism. In particular, the "Temple of Peace", also known as the "Lower Grotto" - a place of the solitude of the ruler for philosophical reflection. This part of the park in Otrokov is the most in line with romantic trends. In the compositional solution, the Upper Grotto harmonizes with the Lower Grotto, a gallery in a rock ledge decorated with a stone image of the head. Appropriate architectural and landscape framing was introduced by I.-S. Markhotsky's "Feast of Ceres" is a multi-day celebration of harvest festival on the ancient Roman model. The arrival of a large number of guests (up to 150 carts), the participation of the entire local population, the pomp and scale of the action contributed to the appearance of symbolic altars, arrangement and landscaping of roads in the estates, registration of places for registration and recreation.

One of the key aspects of the influence on the semantics of the park of the XIX century. consider romanticism in literature and the fascination of educated sections of the population. These, of course, included the Podolsk gentry. The most

popular was "Gothic novels" and knightly sagas of the mid-XVIII - early XIX century. Landscapes, plots, and heroes, sung by the classics of the genre by W. Beckford (1760–1844), M. Shelley (1797–1851), K. Reeve (1729–1807), and W. Scott (1771–1832), influenced the emergence of park complexes. relevant structures. In an attempt to recreate the moods and attributes of the Middle Ages in their possessions, the owners of the estates erected buildings resembling knights castles, ruins, and so on. In particular, a tower in the Gothic style was built in Maliyvets Park. The possessions of Yu. Putyanin (1803–1883) in Hlibov were decorated, in addition to the tower, with outbuildings in the neo-Gothic style. Similar fashion elements are distributed in the park complexes of Podillya: the neo-Gothic tower in Kryvchyk (Krupensky), "neo-Gothic castles" - outbuildings in Makov (Ratsiborovsky). "Everything - the smithy, the shed, the greenhouse, even the chicken coops and the so-called Goat - resembled medieval fortresses with jagged towers and high walls." [7, p. 151]. Literary influence is also felt in the appearance of mysterious grottoes in the park complexes of Tsivkivtsi (Pyasetski), Maliivtsi (Orlovski), Mykhailivtsi, Otrokov (Markhotsky). A striking manifestation of the influence of the romantic views of the owners of estates on the way of life is the arrangement of the symbolic grave of the English doctor J. Howard (1726–1790) in the park complex of the village of Kovalivka (Potocki estate). The wife of the owner E. de Lin (from Mossalski), having received a European education, was concerned with charity and was sympathetic to like-minded people. A well-known philanthropist, public figure, J. Howard died in the Kherson province, preventing an epidemic. The owner of the park, in the spirit of romanticism, arranges a monument-obelisk for him. It is probable that in Kovalevsky Park there was only a symbolic tomb of Howard, the purpose of which was to evoke sadness, sorrow and other sentimental emotions, at the same time real mausoleums, tombs and chapels were built in some park complexes. The most striking examples of such park architecture are the mausoleum in Chervonohrad, the church-tomb in Bilche-Zoloty, the chapel in Verkhivka, the church-tomb in Pechera.

It should be noted the role of estate book collections in the political life of Podillya. The palace and park complexes we explored were located in the territory covered by the Polish uprisings of 1830–1831 and 1863–1864, so the noble archives, spiritual and secular literature with content that did not correspond to

imperial doctrine, interested both the insurgents and the Russian authorities. As a result, estates with rich collections and book collections became centers of free thought. In Tereshki (A. Grokholsky (1767–1808)) there was a library with a fund of up to 2,300 volumes, mainly in French and mainly in economics and philosophy. The large Orsini-Rosenberg library was kept in the Duchess's house, in particular archives and descriptive files of this family. Among others, a valuable source on the history of the early nineteenth century were the memoirs of the lieutenant of the Italian legions M. Rozhalovsky, with recollections of political events associated with General G. Dombrowski and Napoleon I. Among the Polish, French, German, Italian books Borkowski Library in Klymashivtsi (about 10,000 volumes) were rare Ukrainian old prints. K. Borkovsky himself supplemented the library with his manuscripts on philosophy, literature, as well as Moliere's translation. In Podillya there were quite powerful book collections and collections in Golozubyntsi (Skibnevsky), Govory (Tyshkevych), Yaskivtsi (Bernatovych), Ivankivtsi (Glembotsky), Rykhta (Pidvysotsky), Skazyntsi (Potocki, Lyantsnovsky, Yantskoronsky).

After the suppression of the uprisings, to ensure the further spread of "sedition", book collections, and in some places estates, were confiscated. As a result, not only historical but also valuable artistic heritage was lost. It is well known about the complete decline of the cultural traditions of the "Minkovetsky nobility" after its confiscation from the heir I.-S. Markhotsky - King. Surviving archival lists testify to the former wealth of the funds. The library of historical, heraldic and memoir documents kept in Skazyntsi (Zaleski) deserves attention. Later, as part of the Ossolineum collection in Lviv, the Szazynets archives became a valuable source of information about the Markovsky family, as well as related families - Cholgansky, Khotsimsky, Davidovsky, Kalinovsky, Kossakovsky, Potocki, Lyantskoronsky, Stadnitsky. In all, about 200 documents are known, mainly from the eighteenth century, including wills, correspondence, autographs, and royal, and hetman. The same Zaleski owned antique furniture, which, according to O. Pazhimsky, attracted general attention to their owners [2, p. 83]. The estate in Rykhta (Pidvysotsky) was famous for its library with rare collections. It consisted of 4,000 volumes of old prints and newer books, including Polish Bibles, from the oldest to the latest editions. In particular, Minkovets printed publications were among the great rarities in the book collection. The most

valuable in this collection was considered to be collections of manuscripts and family archives.

The Zaginetsky estate (Stazhynsky) contained a collection of works of art, including sculptures by J. Hudon, portraits by A. Graff, J. Lampi, Saxon tableware, tapestries, and a library containing 16,000 volumes. In the department of manuscripts of the book collection, there was a manuscript of Valery Maxim - in French (XIV century), as well as manuscripts in mathematics of the XIV century. Among the printed publications were valuable: a Parisian copy of "Horae V.V.M." with original woodcuts; Nuremberg Bible of the XV century; J. Balba's Catholicon, published by J. Fust, and many Polish incunabula, including J. Dlugosz's Life of St. Stanislaus, J. Tukholchyk's Opuskul, J. Lasky's Statute of 1506, and others. In addition, the works of S. Klonovich, J. Belsky, M. Ray, "Brest Bible", "Ostroh Bible", Sejm diaries, editions of various classics and works of travelers were presented. An illustrative list of collections confirms the scale of the phenomenon of collecting as a demonstration of the wealth and antiquity of the owners [5, p. 98].

Among the estates should be singled out the possession of bright extraordinary personalities who influenced the history, politics, art, culture not only of Podillya, but also of Europe and the world. One of the most famous was the Danish citizen T. Lange (1851-1915) - a scientist, linguist, philologist, translator, journalist, poet, diplomat. From 1883, resting and working on the estate in Napadivka, he translated into Danish "A Word about Igor's Regiment", works by O. Pushkin, M. Lermontov, I. Turgenev, O. Ostrovsky, T. Shevchenko, L. Tolstoy, F. Dostoevsky, A. Chekhov, as well as ancient authors. After retiring, settling permanently in Napadivka, T. Lange discovered new scientific fields - agronomy and botany. His research interests included not only ornamental park vegetation, but also the cultivation of citrus and pineapples exotic to Podillya.

A significant role in the history of Podillya was played by the Przezdetsky family, from which scientists, scientists and cultural figures came. Thus, K. Przezdetsky (1782–1856) was one of the outstanding breeders and agronomists of the Podolsk region. He supported art, maintained an orchestra led by the Italian L. Tonini at his own expense, opened a four-grade school, and collected a collection of paintings by European artists. Przezedziecki were patrons, supported artists, poets, musicians. Thus, in 1830, the Italian artist M. Baccelli (1769–1850) lived to

his old age and died on the estate. In 1847, the prominent composer and musician F. Liszt (1811–1886) visited Black Island. According to local historians, it was there that he wrote and performed his famous rhapsody for the first time № 2. Their family library (over 10,000 volumes) once attracted the biker L. Glibov (1827–1893), who was a frequent visitor to the Black Island. Maintaining book collections on estates was both a requirement of the Enlightenment and Romanticism and a fashion trend where the absence of a library was considered a "bad tone" and automatically excluded an aristocrat from the upper echelons of society. According to D. Diderot "At this time, every more or less well-off person, any individual, if he is not completely uneducated - had his own library, more or less large" [6, p. 208–209].

Grandson of the founder of the estate, A.-N. Przezdecki (1814–1871) became famous for his trips to Volyn and Podillya, on behalf of Kyiv Governor-General D. Bibikov (1792–1870), to collect statistical data. He later published notes in two volumes of Podole, Wolyn, Ukraina. Obraz miejsc i czasow », published in Vilno. Planning to publish the third volume of the work, the author published some excerpts in the journal "Atheneum" by Yu. Krashevsky (1812-1887). The essays of the book describe the noble families, their history, life, which contributed to the popularization of Podolsk estates in Europe and the Russian Empire, as the author describes them quite vividly [9, p. 18]. The affiliation of the Przezdetskis to the Oginskis, related to the Vyshnevetskis and the Pulawy Radziwills, helped to increase their status and increase their wealth. Therefore, their estate was also impressed with luxury, in particular the park created by D. McClair. The author's artistic idea was to use an entrance alley surrounded by trees of the park, which led from the main gate to the lawn, which overlooked the two buildings on the hill, which served as the second entrance. Then the alley led around the ground floor from the lawn and flower beds with plantings of pink acacias to the palace portal.

The windows offered a panoramic view of the park, in the planning of which the stairs leading down to the lake and the bridge were successfully used, accentuating the view of the observer on the island, where concerts were held. In the background was the old alder forest. D. McClair here used the techniques inherent in the art of gardens of the East, beating the color saturation, placing on the background of alders darker pines and lighter - pyramidal poplars. This

certainly gave the impression of a deep, three-dimensional background. The main compositional center of the park was a well-used lake, decorated with dams, bridges between islands, pavilions, it served as a decoration during the tour, and was a place for entertainment, walks and contemplation of the surrounding landscapes. [8]. Due to the secular nature of the Przezdetskis, the popularity of their family among the nobility and artists, the park was an ideal place for the secular life of the estate.

Conclusions.

In the course of our research, the aspects of the influence of cultural traditions of the period of development of park formations on their development are considered. The direct dependence of the peculiarities of the artistic solution of the composition of Podolsk parks with regard to the preferences, education, socio-political position and worldviews of the owners has been established. The dependence of stylistic and semantic orientation of compositional decisions on the main tendencies of world culture is confirmed. Summing up the research of landscape and park art objects as a component of the life of the region, we state the formation of special conditions for the emergence of integral estate structures of Podolsk palace and park ensembles. The development of artistic tendencies reaches a level that corresponds to a set of spiritual needs expressed in the search for the inner world in reality, interpreted through the idealized past.

The external world of the noble estate in the form of "English style", combining the previous history of the development of landscape art, creates an ideal image, accessible and at the same time mysterious. Embodied according to the wishes of the owner, his tastes, education, life milestones, the park is able to surprise every time, encouraging to read the composition differently, depending on the mood, season, time, weather, events outside it. Traveling through the park, the spectator had the opportunity to see different parts of the world, overcome time, achieve inner balance and realize themselves.

The structure of the landscape park during the transformation acquires features similar in spirit to the Podolsk nobility. In the parks of the new type, the traditional gardens and groves in Podillia, the harsh landscapes of the North, the exotic motifs of the East, and the grandeur of absolutism are appropriate, which corresponded to the mentality of "Kress" landowners in their desire to feel their significance.

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PRACTICE AS AN ESSENTIAL PART OF PROFESSIONAL TRAINING OF FUTURE SOCIAL WORKERS

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DOI: 10.31891/monograph/2021-10-16

Insufficient experience in training social workers in Ukrainian universities leads to the necessity to study world practice in this area, which should help bring Ukrainian educational standards in the sphere of social work closer to international ones. As Ukrainian scientists state, mastering the world experience of social work, simultaneously developing their own models, theories and methods of social work, taking into account cultural traditions, the state and resources of the modern Ukrainian society, will become prerequisites and at the same time solid basis for the development of the profession of a social worker, the creation and implementation of many social programs aimed at solving urgent problems of citizens of Ukraine.

As we know, social work became an integral part of social scientific thought and social practice about 100 years ago. Its formation, institutionalization and the conquest of social status took place under difficult conditions of constant struggle between paradigms and concepts. Social work has become a phenomenon of modern times, it has formed its own set of problems, interacting with various spheres of scientific knowledge. The versatility and multi-functionality of social work is the main difficulty in solving many theoretical and methodological issues associated with the role and place of social work in the system of social-scientific knowledge. To clarify some positions on this issue, it is necessary to address to the problem of finding the origins of the theory of social work, determining its founders, to designate certain traditions in the evolutionary development of scientific views on social work, to consider the conditions that influenced the formation and development of social work (Чотчаева, 2004; Романова, 2015).

Consequently, there is an urgent demand for skilled creative professionals able to meet the increasing consumer demand. Modern society needs skilled, enthusiastic specialists able to promote this area of activity. Practical skills of future social workers enable them to make a positive and meaningful contribution to the society.

This article is devoted to practical learning of the future social workers as a part of their professional training at the university. Very often practical experience

enriches classroom teaching and vice versa theoretical learning influences professional settings. Practical learning can take different forms from life brief, placement, internship, apprenticeship, volunteering to partnership with different organizations. Future social workers should be equipped with relevant skills, knowledge and expertise, and it becomes possible when businesses will play a more active role in the design and delivery of the curriculum. Practical learning brings professional expertise into a university and plays a great role in improving student subject, career and personal development, realizing the basic goal of higher education (University Alliance, 2017, p.13).

Therefore, the content and the extent of practical learning within the curriculum depend on the specialty. The objective of the article is to reveal the role of practical learning of future social workers in comparison with traditional lectures, seminars and other forms of classroom training.

It was outlined that practical learning of future social workers has its advantages for students, teachers and organizations. Obviously, practical learning benefits students. They become more motivated, engaged, show better outcomes and higher readiness for work, deeper understand practical aspects of their future profession, obtain soft skills (team work and decision making), technical skills and establish professional networks which can be precious in an increasingly competitive graduate employment market (University Alliance, 2017, p.13).

Practical learning of future social workers has its positive impact on teaching staff as they become real practitioners in their specialty. This enables them to support their students and encourage engagement, creativity and innovation in teaching and their own practice. Teacher-practitioners have broader perspectives on their work, stimulating them to study new approaches, methods, forms and techniques.

Sharing knowledge, skills and experience with both colleagues and students in mutual learning process is valuable, as each participant finds new ideas and data from different perspectives, which enhances close interaction and profound discussion.

As a rule, many students of social work departments of higher educational institutions have never had any feedback on their practical outcomes, so they often resist the idea of allowing a teacher to become critically involved in their work. Much effort should be made to help students comprehend and believe in the

effectiveness of practical learning. A teacher-practitioner should develop keen emotional intelligence, and abilities to manage this complex process thus design of the curriculum and learning materials depends on them. Supported by a teacher-practitioner students are able to analyze proposed material, present own findings, develop solutions and recommendations on the issue, complete case studies, prepare final reports and outline future perspectives. Teacher-practitioners offer support and supervision to social work students, not only performing the regulatory supervision required, but also facilitating feedback and reflection on the skills students learn during their work experience. Professionals are often invited to teach face-to-face, including guest lectures and study visits, presentations, job fairs etc. Variety and depth of the practical experience offered to the students should be combined with the classroom activities.

Organizations which are immediately involved in practical learning of students enjoy the most benefits as students usually add capacity, introduce new ideas and initiatives while developing their own practical skills. Moreover, participating in design and delivery of relevant courses, potential employers can be sure that graduates of social work specialties obtain both the subject-specific theoretical knowledge, practical, technical and soft skills necessary for their future profession. A supply of competent specialists is a result of such an investment, which promotes social work as a sphere of professional activity. Students who undertake apprenticeship with specific organizations are often employed earlier than their competitor candidates. By contributing to practical learning, organizations can find new routes to engage with the higher education sector, facilitating new collaborations, research and innovation.

Bringing practice in university and involving students into practice creates a wider system of exchange, when universities become centres of regional and state economic strength, increasing their influence on the society. Practical learning must be responsive to the changing needs of the society for such economic impacts to continue. Consequently, social benefits of practical learning are obvious as a pro-bono consultation of social work students offers support for people who could not otherwise access advice, while subjecting students to new areas of social practice and providing them with a more client-facing experience. Assisting those who need social advice but cannot afford it often has a big impact on the students' view of their social responsibilities as social workers in providing access to just

treatment. Such free social representation service is often commented on favourably by professionals at social centers.

Practice can also encourage active citizenship position, which can have various bonuses from fostering voluntary activities to improving political situation as a whole. It is self-evident that benefits of practical learning can vary from those directly involved in teaching-learning process, influencing potential employers, to meeting the needs of national economy.

The growth of social work means the landscape of the sector is changing for better, but there is limited expertise in vital skill spheres. Traditionally, social services organisations recruit from universities. But these recruitment pools are no longer diverse enough to keep up with this quickly developing sector. Such a situation makes the creation of internships in social services crucial to the sector's growth and future employment opportunities. Following recent reforms to public policy some organizations want to make their intake more diverse with wider range of skills. In order to operate successfully internships should match up to any opportunities available through studying a degree. Sound academic contribution is decisive in order to support the credibility of both the higher education and internship. Social work organizations are searching for partners with education providers that can give their potential employees theoretical knowledge and practical skills that are relevant to their professional duties.

However, practical learning is rather difficult to organize as it places additional responsibilities on universities. More teacher-practitioners and more financial resources are needed in comparison with traditional educational process; consequently, students will require access to services to let them practice theoretical material they are learning. It should be taken into account that the quality of such education depends on the quantity of full-time teachers as temporary lecturers are not fully involved into academic community and cannot devote enough time to their students, providing detailed comments on their individual tasks. Sound leadership and institutional support to practical learning is decisive to settle these issues. Maintaining links with professional organisations can be difficult if this depends on a single person. Rather expensive may seem the necessity to establish and maintain long-lasting relations with professional partners, units, organizations. Even costlier is the requirement to construct or rent spaces or clinics to provide social services to those who need it. Institutional

attitudes are of crucial importance to integrating practicing teachers into the broader faculty and relevant staff development so that such professionals do not feel like they enter either the academic or professional realms. This is quite a challenge, as it is more difficult to circumvent the different staffing plans. However, through the use of new technologies it is possible to promote a sense of community and interaction among employees. Program leaders have to work hard to stimulate discussion and sharing of best practices to drive innovation.

Probably one of the most valuable effects of practical training for future social workers is that they have great satisfaction in helping those in need. Students working in the clinic learn new things not only about social work, but also about its importance for the life and well-being of people. By bringing social work closer to life, practical training can be a powerful tool for protecting human rights and strengthening the rule of law. Practical training programs are a mechanism for practical training of future social workers and promoting their understanding of the ethical, professional and practical problems faced by professionals. Students gaining "real life" work experience in the context of hands-on training can lead to the creation of a new generation of social workers.

Practical "training of bachelors of social work is carried out according to the following structure: educational practice and industrial practice, in addition, students actively "participate in volunteer activities and act as volunteers in social services" (Полевая, 2011, 55).

During their practical learning, students get acquainted with measures of social support for large families, low-income families and ordinary families with children. It is important here that students personally communicate with these clients of social work, learn about their problems, and familiarize themselves with the current regulatory framework and the mechanism for providing assistance to a family. When providing social assistance to the population, trainee students have the opportunity to get to know the procedure for assigning and providing targeted social assistance to low-income families; students, during the internship, will learn the procedure for assigning payments to families with disabled children, large families in the department for the provision of social support measures for housing and communal services; students will go into the procedure for providing regional social supplements to pensions up to the subsistence level to non-working citizens, including minor children, recipients of survivor's pension in the department of

social supplements to pensions. The participation of students in extracurricular activities contributes to the disclosure of their creative abilities, diversified personality development, training in professional actions necessary for a future bachelor of social work to prevent family problems.

As this article shows, the advantages of such a learning model protrude students to include not only those involved in teaching, but also employers and the universities themselves. More efforts should be applied to appreciate these benefits and ensure that learning by doing continues to improve. Practicing teachers and practical learning in general are highly valued by students because they bring practical experience, credibility, and access to professional networks, also they equip students with the skills necessary to be successful and competent.

It was found out that wide-ranging cooperation between universities and professional organizations, with an accent on both classroom and broader strategic issues, encouraged ongoing professional development and certainly practice in all areas, capitalising on respective expertise to the benefit of students. Along with the ability to conduct practical research and incorporate reflective practice, teachers stat that under such conditions they ontain a much broader base of knowledge, understanding, and skills than if they were working in a single setting.

Employers are already willing to play an active role in ensuring that students acquire the skills they need and are quickly incorporated into working life, while students appreciate the opportunity to learn on the job.

Of course, there are some problems associated with adopting learning by doing. While higher education providers should be motivated to incorporate more hands-on learning into their curricula, it is also essential to appreciate various issues connected with teacher recruitment, training, retention, their schedule, and how these staff can be supported to value both elements of their professional sphere and teaching.

As the political landscape in Ukraine continues to evolve, we hope that through this process the value of practical learning will be further recognized as well as it will overlap with other national political agendas such as state and local growth. By including more data and involving more institutions from across Ukraine, it will be crucial for institutions to express the idea of good teaching fluently and coherently.

This includes talking about the role of practical learning and providing an evident proof of the influence it can have on student learning and future outcomes. Practical learning is an important part of the complex network of Ukrainian higher education. We hope this information will allow universities and other institutions across the sector to examine this topic in greater depth and help anchor and disseminate practical.

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DEMOGRAPHIC SITUATION IN UKRAINE AND POLAND

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DOI: 10.31891/monograph/2021-10-17

1. Introduction

One of the most important factors in the country's development is its population, its size and structure. The large number of able-bodied population contributes to the economical development . At that time, the growth of elder people's share and aging lead to a number of socio-economic problems: pension reform, social protection, active aging and effective application of the elder generation's potential in certain spheres of economic activity.

In the research literature, depopulation is used as the main indicator. However, although this indicator is useful for demographic trends, depopulation is rather a symptom than a cause of population decline, which is the result of a complex "closed circle" of interconnected economic and social factors that highlights the acute problems of regional development and governance (Espon, 2017). In addition, in different countries this term is used differently. In Poland, this is a process of population loss, and in Ukraine this term characterizes a decrease in the population due to the low birth rate, surplus death and a negative balance of migration (Rink, Haase, 2009). Although most scientists define the depopulation process as a negative phenomenon, there are no generally accepted goals or principles regarding the desirable limit of demographic change in the countryside: the goals vary between "reduction", "stopping" and "returning" the depopulation of the rural areas (Karcagi-Kovats, Andrea, Katona- KovacsJudit, 2012).

Demographic development is a process of preserving the population size as a result of historical progress. When this measure is fundamentally violated due to a decrease in the population and a decrease in its quality, there is a demographic crisis, during which demographic development is slowed down; there is a "demographic stagnation" that can eventually become a demographic catastrophe. The demographic catastrophe manifests itself in the transformation of the country or its individual regions into areas of demographic disaster (demographic distress), which manifests itself in a massive population`s outflow, in part or in total

depopulation of the territories [Steshencco, 2013]. In Ukraine, such areas of demographic disaster, primarily, are rural areas.

Depopulation occurs directly through the balance of two main phenomena: fertility, which is the result of the births and deaths number ratio and pure migration. The influence on the intensity of these phenomena by many factors, from the question of religion, culture, traditions, system of values, very important issues of economic and cultural life, perception of the surrounding reality. These factors determine the number of children and the choice of residence place, as well as living and working conditions and health systems and affect the length of our lives (Rakowska, 2011).

According to (Brown 2013), demographic challenges in Europe include three components: a decline in population growth, driven mainly by positive immigration, aging and urbanization. At the same time (Skryzhevska, Karácsonyi, 2012), the demographic crisis is characterized by depopulation, aging and a decrease in the expected life expectancy, as well as low fertility and marriage, deteriorating health and degrading the education quality of rural residents, accompanied by displacement of young and physically active people of the population.

2. Material And Methods

The main purpose of the presentation is to identify the main regularities in the demographic situation of Poland and Ukraine. The research was conducted using a literary review of the topic. Empirical data comes from the State Statistics Service of Ukraine and the Central Statistical Office of Poland. In the analysis of statistical data, the method of comparative research, which allowed identification on a national scale, was used.

The population of Poland increased by 100,000 during 1990-2020, while Ukraine lost 9 million. The reasons for such large population losses in Ukraine are related to the loss of part of the territory. For an objective comparison, it is worth studying the structure of the population (Fig. 1).

In 2020, in Ukraine and Poland, the population aged between fifteen and sixty-four was the largest and constituted 66-67 percent. This situation is called a "demographic window", when a very large proportion of the working population.

But children from birth to the age of fourteen were few: 15,2 percent in Ukraine and 15,4 in Poland. Today, in both countries, the population is sixty five years older than 17-18 percent, indicating an aging population.

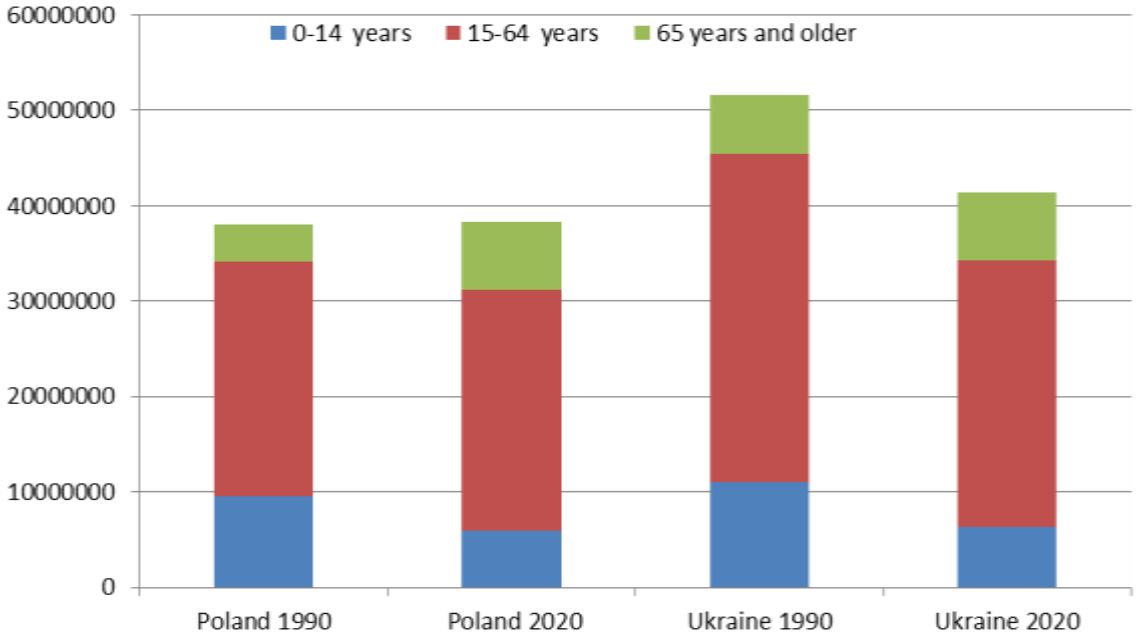


Figure 1. The population of Ukraine and Poland, in the year 1990 and 2020

Source: Own study based Own study based on State Statistics Service of Ukraine and Central Statistical Office Poland

There has been no replacement of generations in recent years. The youth index has deteriorated significantly, if in 1990 children aged 0-14 years accounted for elderly people over 65 years old 245 in Poland and 175 in Ukraine, then in 2020 these indicators are almost the same: 82 children in Poland and 87 in Ukraine per 100 people over 65 years old. This situation will contribute to the fact that in 30-40 years the entire working-age population will become of retirement age, and then there will be a massive aging of the country's population.

During the years 1990 to 2020, the Polish population did not change. At the same time, the number of children aged from birth to fourteen years decreased by 3,6 million or 38 percent. And the number of people aged sixty five years and older has increased by 3,2 million. The situation in Ukraine is worse, as the entire population has decreased by 9 million, and children from birth to fourteen have decreased by 40 percent or 4.5 million.

Thus, nowadays both countries have problem of population aging. The reason of this situation is population reproduction (table 1).

The reasons for the population`s loss in Ukraine was high mortality rates, which prevails in the birth rate. If in 1990 was estimated a predominance of mortality over birth rate, in 2020 the situation changed.

Table 1. Natural population movement of Ukraine and Poland per 1000 people, in the years 1990 and 2020

Years	live births	deaths	natural increase
Ukraine			
1990	12,6	12,1	0,5
2020	7,8	15,9	-8,1
Poland			
1990	12,4	9,5	2,9
2020	9,0	12,8	-3,8

Given the almost identical population structure, it can be argued that Ukraine had a much worse population reproduction. In 1990, the birth rate per 1,000 people was almost the same in both countries, while in Ukraine the death rate was 2.6 per 1,000 population. In 20 years, the situation has worsened: the growth rate of mortality in Ukraine was higher, and the growth rate of birth rate was lower. Due to this, in 2020, Ukraine lost 8.1 people per 1,000 people, and Poland 3.8 people.

The main reasons are the declining birth rate, which contributes to a decrease in the number of children and an aging population. Due to the large number of elderly people, mortality will continue to rise. The number of women of childbearing age is important, as well as the number of children born to one woman. (Table 2)

Poland from 1990 to 2020, women aged from fifteen to forty nine have become less than 1 million or 10 percent. At that, fewer women of younger age groups became. In Ukraine, the loss of women of childbearing age is significantly more than 2.5 million or 30 percent In Ukraine, these indexes are estimated at 2,6 million women or 21%. It is also worth noting that the decrease in women`s population is most observed at the age of 15-25 years. That is in the young.

Table 2. The number of women in Ukraine and Poland in 1990 and 2020, thousand

Years of life	Poland		Ukraine	
	1990	**2020**	**1990**	**2020**
15–17	915	551,4	1785	923
18–19	562	368,5	1643	970
20–24	1265	1007,1	1935	1 256
25–29	1329	1222,3	1989	1647
30–34	1625	1431,2	1906	1739
35–39	1636	1631,4	1566	1584
40–44	1389	1551,3	1519	1542
Total	**8721,0**	**7763,2**	**12343,0**	**9661,0**

Also, an important factor is the decrease in the birth rate of women (Fig. 2). As we can see, in recent years the birth rate per woman has dropped significantly and in 2020 amounted to 1.2 children in Ukraine and 1.4 children in Poland. The combination of declining women of childbearing age and declining birth rates will continue to reduce the number of children born and the aging of the population.

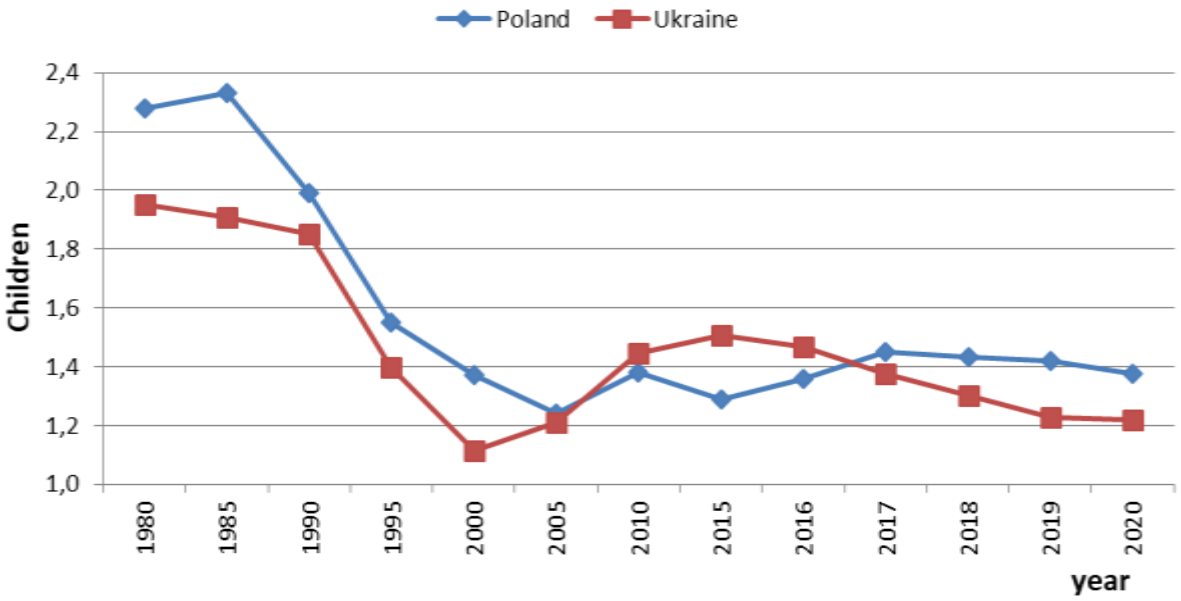


Figure 2. Total fertility in Ukraine and Poland, in the years 1980 -2020

4. Conclusion

The above data represents that here is a high quantity of elderly people in Ukraine and Poland, and in the long run, aging will increase. The overall birth rate in Ukraine and Poland is rather small and it should be emphasized that one should not expect a return to a high birth rate (two and more children). The improvement

of the demographic situation is possible by well-judged social and demographic policies.

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THE ROLE OF DIGITAL TRANSFORMATION IN THE MANAGEMENT OF THE ENTERPRISE

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DOI: 10.31891/monograph/2021-10-18

Formulation of the problem.

The digital transformation taking place in society is an important step in the economic activity of the state and a significant impetus for the development of innovation processes and increasing the competitive advantages of business. Most global and national companies in the perspective of their operation, take into account the digital changes. Digital transformation processes, as well as global changes, contribute to investment and innovation development, economic growth and the creation of a favorable specific environment for enterprises [1].

At the level of our state, digitalization (digitalization) is enshrined in laws and regulations. Thus, the Law of Ukraine «On the National Informatization Program» [2] provides for the introduction of a national informatization program that will create legal, organizational, scientific, technical, economic, financial, methodological and humanitarian principles for regulating the process of its formation and implementation. Fulfillment of the set tasks in this direction will contribute to the growth of the country's economy as a whole and will form a high level of competitiveness of domestic enterprises in the international market. Recently, the dynamics of domestic business development has seen positive changes in the direction of introduction and dissemination of Internet technologies, electronic document management, logistics and improvement of customer service [3-5]. It is increasingly difficult to imagine the functioning of enterprises without the use of modern information technology in order to improve both production activities and management component of the enterprise. That is why the issue of enterprise management in the context of globalization and their adaptation to the conditions of digitalization is very important.

Therefore, the focus on innovative development requires the management of enterprises to perform new, more complex tasks, the importance of which is associated with increased competitiveness in international and domestic markets. The introduction of innovative technologies opens new opportunities for further

effective development and is an effective mechanism for implementing positive change.

Analysis of recent research and publications. Many works by both domestic and foreign authors are devoted to the issue of transformation and identification of the peculiarities of the impact of digitalization of the economy on the business sector: I.B Markovich, I.V Strutynska Chesnokova N.V, T.I Batrakova, A.V Kuznetsova . The authors study the problems of digital economy development and the current state of digitalization of the domestic economy. However, despite the numerous developments in this area, additional study is needed in the management of enterprises in the context of digitalization and global economic transformations, which will optimize, automate management processes, improve productivity based on new management decisions.

Selection of previously unsolved parts of the overall problem.

Various aspects of the digital economy have been studied in the scientific literature, but in Ukraine these processes have not yet reached a full level in comparison with developed foreign countries. Digitalization requires the use of qualitatively new approaches that will be drivers of digital transformation in enterprises. Determining the role of digitalization in competition, outlining the prerequisites, opportunities, challenges and problems of digital development, substantiation of tasks for the introduction of modern digital technologies in enterprises has led to the relevance of the research topic.

The purpose of the article is to determine the impact of digitalization on the process of enterprise management, to identify the features of the use of digital technologies to increase its competitiveness.

Presenting main material.

Digital technologies open new perspectives and opportunities for the development of the domestic economy and improving the quality of life. The rapid and profound consequences of the transition to digitalization will be possible only when digitalization becomes the basis of our society, business and government agencies. Digitalization is one of the main vectors of development of the Ukrainian economy in the coming decades. Ukraine's digital development is to create market incentives, motivations, demand and needs for the use of digital technologies, products and services among the Ukrainian sectors of industry, life, business and society for their efficiency, competitiveness and national development. Digitization

involves the use of electronic-digital devices, tools, systems, as well as the establishment of electronic-communication exchange between them, which actually allows the integrated interaction of virtual and physical, ie creates cyberphysical space [6-7].

The term «digitalization» comes from the English word «digitalization», which translates as digitization. That is, literally in translation "digitalization" is the process of transferring information into digital form, converting paper books into electronic, photos into images on the screen [7]. «Digitalization» is recognized by scientists as a process of using, transferring and translating information into digital format; system of data collection, storage, analysis, application of artificial intelligence; transformation of digital technology penetration to optimize business processes. The concept of "digitalization" means the process of systematization, use, processing of information in digital format, in order to improve customer service in the business environment [8].

Digitalization involves a set of tasks that will positively affect the economy, business, society and life of the country as a whole. The main goals and directions of digital development are as follows (Table 1).

Table 1. Tasks and directions of digital development

The task of digitalization	Directions of digital development
Economic growth and investment attraction	Bridging the «digital divide» through the development of digital infrastructures
Improving the competitiveness of economic sectors	Development of digital competencies
Creation of high-tech industries, technological and digital modernization of industry	Introduction of the concept of «digital» jobs
Access to the benefits and opportunities of the digital world for the population	Digitization in the real sector of the economy
Realization of human capital, development of digital industry and digital entrepreneurship	Implementation of digital transformation projects

Thus, the digitalization of the economy is an innovative dynamic process based on the active introduction of innovations and information and communication technologies in all economic activities and spheres of society,

which increases the efficiency and competitiveness of enterprises, economy and living standards [2; 6; 8].

At the same time, the digital economy is the basis of the Fourth Industrial Revolution [4] and the third wave of globalization. A characteristic feature of the digital economy is its connection with the on-demand economy, which involves not selling goods and services, but gaining access to them just when it is needed. Orders are received online, and their execution is offline [5].

The International Organization for Economic Cooperation and Development (OECD) identifies three main components of the digital economy:

– support infrastructure (hardware and software, telecommunications, networks, etc.);

– e-business or e-business (conducting business and any other business processes through computer networks);

– e-commerce or e-commerce (distribution of goods via the Internet) [3; 8].

Studies have shown that on the basis of the introduction of digitalization in the activities of enterprises they can be classified according to certain levels (Fig. 1).

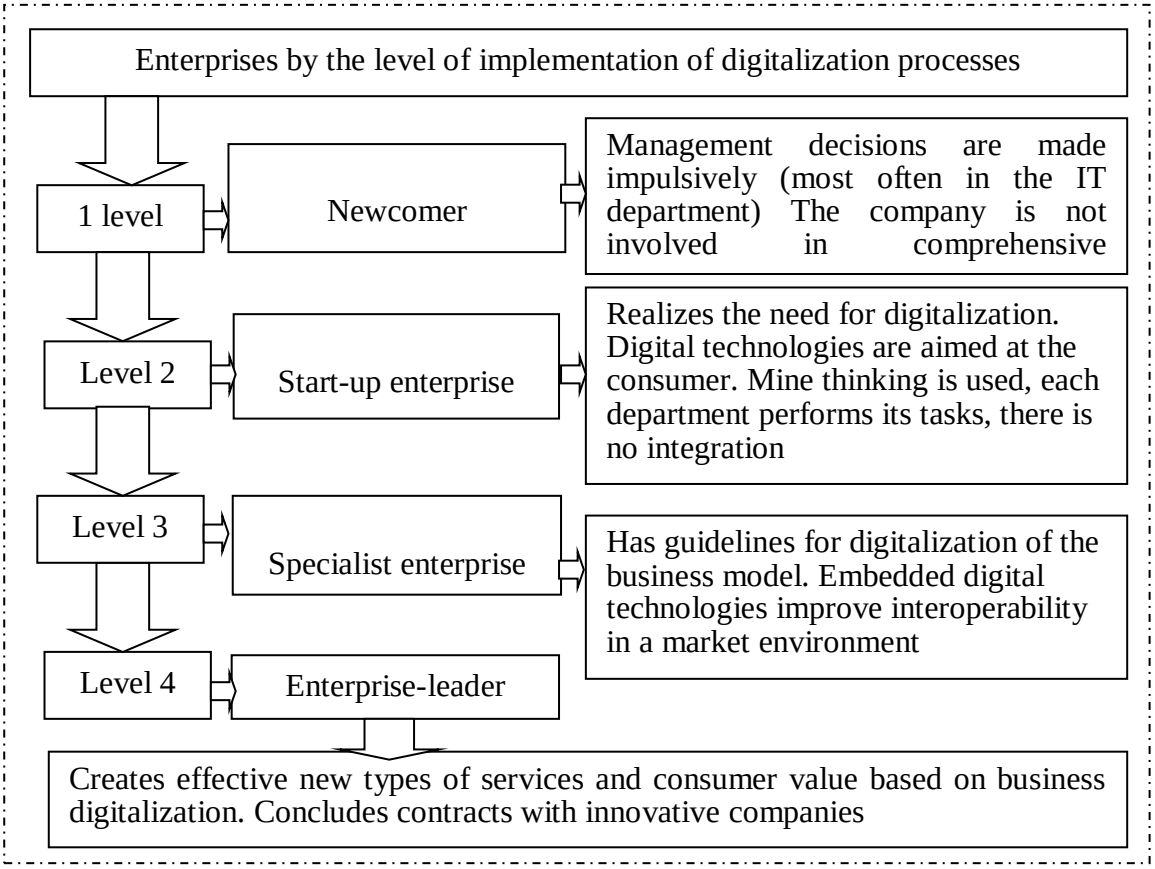


Fig. 1. Classification of enterprises by level of digitalization

Thus, modern enterprises today need to focus on the introduction of cyberphysical systems in their own activities, which will allow them to instantly receive and transmit information; to introduce the Internet of Things, which will contribute to the creation of a single information space within the enterprise, regardless of the level of management; introduce big data, which will increase the efficiency of analysis of data coming from the internal and external environment; use autonomous work, which will improve the process of customer service; design new services using 3D modeling and 3D graphics, which will reduce resource consumption.

Despite the above, the state of digital transformation in domestic enterprises can be described as follows [4]:

- more than 60% of companies already use digital technologies for customer needs;
- up to 20% are just starting to get acquainted with digital and take the first steps towards implementation;
- about 15% of companies attract and serve customers using digital technologies;
- only 3-4% of companies are fully digitalized.

Therefore, digital technologies must be accessible both in terms of organizational, technical access to relevant digital infrastructures, and in financial and economic terms, ie through the creation of conditions and incentives that will encourage business to digitize. Dissemination of the latest technologies and management systems will have a positive impact on the quality of production and provision of services, by providing information to all participants in market relations. At the same time, modern enterprises face a number of problems related to the technological equipment of networks, economic security, the optimality of management decisions to create a single digital infrastructure.

Note that Ukraine has all the necessary conditions for a digital breakthrough and technological transition to a higher level, namely [1; 5; 7-17]:

– ability to produce and use information and communication and digital technologies, availability of professional staff;

– access to appropriate equipment, technologies, dissemination of technologies in society and business;

– sufficient level of system integration of technological products and services, from design to complex implementations of various technologies, software and hardware;

– creative culture and ability to generate ideas.

Thus, the digitalization of business is the driving force behind its promotion. The main advantages of digitalization of enterprises are: automation of production and other internal processes of the enterprise, optimization and improvement of internal and external communications, reaching a new level of customer service, increasing competitive opportunities by optimizing the management process.

Conclusions.

Thus, digitalization is one of the key factors in the development of the enterprise, which involves not only the introduction of innovative technologies, but also change management. As a result, there is a transformation of the specifics of the impact on both individual structural units of the enterprise and the management system of the enterprise as a whole. The digital transformation requires significant changes in the business and economic environment, which should be aimed at tracking global digital trends, opportunities for the introduction of innovative digital technologies, monitoring and assessing the stability of the enterprise.

Thus, the successful operation of the enterprise depends on a large number of factors, but the variability of the external environment requires constant compliance with all world trends and standards, providing competitive advantages that will stably support the business. The need for digital transformation is due to the desire to constantly improve processes, and on the part of enterprises - to improve their own competitive position in the market, which in turn has a positive impact on the country's economy and its investment attractiveness. The development of digital technologies is an important way to improve the business infrastructure, which affects and determines the pace of development of the enterprise and the country as a whole.

Prospects for further research are to study the development of industrial enterprises in the context of digitalization, as well as to identify factors influencing their innovative development.

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ASSESSMENT OF CLUSTER TOOLS FOR THE DEVELOPMENT OF SOCIO-ECONOMIC SYSTEMS IN THE CONTEXT OF FORMING A MODEL OF THEIR SECURITY-ORIENTED MANAGEMENT

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DOI: 10.31891/monograph/2021-10-19

The spread of the impact of global integration processes on the development of the national economy leads to a revision of existing approaches in domestic practice to the formation of the institution of national security at both state and regional levels. The need to take into account the threats and challenges that arise in the process of international cooperation requires the improvement of tools to protect the national interests of the state not only in political but also in socio-economic and innovative aspects. The growing role of integration factors in the formation of competitive advantages of the territory, on the one hand, contribute to the shift of attention from national to regional level and necessitate consideration of the integration component in determining the level of their economic security, on the other, provide greater diversification of approaches systems.

In general, a significant number of works by both domestic and foreign scientists are devoted to building an effective model of the functioning of the economic security system of the region. For example, the team of authors edited by V. Geetz [1] on the basis of the model of classification of threats to economic security of the region determine the influence of the most important factors of regional development on the behavior of individual threats. Sukhorukov A., Moshensky S., Petruk O. [2] assess the state of economic security of the regions of Ukraine, taking into account the threat of a decline in industrial production. The study of factors of industrial threats depending on the production specialization of the region is presented in the work of Golovchenko O. [3].

Babets I. [4] studies the factors of industrial production and the problems of formation of industrial security of Ukrainian regions, as well as determines the impact of industrial and technological threats on the level of economic security. According to Bilyk R. [5], in order to adequately assess the level of economic security, it is necessary to constantly monitor the impact of various factors, as their action is multipolar and, depending on the situation, they may hinder or contribute to security.

The approach of Ivanova N. is interesting for the purposes of research [6], which proposes to include the following factors in the list of threats to the economic security of the regions:

– loss of markets, which directly affects the economic security of the region, because the loss of markets for products (services) of economic entities reduces the indicators of gross regional product and sales of industrial products (services), which reduces the welfare of the region. To avoid this threat within the regional administration, the scientist proposes to develop programs to strengthen the competitiveness of regional industry;

– loss of competitiveness and competitive advantages, in particular, the main consequence of the loss of competitiveness of the region, the author considers the deterioration of living standards;

– population migration is one of the main threats to regional economic security, which is also a consequence of inefficient regional governance. With the intensification of migration processes, there is a loss of human and labor potential, which leads to the destruction of the industrial potential of the region [6].

Analysis of the works of scientists shows that the category of economic security is most often considered in terms of threats (primarily external) that arise in relation to the socio-economic system. Accordingly, the attention of researchers is mainly focused on finding ways and tools to reduce external factors of negative impact on the economic development of the territory.

Reducing the impact of direct methods of state regulation on the development of socio-economic systems, which is characteristic of the knowledge economy, has contributed to the emergence of new forms of integrative entities, including local authorities, which in a dynamic environment are able to respond more quickly to changes at the national and international levels. We believe that the cluster form of business organization, which has been effectively tested in both developed and developing countries, is an integral part of the development of socio-economic systems of innovative type, which use a modern set of tools to protect their own interests. The formation of regional clusters contributes to the structuring of relationships between the subjects of market interaction, respectively, the socio-economic system becomes more flexible to innovative transformations. The variety of manifestations of the phenomenon of clustering, multivariate cluster models, differentiated tools of cluster policy allows you to

widely use this form of integrative education in building a model of security-oriented management of the territory.

The formation of a cluster in the socio-economic system allows to optimize the spatial organization of the region and find more effective forms of innovative interaction of economic entities in a given area. As a result, in the regional plane we observe a decrease in the impact of the external environment on the development of both individual subjects of market interactions and the socio-economic system as a whole; strengthening the competitive position of the territory at the national and international levels allow local authorities to create an effective system of protection of regional producers and the local market as a whole. On the other hand, the new opportunities provided to businesses by strengthening the system of regional support and protection, allow them to find new forms of cooperation, which in the future will strengthen their competitive position at the national and international levels, and increase their degree. economic security and the territory of their operation.

Some studies of the relationship between the level of economic security of the region and the existence of clusters in them have been the subject of study by both domestic and foreign scientists, in particular, Voynarenko M. [7], Yasheva G. [8], Uskova T. [9] as a key regional economic advantage from the creation of the cluster identified the growth of competitiveness of the socio-economic system; Sokolenko S. [10] focused on improving the quality of workers and the formation of a local concentrated labor market; Degtyarev P., Polosin I. [11], Asaul A., Skumatov E., Lokteeva G. [12] emphasized that the emergence of integrative entities in the region allows to better define territorial priorities and, accordingly, to defend regional interests, and ensures the effective redistribution of productive forces in a given area.

We support the opinion of A. Borzunov [13] that the world experience of advanced countries convincingly proves not only the efficiency but also the inevitable regularity of cluster formation; it is due to their functioning that instead of the traditional object management in the region, a single system is created, which includes all components of the product (services) and / or institutions involved in its creation. Undoubtedly, the use of a cluster approach in planning the development of the regional economy allows to ensure effective protection of all participants in intra-regional cluster interactions from threats from the external and

internal environment by creating a basis for harmonizing economic conditions and active information and advisory exchange within the socio-economic system.

The effectiveness of the cluster mechanism is also due to the reduction of the element of uncertainty and a high degree of market foresight for all participants in the cluster. Thus, to ensure the sustainable development of both Ukraine as a whole and its individual regions, it is necessary to develop and implement a consistent cluster policy.

Figure 1 shows a graphical representation of the role of the cluster in building a sustainable security-oriented socio-economic system (built by [13]).

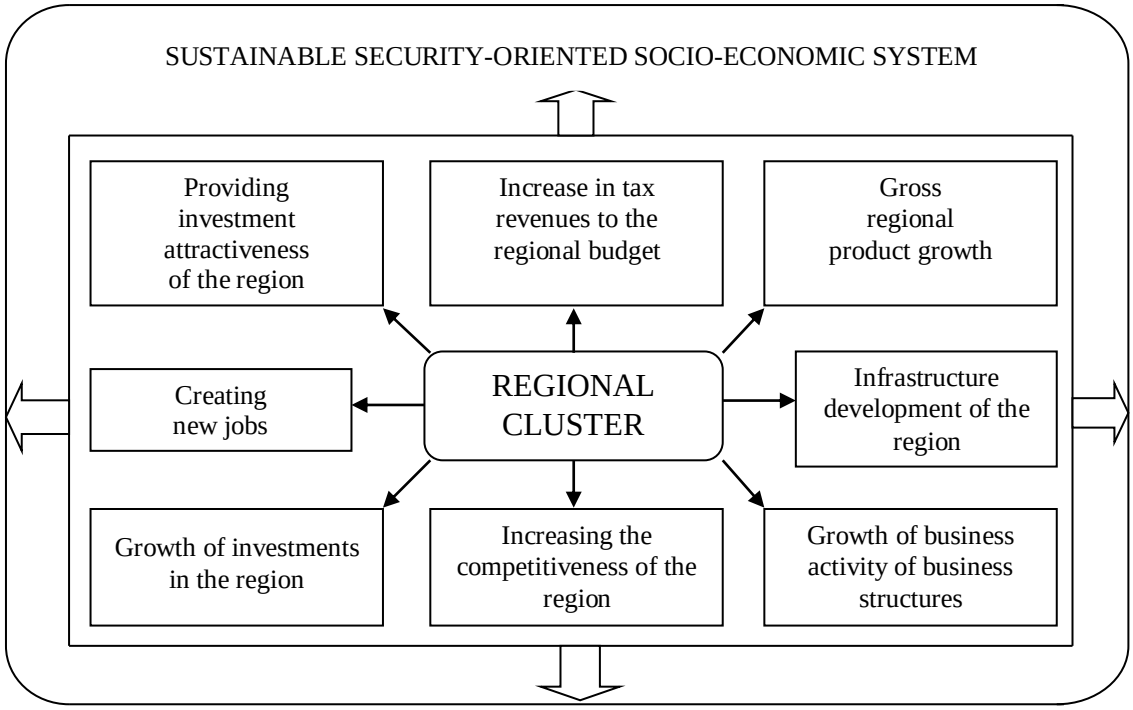


Fig. 1. The role of the cluster in creating a sustainable security-oriented socio-economic system

As we can see, the creation and functioning of at least one cluster in the socio-economic system can increase the level of economic security of the region. Accordingly, local authorities should be interested in continuous monitoring of the activities of existing clusters, which requires an analysis of relationships with other actors in the socio-economic system, and actualizes the analysis of the level of institutional interaction within the region.

Undoubtedly, the formation of clusters in the region is one of the manifestations of institutional relations. The order of assigning the cluster to the institutions of socio-economic orientation is due, in our opinion, to the dual nature

of the formation of voluntary territorial and sectoral associations. The dual nature of cluster formation is manifested in the fact that on the one hand, the emergence of a cluster in a certain area must be preceded by a number of socio-economic preconditions that contribute to the unification of enterprises in the business network and in a certain area leads to a change in economic behavior of market participants, determines the need for new elements of infrastructure, helps to identify "points of economic growth of the territory" and, ultimately, bringing the region's economy to a qualitatively new level.

The study of clusters as an institutional category, in our opinion, allows us to reconsider the role of each of the participants in the territorial-sectoral association in shaping the overall potential of the regional economy as an open socio-economic system. The role of government as one of the participants in the cluster is considered not only as a regulator of economic behavior of economic entities in a given area, but also as an active participant in market relations; formation of various forms of public-private partnership and cooperation allows to determine the most acceptable for the economy of the region tools of indirect support. Research of the business sector in terms of participation in the cluster and other forms of business networks is not limited to finding reserves to increase its level of profitability; it becomes important to study the sources of integration and synergetic relations, provided that the competitive advantages of each of the participants are preserved and increased. Institutions in the region cease to be considered only as one of the elements of market infrastructure and become an important component of the innovation potential of the socio-economic system.

Like any other institutional category, a cluster has several unique features that at the same time allow it to be identified as an institutional concept. Identification of these signs requires consideration of the following important provisions:

– the cluster is manifested through the interaction of human capital. It is the human resource that provides the basis for the search for common interests and the development of various forms of cooperation among the authorities of the region, enterprises and institutions. Interest in the implementation of constructive dialogue and the need to create additional competitive advantages encourages participants in regional economic cooperation to form clusters;

– the cluster realizes its potential through the use of the advantages of the organizational resource. Establishing horizontal and vertical schemes of cooperation among small and medium enterprises and elements of market infrastructure in a given area allows, on the one hand, to build effective channels of added value, on the other – to maintain motivational mechanisms among participants and increase their competitive advantages;

– the cluster is a component of the regional innovation system, respectively, the development strategy of the territorial-sectoral association should be mutually consistent with the innovation priorities of the socio-economic system.

The presence of a strong relationship with the institutional structures of the region determines the need to take into account the role of institutions in ensuring the environment of the cluster. In general, the assessment of the cluster life cycle through the prism of institutional theories suggests that from the standpoint of institutionalism clusters can be considered as multi-institutional formations, the composition of which varies at each stage of the life cycle of education.

Usually the life cycle of a cluster is described by analogy with the life cycle of the organization. In particular, the team of authors led by T. Uskova [14] noted that the development of the cluster occurs through the following stages: agglomeration, emergence, development, maturity, transformation. According to Alekhine A. [15], the life cycle of a cluster is based on the life cycle of a product or production, so after the stage of maturity, the researcher proposes to introduce the stage of decline of the association. We believe that the contradiction of the application of the last stage in relation to network associations is evidenced by the fact that usually most clusters are characterized by the production of not one but several products, so their decline is unlikely due to the end of the life cycle of one product or production.

For the purposes of the study, we support the opinion of D. Yermolaev and E. Natashkina [16], who represent the cyclicity of the cluster due to the change of the following four stages: protocluster, superprotocluster, growing cluster, cluster in decline. The protocluster stage is characterized by the lack of a strategic goal of the association and the mechanism of cluster formation. This moment corresponds to the emergence of territorial-sectoral association, but the mechanism of association of potential participants in the cluster has not yet been determined. The emergence of such a mechanism allows us to move to the stage of

superprotocluster. In essence, the stage of the superprotocluster is transitional, characterized by high dynamics, there is a rapid quantitative and qualitative increase of integrative potential, which can trigger the transition of the union to a qualitatively new level - the stage of growth. The growth stage is characterized by the orderliness of the relationship between the members of the territorial-sectoral association and the increase of competitive advantages of the cluster, contributes to the stability of the institutional formation and its adaptability to the changing environment. At the same time, progressive trends at the stage of cluster growth allow it to stay at this stage for as long as possible, to move to more complex quantitative and qualitative forms, in particular, from industrial to innovation-oriented, and from innovation-oriented to innovation-forming network formations [16].

The difference of the proposed approach is that upon completion of each of the states it is possible to move to both the next and previous stage. In addition, scientists note that the stage of cluster decline is inevitable, because any progressive development has its limits, but after the collapse of the cluster system, participating companies move to the state of the protocluster of a qualitatively new level.

Knowledge of the stages of the cluster life cycle allows to develop institutional mechanisms for managing intracluster interactions. It is obvious that at the stage of protocluster and superprotocluster it is necessary to direct efforts on creation of principles and mechanisms of association of the enterprises in a cluster. In this case, the undisputed leadership in the use of institutions of initiative, innovation, information, integration and interest, the mechanisms of application of which are described in detail in [17].

At the stage of cluster growth it is necessary to support the emergence of new competitive advantages in the cluster, a fuller use of reserves for the formation of competitiveness. Also, management at this stage should be aimed at creating obstacles to the transition of the cluster to the fourth stage - the stage of disintegration. Our research in this direction leads to the conclusion that at the stage of growth the activity of cluster models in the economy is supported by the interaction of two institutional "triangles": cluster-forming - three "C" and cluster-supporting - three "S", developed by M. Voynarenko [7].

The stage of cluster decline does not require management, but involves the implementation of efforts to restructure the territorial-sectoral association, including through the formation of a new cluster at a qualitatively new level. The general algorithm of institutional support of the cluster at each stage of the merger life cycle is presented in Fig. 2.

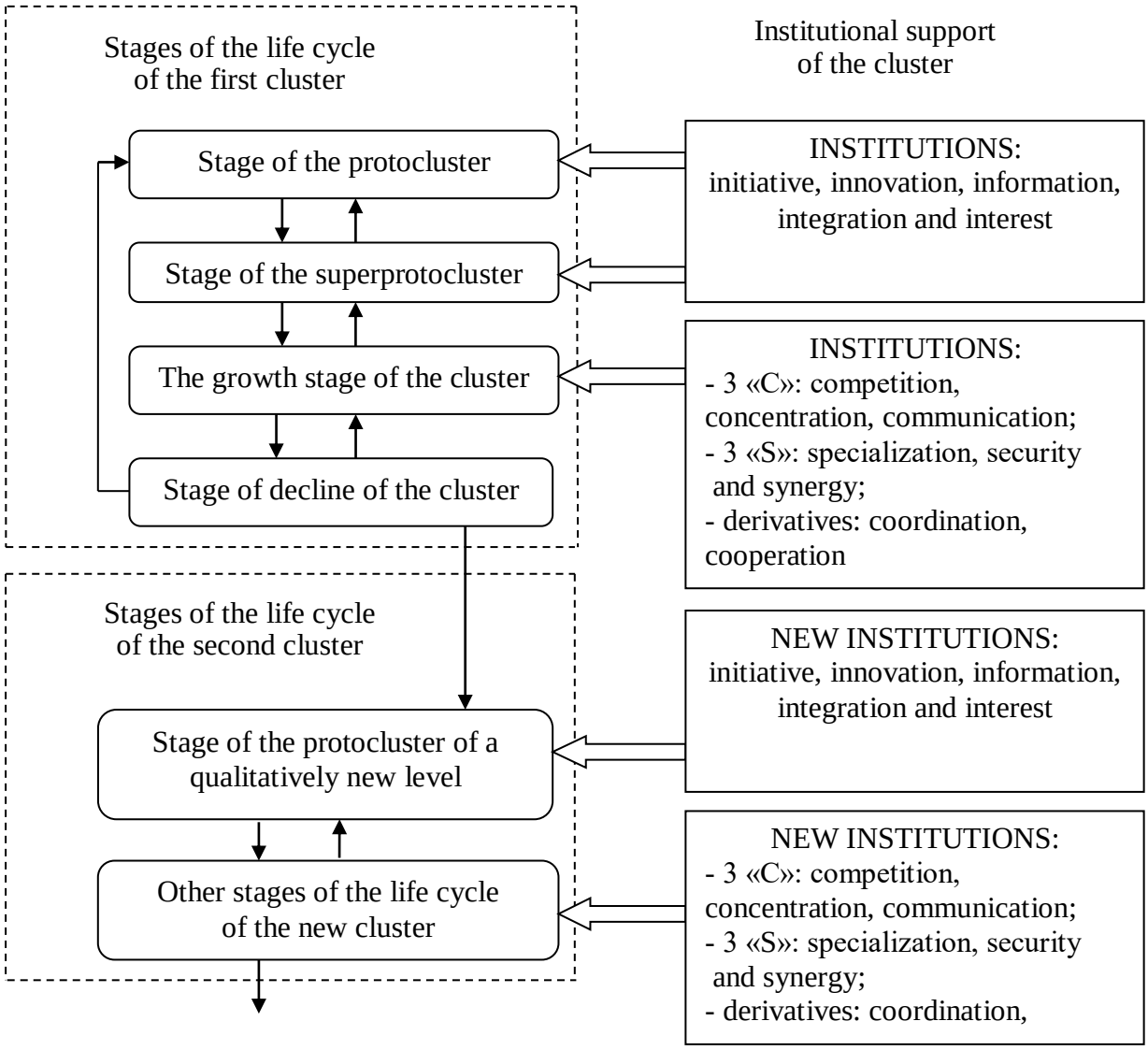


Fig. 2. Components of the cluster's institutional support system at each stage of the merger lifecycle*

* – built by the author

Studies have shown that, depending on the stages of the cluster life cycle, there is a specific institutional support. The structure of institutional support depends on the level of complexity of the tasks to be achieved, in particular, it can be both the formation of the overall goal of the integrative association, and the

maintenance of its competitive advantages. The choice of components of institutional support is determined by the intensity of intracluster interactions, the nature and strength of transformations arising from the external or internal environment of the association, the motivation of economic actors, their level of awareness of available alternatives to institutional reforms, and the magnitude of positive synergies. derived from their interaction.

In general, we can conclude that today the reliable competitive position of the regions and increase the level of their competitiveness are becoming important conditions for sustainable security-oriented development of the regional economy. At the same time, increasing the competitiveness of the region is considered not only as a tool for the development of its economy, but also as a major factor in improving the level and quality of life. This approach to the development of socio-economic systems allows to analyze as factors of the economic process that create or weaken the threat to economic security of the region, not only factors of production but also its competitive weaknesses and advantages in such competitive fields as capital market, investment market, market labor market, market of goods and services.

Under these conditions, the application of cluster theory to the innovative and competitive development of the regional economy is a necessary condition that allows a clearer picture of the modern development of integrative entities and assess their impact on the level of economic security of the socio-economic system as a whole. Undoubtedly, taking into account the institutional component in building a model of security-oriented management of socio-economic systems will improve the quality of research by increasing the possibility of taking into account additional factors of intra-regional cooperation.

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KEY TRENDS AND ACTUAL PROBLEMS OF DEVELOPMENT OF THE DOMESTIC INSURANCE SECTOR

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DOI: 10.31891/monograph/2021-10-20

1. Introduction

Ukraine's strategic course for integration into the European and world community is a crucial factor in economic, political and social change, as well as in the regulation of the insurance sector. In recent years, the strategy of Ukraine's insurance development has been accompanied by the improvement of the legal framework, the introduction of new insurance products, and the adoption of measures that help increase the reliability of insurance companies and insurance intermediaries.

The Ukrainian insurance market is one of the most promising in terms of development potential. However, insurance in Ukraine covers less than 10-15% of the insurance field, while in Western Europe - more than 94%. Modern modification of the domestic insurance business, which is taking place under the influence of institutional changes, reorganization of the regulatory and supervisory system, technical innovations, provides for further integration into the international financial environment, the key aspects of which are modernization of insurance services.

This is also confirmed by the realization of the global risk of the COVID-19 pandemic and the application of unprecedented quarantine restrictions worldwide, which has necessitated the use of new and unconventional approaches, methods, tools and technologies in various spheres of life and business.

Therefore, to successfully overcome new challenges and threats to the domestic insurance market, there is an urgent need to continue research on the theoretical and organizational basis and practical aspects of improving the implementation of insurance services using the world's leading experience in this field.

2. General condition, tendencies and problems of development of the domestic insurance sector

The total number of insurance companies (IC) as of 31.12.2020 was 210, including life insurance - 20 companies, non-life insurance - 190 companies (as of

31.12.2019 - 233 companies, including IC "life" - 23 companies, IC "non-life" - 210 companies). The number of insurance companies has decreased significantly, so in 2020 compared to 2019, the number of companies decreased by 23 insurance companies, compared to 2018 decreased by 71 insurance companies. The main reasons for the gradual reduction in the number of domestic insurance companies are the difficult economic and political situation in the country and the concentration of insurance companies on unprofitable types of insurance.

In 2020, the share of gross insurance premiums in relation to GDP was 1.1%, which is 0.2 percentage points. less than in 2019; the share of net insurance premiums in relation to GDP remained at the level of 2019 and amounted to 1.0% [2]. For comparison, in Europe - 5.0%, the world average - 6.1%. The leaders in this insurance indicator in the world are Great Britain, Japan and France [8].

During the analyzed period of 2018-2020 [7] the number of concluded insurance contracts continues to decrease, absolute and relative changes in indicators are respectively - (- 4 153.8) thousand units (- 2.1%) in 2019, and (- 76347, 2) thousand units (- 38.8%) in 2020. The share of net insurance premiums in gross insurance premiums in 2018 was 69.7%, in 2019 - 74.7%, which is 5.0% more compared to 2018. In 2020, the share of net insurance premiums in gross insurance premiums was 89.3%, which is 14.6% more than in 2019. The volume of gross insurance payments / indemnities in 2020 compared to 2019 increased by UAH 514.4 million (+ 3.6%) and amounted to UAH 14 852.7 million, the volume of net insurance payments increased by UAH 411.4 million (+ 2.9%) and amounted to UAH 14,451.9 million. If we compare with the situation in 2019, there was an increase in gross insurance payments / claims against the indicators of 2018 by UAH 1 474.9 million (+ 11.5%) to UAH 14 338.3 million, and the volume of net insurance payments - by up to indicator of UAH 1 607.9 million (+ 12.9%).

The level of insurance payments (the ratio of payments to insurance premiums) is an indicator that affects consumer confidence in insurance products offered on the market. The benchmark for this indicator is often the average level of benefits for the UK as a historically developed country with a highly developed insurance market and standards. The dynamics of the level of gross insurance payments during 2018-2020 was positive and increased from 26.1% (2018), to

27.1% (2019) and to 32.9% (2020). Instead, the level of net payments did not show a steady trend of change and ranged from 35.5% (2019) to 36.1% (2018).

The main feature of the finances of insurers is the allocation of insurance reserves as part of the attracted capital. The need for the formation of insurance reserves is due to the probabilistic nature of insured events and the uncertainty of the time of occurrence and the amount of losses. Insurance reserves - a value that determines the monetary value of the insurer's obligations under insurance contracts (reinsurance), calculated in accordance with the requirements of the law in order to ensure future insurance payments depending on the type of insurance. The volume of insurance reserves formed by insurers in Ukraine in 2019 increased by UAH 2 583.2 million (+ 9.6%) compared to 2018, and in 2020, respectively - by UAH 4 633.3 million (+ 15.7%) compared to from 2019.

The tendency to increase during 2018-2020 is also characterized by the total assets of insurers, which at the initial value of UAH 63 493.3 million increased to UAH 64 925.2 million, although the annual growth rate was 0.6% and 1.7%, respectively.

At the same time, the assets of insurers defined by law to cover insurance reserves grew faster (+ 9.7% in 2019 and + 3.4% in 2020), resulting in their total value amounted to UAH 46 113.6 million in 2020 against the initial 40 666.5 mln.

Instead, the amount of paid-up authorized capital of insurers during the period under review continued to decrease and from 12 636.6 million UAH in 2018, initially decreased to 11 066.1 million UAH (-12.4%), and according to 2020 amounted to - 9748.1 million UAH (- 11.9%).

Assessing the structure of receipts of gross insurance premiums for 2018 - 2020 (*Tab. 1*), it is worth noting significant structural changes.

Thus, with a relatively proportional distribution of gross insurance premiums from all categories of counterparties (37.4%; 35.1%; 27.5%) in 2018, according to 2020 there was a significant reformatting with the allocation of the predominant share of gross insurance premiums from policyholders - individuals in the amount of 50%, a sharp decrease in gross insurance premiums from reinsurers to 9.3% (UAH 4 201.8 million in 2020 against UAH 13 588.4 million in 2018), resulting in a slight increase gross premiums from legal entities amounted to 40.7% (2020) against the initial 35.1%.

Tab. 1. The structure of the receipt of gross insurance premiums for 2018 - 2020 *

Indicators	2018		2019		2020		Growth rates	
	million UAH	%	million UAH	%	million UAH	%	2019/ 2018, %	2020/ 2019 ,%
Gross insurance premiums, of which:	49 367.5	100	53 001.2	100	45 184.9	100	7.4	-14.7
from insured persons-individuals	18 431.0	37.4	21 632.0	40.8	22 577.0	50.0	1.,4	4.4
from entities	17 348.1	35.1	19 034.8	35.9	18 406.1	40.7	9.7	-3.3
from reinsurers	13 588.4	27.5	12 334.4	23.3	4 201.8	9.3	-9.2	-65.9

*Compiled and calculated according to [7]

In terms of types of insurance, at the end of 2020 [6] the level of life insurance payments was generally lower than in previous periods, although it increased slightly at the end of the year and amounted to - 13%, while for risk insurance during 2017-2020 was characterized by an overall annual increase in the level of insurance payments, as a result of which in 2020 the maximum figures were reached at 35% with slight fluctuations. The largest share of both insurance premiums and insurance payments in the overall structure belongs to the auto insurance segment (casco insurance, compulsory insurance of civil liability of owners of land vehicles and Green Card), with the growth of the share of auto insurance premiums outpacing the growth rate of insurance payments (28% and 35% against 47% and 49 %).

The profitability of insurers has doubled compared to 2019, but in the fourth quarter the profits for risk insurance were moderate, and for life insurance a slight loss was recorded (*Fig. 1*). The return on assets of insurance companies in Ukraine is 3.4%.

Assessing the performance indicators in terms of insurance payments as of 31.12.2020 and 31.12.2019 [5], we note that the vast majority of insurance companies in Ukraine have actively responded to changes in the market environment and were able to overcome the challenges of the coronary crisis by increasing insurance payments.

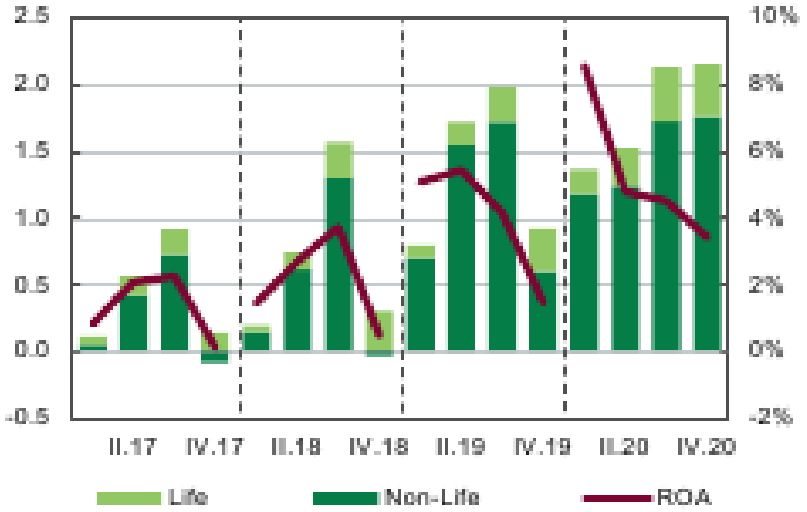


Fig. 1 The financial result of insurers in Ukraine (cumulative total), billion UAH [6]

Regarding the structure of insurance portfolios of insurers, they are quite differentiated and the directions of their formation are determined by development strategies, while according to the end of 2020 it is necessary to note the general predominance of property insurance payments 14310666.8 thousand UAH in the total amount of 31395455.4 thousand UAH.

Indicators of insurance payments at the end of 2020 also indicate the predominance of property insurance indicators, both in general and for most insurance companies. As for the level of payments, for most insurers it was in the range of 25-60%.

Regarding insurance services in the most popular segment - auto insurance, we can observe a significant degree of market concentration, where the key insurers are ARX, Arsenal Insurance, Uniqa, UIG, IG TAS, Universalna, INGO, Oranta, UPSK, Knyazha. At the same time, not all powerful insurers in the spread of the corona crisis, including auto insurance, maintained a competitive position and improved performance, while medium-sized insurance companies, which had the ability to respond more quickly to adverse economic conditions, were more mobile and motivated to organize insurance services and further development of companies in post-covid realities.

3. Features of the operation of the insurer, focused on the active development of activities (PJSC "IC" Euroins Ukraine")

One of the first in the domestic risk insurance market to announce the successful results of its activities in 2020 was Insurance Company "Euroins

Ukraine" [3], the stated purpose of which is to enter the TOP-10 insurers of Ukraine. The strategy of PJSC "IC" Euroins Ukraine" envisages activities in all sectors of the Ukrainian insurance market. The company has licenses to provide insurance coverage for almost the entire range of voluntary and compulsory insurance.

Given that the effectiveness of the insurance company in general and directly the insurance activities of PJSC "IC" Euroins Ukraine"for 2018-2020 can be assessed using the indicators of financial statements [4], we will conduct an analytical study of the financial results of the insurer. Since the insurance company carries out not only the main (insurance), but also investment and financial activities, the insurer's profit is also the result of the financial results of all these activities. The insurer's profit consists of: profit from insurance activities (the difference between the amount of earned insurance premiums and the cost of insurance services) and profit from non-insurance activities (the difference between the amount of earned insurance premiums and the cost of insurance services).

Net earned insurance premiums of PJSC "IC" Euroins Ukraine" in 2019 increased compared to 2018 by UAH 60,339 thousand to the level of UAH 233 491 thousand. In 2020, the net earned insurance premiums continued to grow to UAH 246 506 thousand (+ UAH 13 015 thousand), but the growth rate was much lower than 5.57% against the previous 34.85%. In general, the determined growth is a significant positive result from the direct implementation of insurance activities. The gross amount of signed insurance premiums during 2018-2020 increased, but in 2019 there was a decrease of 10 782 thousand UAH (-3.9%), which was offset by a significant increase in 2020 by 91 249 thousand UAH (+ 36.07%) to 344 239 thousand UAH. The insurer's premiums transferred to reinsurance had similar directions of changes, but in total they increased from UAH 45 050 000 (2018) to UAH 79 328 000 (2020).

Changes in the reserve for unearned premiums, their gross amount, decreased from UAH 51 857 thousand in 2018 to UAH 43 684 thousand in 2020, the minimum value was recorded in 2019 - UAH 1 245 thousand. Instead, the change in the share of reinsurers in the reserve for unearned premiums was increased from UAH 6 791 thousand (2018) to UAH 25 279 thousand (2020).

The cost of insurance services sold in 2018 amounted to UAH 12 468 thousand and continued to grow during the period (+ 22.25% - 2019; + 12.84% - 2020) amounting to UAH 17 199 thousand in 2020.

Net incurred losses on insurance payments peaked by 38.63% in 2019 to 111 651 thousand UAH against 80 536 thousand UAH in 2018. At the end of the study period, this figure was reduced to 85419 thousand UAH.

Gross profit of PJSC IC "Euroins Ukraine" from insurance activities in 2018 amounted to UAH 80 148 thousand, and continuing to grow annually by more than a third (33% and 34.98%) in 2020 amounted to UAH 143 888 000, which is positive shift for the insurance company.

In 2018, there are expenses from the change of other insurance reserves in the amount of UAH 16 468 thousand, which according to the results of 2019 the insurance company managed to translate into income in the amount of UAH 1 290 thousand and increase to UAH 7 525 thousand in 2020.

The increase in the amount of other operating income from UAH 8 363 thousand (2018) to UAH 24 256 thousand (2020) is also quite positive.

Regarding the expenditure component, in 2020 there were positive changes in the optimization of administrative costs – 35 394 thousand UAH as opposed to the initial level – 36 741 thousand UAH and other operating expenses 5 009 thousand UAH against 13 330 thousand UAH in 2019.

The absolute increase in sales costs from 74 315 thousand UAH (2018) to 117 293 thousand UAH (2020), may be justified by the active increase in business volumes and the development of the customer base.

Given the value and changes in the described indicators, the financial result from the operating activities of PJSC IC "Euroins Ukraine", despite the negative financial result of 2019 (- 21 144 thousand UAH), which followed the successful 2018 (40 513 thousand UAH), in In 2020, it was possible to translate into the plane of positive values and consolidate at the level of 17 973 thousand UAH.

Given the positive financial result from other activities of the insurer according to 2020 (29 299 thousand UAH), in general, after taxing for the first time in the period managed not only to remove the insurance company from the category of unprofitable, but to achieve a significant level of net profit of 37 548 thousand UAH.

Thus, in the conditions of economic and social instability, PJSC Euroins Ukraine Insurance Company demonstrated a significant improvement in key financial indicators based on the results of direct insurance activities, the main evidence of which is the dynamic increase in gross insurance premiums in 2020 by 36%.

Analysis of the structure of the insurance portfolio of PJSC IC "Euroins Ukraine" according to 2020, indicates the orientation of the insurer to actively conduct insurance business in the auto insurance sector, the total share is 70.95%, of which 49.1% are insurance services for compulsory insurance of civil liability of owners of land vehicles and 21.85% - casco insurance. Voluntary health insurance services account for 6.77% of the total structure, property insurance and voluntary insurance against fire and natural disasters are 3.95 and 3.98%, respectively. The share of other types of insurance services in the insurer's portfolio in 2020 did not exceed 3.48%. Given the above, it is quite obvious that the main amount of insurance premiums of PJSC "IC" Euroins Ukraine "comes under contracts for compulsory insurance of civil liability of owners of land vehicles, and for the period 2018-2020 growth of gross insurance premiums The insurer was due to the rapid increase in the volume of this type of insurance services (from 106 867 thousand UAH in 2018 to 169 006 thousand UAH in 2020).

Fluctuations in the volume of gross insurance premiums for land transport insurance in 2019 (up to UAH 68 724 thousand) were managed to neutralize in 2020, the amount of attracted gross insurance premiums amounted to UAH 75 221 thousand against UAH 67 739 thousand initial. Also during 2018-2020, in accordance with the impact of the pandemic and societal needs, the insurer actively worked to increase the provision of insurance services for health insurance. Thus, the volume of gross insurance premiums from the initial level of UAH 9 823 thousand was increased to UAH 23 307 thousand (the growth rate of the indicator in 2020 was 117.4% - it was the maximum).

Regarding other types of insurance services of PJSC IC "Euroins Ukraine", despite the fluctuations of their volumes in the direction of decrease in 2019, at the end of the period, in 2020, the indicators managed to improve.

Regarding the gross insurance payments of PJSC IC "Euroins Ukraine" in 2018-2020, they were determined primarily by the priority areas of the insurer to provide insurance services. In particular, the largest was the amount of gross

insurance payments under civil liability insurance contracts for vehicle owners, which increased during 2018-2020 (UAH 34 528 thousand in 2018, UAH 56 916 thousand in 2019 and UAH 58 832 thousand in 2020). Gross land insurance payments in 2020, on the other hand, decreased to UAH 37 265 thousand as opposed to UAH 50 934 thousand in 2019, which may be primarily due to the impact of quarantine measures and restrictions on movement and as a consequence of reducing the degree of risk. In turn, the gross insurance payments of PJSC IC "Euroins Ukraine" in 2018-2020 for health insurance increased and from the initial level of 2786 thousand UAH in 2018 increased to 11 489 thousand UAH in 2020.

4. Conclusion

Thus, current trends in insurance services are determined by the rapid dynamic processes of the economic environment and are directly affected by the COVID-19 pandemic, a balanced and prompt response to which will provide domestic insurers with high competitive potential.

Given the above, one of the key areas that will ensure the successful operation of the insurance business and optimize costs is the active implementation and use of information and innovation technologies.

Thus, when using online insurance there is an opportunity to reduce costs by excluding from the chain of sales of insurance intermediaries, reducing commissions, reducing the cost of renting premises, etc. [1]. Also, the advantage of digital insurance is to reduce the likelihood of fraud and increase the security of insurance transactions, because if you purchase a policy through an insurance intermediary there is a risk of not paying the latter insurance premium, as a result of which the insurance contract may not enter into force. Along with economic efficiency and security, digitalization in insurance is convenient.

Given the current trends in the provision of insurance services and the active dissemination of access and use of the Internet by residents of Ukraine, with appropriate legal support and even the current functionality of mobile applications and online sales, the share of premiums from online transactions can reach a third of the total.

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PROBLEMATIC ASPECTS AND STRATEGIC GUIDELINES FOR STRENGTHENING THE TECHNOLOGICAL COMPETITIVENESS OF UKRAINE'S ECONOMY IN THE MARKETS OF THE EUROPEAN UNION

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DOI: 10.31891/monograph/2021-10-21

1. Introduction

Today, the economy of Ukraine is characterized by: the disorientation of enterprises to attract and implement advanced technologies and create new modern industries with a high level of added value; monopolization of markets, which leads to the leveling of the innovative factor of business competitiveness; underdevelopment of the intellectual property market and the system of relations, which would stimulate the growth of intellectual capital; lack of full-fledged infrastructural support of innovation and technological activity; limited financial and investment, logistical, technological, intellectual and other important components of resource provision of innovative development; unformed competitive environment, high level of transaction and transformation costs, which suppress innovation and technological activity, directing capital to more primitive forms of commerce.

It is obvious that these factors are systemic obstacles to qualitative structural changes on the way to the formation of a technologically competitive domestic economy and its real sector. That is why it is important to focus on the strategic priorities of public policy on their elimination and overcoming.

2. Restoration of economic growth and competitive positions of Ukraine's economy in the markets of the European Union

Ukraine has intellectual and natural resource potential, but in the era of information economy, total informatization and digitalization, it requires the implementation of a balanced state policy aimed at strengthening the technological competitiveness of the national economy.

The low level and deterioration of innovation activity in the economy of Ukraine had a natural consequence not only a negative impact on the weakening of

international competitiveness, but also the deterioration of the country's place in the system of international ratings of innovation and technology and efficiency.

Therefore, it is necessary to realize that today there is a specific environment (internal and external), in the conditions of which we have to form the strategic foundations and guidelines of public policy. Failure to take these conditions into account will mean low adaptability of strategic elements, the possibility of their contradictions, lack of implementation potential due to the presence of objectively powerful obstacles. Moreover, in the markets of the European Union the implementation of state policy will be hindered by conflicts of interest on the part of both internal and external actors [1, p. 7-24; 2, p. 64-76].

The formation of an effective state policy for leveling hybrid threats should be based on identifying areas and areas of their spread and penetration into the national economy, forecasting the relevant consequences, and ultimately – identifying priority areas within which a set of effective tools will be developed and implemented. Among them, one of the leading places is given to the technological development of the economy, in which the country receives a much higher degree of resistance to hybrid aggression.

3. Strategic priorities of the state policy of ensuring technological competitiveness of the economy of Ukraine

It is highlighted primarily about ***the intensification of technological development of the economy*** as a strategic priority № 1. This is a qualitative component of this priority. Quantitative refers to the increase in the number of created, implemented and used advanced technologies (including information), as well as their share in the total volume of technological processes used by business entities, the share of advanced technologies in the total number of technologies (technological processes) in business processes. of the real sector of the national economy.

It is obvious that the achievement of this priority of state policy directly correlates with the strengthening of technological competitiveness of the national economy of Ukraine, because in the markets of the European Union the more subjects of basic economic activities will use modern technologies, the higher the technological activity in the economy [3, p. 17-37].

Strategic priority № 2 should determine the ***growth of the overall level of innovation activity in the economy of Ukraine***. We are talking about increasing

the share of enterprises that create and implement innovations in the total number of economic entities, increasing the level of innovation activity in the segment of small and medium enterprises, creating new innovation-active and innovation-oriented enterprises, increasing production of innovative products and products in production which uses technological innovations, increasing the share of innovative products in total production, sales and exports (products, works, services).

In fact, technological development is focused on the creation and implementation of new modern advanced technologies in two key areas in the markets of the European Union: 1) new sectors of the economy and industries, the formation and development of which is expected in the near future; 2) new technologies and technological solutions, which already determine the degree of technological structure of the economy and on the development of which researchers are working and which will soon determine the level of scientific and technological development of countries.

Instead, innovative development sets the general background of research and innovation, the level and scale of its demand by the real sector of the economy, the willingness not only of enterprises but also of society as a whole to focus on innovation and their contribution to key business results - added value. efficiency, competitiveness, etc. Comprehensive innovation activity in the markets of the European Union is a direct way to develop and ensure the competitiveness of the economy on an innovative basis, strengthen the capacity to create new technologies in various fields of science, social life, economic activities, areas of consumer demand and demand for industrial products.

Strategic priority № 3 concerns ***the formation of a competitive intellectual property market in Ukraine***. Obviously, the result (as a desired end result of regulation) is the development of this market, but the aspect of competitiveness allows us to point the way we need to go. The point is that, as the experience of countries with a high level of intellectual property development shows, it is competition and the competitiveness of this market that is the leading factor in development. There is no doubt that in the field of intellectual property Ukraine is characterized by a number of other acute problems, primarily in the protection and enforcement of intellectual property rights. But there are no basic elements of the market, which is even worse, ie there is no transparent system of supply and

demand, there are no platforms for communication, pricing, settlement of other aspects of legal and commercial relations between sellers and buyers, virtually no mediation [1, p. 7-24; 4, p. 8-15].

The arguments in favor of defining the strategic priority № 4 of the state policy of strengthening the technological competitiveness of Ukraine's economy – ***the formation of infrastructure to support technological innovation*** – are as follows. The introduction of modern technologies is a capital-intensive and organizationally complex process. These include in the markets of the European Union high costs for the acquisition of technologies (technology rights), registration of rights to them, including patenting, significant time losses and investment in development, testing and implementation of technologies, information and consulting support for finding the necessary technological solutions and investment design, attracting the necessary staffing (both for research and development, and technical potential for their implementation in production and business processes), services related to the examination of technologies, technological projects, approvals of new technologies and / or product samples in the state standard, certification

Priority № 5 identified above ***concerns improving the parameters of competition and doing business***. According to the author, this is one of the most important tasks, because in the conditions of monopolization of markets and economic resources, economic agents are not objectively interested in carrying out technological activities. They have markets for standard products and carry out their production and sales almost without competition.

In a healthy competitive environment, this type of problem is directly regulated by the market. But in Ukraine the market alone is not able to regulate these processes mainly due to the merger of business and government, administrative pressure on business, the difficulty of entering monopolized markets, pressure on the domestic market of primitive but cheap smuggled and counterfeit products [5, p. 3173-3182].

Therefore, an active and balanced state policy is needed, aimed at achieving certain changes and changes, which will result in an increase in Ukraine's position in the ratings of Global Competitiveness, Economic Freedom, Doing Business, Perception of Corruption, etc.

4. Conclusion

The implementation of state policy in the field of technological competitiveness of Ukraine's economy should be a process clearly planned and managed, which requires the definition of its purpose and strategic priorities, based on which all other components of planning will be formed. It should be understood that the policy in the analyzed area is formed in the current challenges of global competition, the main features of which are the impact of global crises and financial and economic instability; increasing external expansion due to the processes of globalization, development of the information economy; the pressure of the country's debt; growth of import dependence; high external labor migration activity; destabilization of economic development through military conflict and hybrid attacks; critical disparities in regional development.

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MEANS OF STATE POLICY TO REDUCE THE IMPORT DEPENDENCE OF UKRAINE'S ECONOMY IN THE CONTEXT OF REORIENTATION OF FOREIGN TRADE TO THE MARKETS OF THE EUROPEAN UNION

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DOI: 10.31891/monograph/2021-10-22

1. Introduction

At the present stage of its socio-economic progress, Ukraine has experienced a number of critically negative and threatening risks and threats to national security. We are talking about external military, political, economic, informational and other aggression, annexation of Crimea, uncontrollability of the Donbass territories, loss of about a quarter of the potential of the real sector of the economy. At the same time, Ukraine has received unique opportunities to qualitatively change the vector of its economic development, integrating into a much more capacious and intellectually innovative market, which is the market of EU countries. According to the implementation of the Association Agreement between Ukraine and the EU in the near strategic perspective, EU markets should become the object of interest of domestic industrial enterprises that create added value, intend to join the development and formation of a competitive national economy. Moreover, as a result of the formation of a free trade zone with the EU, the borders of Ukraine's internal market are actually expanding on the territory of the EU.

However, the macroeconomic preconditions show that domestic actors in the real sector of the economy have difficulties and need resource and economic support for their own progress and expansion into EU markets. The situation will become more complicated every year, because the end of the preferential stage is approaching, when zero duty is applied to domestic exporters and a similar regime will be established for imports to Ukraine from the EU [1, p. 13-17; 2, p. 117-123].

It should be noted that the state resource and economic support and assistance to exporters is implemented in almost all countries that have achieved success in the development of foreign economic activity. And its volume, of course, depends on the state of socio-economic development and financial and investment opportunities of states, but it is implemented everywhere, and the role of the state is important in these processes.

In addition, it is necessary to highlight other factors (arguments) that prove the importance of implementing the state policy of strengthening the resource support of the real sector of the economy in the face of changes in the foreign economic vector of the state.

First, the objectively high level of complexity and cost of access to foreign markets, including the EU. This requires significant financial costs for marketing research, certification, adaptation to conditions of high competition, logical costs and so on.

Secondly, these are the shortcomings of the economic and legal environment of foreign economic activity in Ukraine, in particular the imperfection of the VAT refund mechanism, the immaturity of the export credit insurance system, including with state support, weak institutional and resource capabilities of domestic financial services market.

Third, these are much worse preconditions for the competition of domestic actors of the real sector of the economy with the enterprises of the EU countries. Thus, in the real sector of the economy, businesses have a critically low financial and economic condition, as evidenced by the high level of losses, low profitability, suitability of fixed assets and turnover of current assets.

The opportunities of the subjects of domestic financial and investment infrastructure remain weak, the instruments of alternative financing (leasing, factoring, promissory notes) are inefficiently used in contrast to the high availability of EU enterprises to the services and resources of financial and investment, insurance and other infrastructure.

Thus, the factors that hinder the formation and implementation of tools for resource support of the real sector of the economy in Ukraine for foreign economic activity in the EU markets include: 1) imperfection of the regulatory framework that establishes and regulates the development and functioning of the system of economic resources; 2) lack of a system of strategy and planning to create in the state a system of organizational and economic support for exporting entities of the real sector of the economy; 3) underdeveloped infrastructure and limited resource-intensive entities that provide investment services necessary for representatives of exporters of the real sector of the economy; 4) relatively high cost of bank credit resources, especially for operations related to foreign economic activity; 5) limited

practices of budgetary and financial support of exporters of the real sector of the economy.

The need to strengthen the resource support of domestic actors in the real sector of the economy in the face of changes in the foreign economic vector of the state is obvious. Accordingly, there are a number of tasks, the implementation of which would allow them to realize their full competitive potential in foreign markets. Obviously, efforts should be directed primarily at eliminating the causes and factors that prevent this.

2. Levels of state policy to reduce the import dependence of the economy by providing support to the real sector of the economy

In this regard, the proposals should address the activities of central government, regional and local, sectoral, as well as functional aspects of the economic system of the country and directly business entities. Only with such a systemic approach is it possible to form an economic resource in a state where there is a war and where budgetary and private-legal finances are objectively limited.

It is objective that the main tasks of state policy ***at the central level*** are to improve institutional and legal support in the field of economic and resource support of domestic enterprises, introduction of strategic planning of these processes, formation of a national system of financial support (refinancing, subsidies, risk insurance and guarantees), as well as attracting investment resources from abroad. The effectiveness of such a vector of public policy will be evidenced by the gradual minimization of state participation in project financing, the active involvement of private investors in financing under state guarantees.

At the regional and local levels, efforts should be focused on building regional infrastructure of state support, activity of small businesses, formation of elements of private-public investment support, formation of export-oriented clusters, involvement of business associations, promotion of investment attractiveness.

At the sectoral and infrastructural level, it is appropriate to intensify efforts to strengthen the capabilities of domestic financial services market participants. In particular, public authorities should take on the main coordination functions in creating and developing a network of credit and financial organizations to support foreign economic activity, ensure higher efficiency of basic functions of

investment support institutions, form platforms for cooperation of foreign economic activity and financial services market, create conditions for wider use of insurance opportunities, to expand the practical use of alternative investment support instruments.

The complexity of the state policy of support of the real sector of the economy in terms of changing the foreign economic vector of the state will be evidenced by the rational choice and application of a set of tools in accordance with certain levels and areas of implementation [3, p. 105-112; 4, p. 855-864; 5, p. 39-45].

3. The system of state policy tools to support the real sector of the economy in the context of reducing the import dependence of the economy

The following should be directly included in the instruments of state policy ***at the central level***.

First, improving the institutional and legal framework for financial and economic support of the real sector of the economy. Here it is expedient to note the significant progress of public authorities, which managed to develop and implement (legislate) procedures to ensure large-scale expansion of exports of goods (services) of domestic origin by insuring, guaranteeing and reducing the cost of export crediting. Thus, it is planned to create an export credit agency, the main mission of which will be to provide state institutional, organizational and financial and investment support to domestic exporters. Such a state institution will function in the form of a public joint-stock company, will have an initial authorized capital and will be provided with permanent budget funding.

Domestic legislation also needs further improvement with: 1) creation and functioning of the subjects of the infrastructure of financial and investment support of foreign economic activity of the enterprises of the real sector of the economy; 2) formation of the system of state management of export support, creation of unified centers of coordination of financial and credit and information and marketing support, attraction of foreign direct investments; 3) introduction of tax benefits for manufacturers-exporters of high-tech products and other incentives for exporters; 4) ensuring the development of institutional and legal bases for cooperation between public and private institutions to support exports and attract foreign direct investment.

Secondly, it is the adoption of "vertical" strategies and state, regional and sectoral programs of financial and investment support of the real sector of the economy with an emphasis on modernization and development of production, technical and technological base and intensification of foreign economic activity.

Third, it is the expansion of budget and financial support and the formation of its infrastructure. These include: 1) the development of the already mentioned export credit agencies and export promotion organizations; 2) creation of an export credit insurance fund (including with the involvement of insurance business entities); 3) creation of specialized venture funds for financial and investment support of priority export-oriented projects; 4) development of consulting infrastructure for the provision of information services, promotion of business reputation of enterprises; 5) initiating the practice of subsidizing exporters for short-term export financing, lending by the exporter to the importer, lending to "new" exports; 6) expansion of the practice of state guarantee of cases (non-payment of the importer, loan security, counter-guarantees, investment protection against political risk, on letters of credit).

Fourth, it is the effective use of investment and innovation opportunities from cooperation between Ukraine and the EU. It should be emphasized that in the framework of the implementation of the provisions of the Agreement there is a relevant section, which provides for the provision of EU investment support to domestic exporters. And this should be used. Moreover, the participation of domestic enterprises of the real sector of the economy in EU public procurement is envisaged.

Fifth, it is financial and economic support for domestic producers by replacing part of their export costs when entering EU markets. We are talking about the active integration and convergence (but also the adaptation of domestic enterprises) of the national system of standardization and certification to European norms and standards. Thus, the produced domestic products will simultaneously meet domestic standards and norms and will be ready for European requirements.

It is positive that at the beginning of 2016 the Law of Ukraine "On Technical Regulations and Conformity Assessment" came into force, which actually introduced the transition from certification to conformity assessment of products, and a number of resolutions of the Cabinet of Ministers of Ukraine and orders of the Ministry of Economy of Ukraine executive authorities during the

implementation of technical regulation functions, the procedures for reviewing appeals against decisions of designated bodies for conformity assessment, formation and maintenance of a database of technical regulations, as well as application forms for the appointment of a certification body in the state certification system, signs of compliance with technical regulations, rules and conditions their application.

It is also possible to replace part of the costs of exporters when entering the EU markets through the full implementation of the "single electronic window" system; promotional support of domestic products, organization of bilateral and multilateral chambers of commerce, business centers, representative offices in EU countries.

At the level of regional and local authorities and public administration, in order to realize the investment and innovation potential of domestic actors in the real sector of the economy, it is possible and necessary to implement the following tools. Yes, the infrastructure of financial and investment support needs to be formed and developed. These are investment and innovation platforms, communication platforms for producers and investors, technical and implementation special economic zones and technology parks, project companies, insurance business entities, investment and information portals, etc.

Executors of the state management system should partially take over the functions of realizing the export potential of small business entities. It is positive that in a number of border regions of Ukraine the adoption of a regional Strategy for the development of small businesses is being actively developed and planned. It is important in this strategic document, as well as further in the relevant programs to provide a section that would address the implementation of this area of potential of small businesses, especially since the regions border on EU countries.

Thus, regional and local authorities need to form elements of private-public support for enterprises-exporters of the real sector of the economy. It is a question of creation of investment funds of support of export projects on branches, territories, sectors of economy, etc.

Given the changing vector of foreign economic policy, the processes of initiating and supporting the creation of clusters with the participation of partners from EU countries, especially in the framework of cross-border cooperation, are of

great practical importance. Here, the interest of domestic industrial enterprises will be to gain access to the latest technologies, high-tech equipment, means of rational use of economic resources, as well as opportunities for cross-border integration into the scientific, technological and innovative environment.

Along with the implementation of cluster initiatives, active promotion of the investment attractiveness of territories, in particular their production and export complex, should be ensured. Accordingly, regional and local public authorities should engage in information and consulting activities, promote exhibition and fair activities, trade and political activities, and involve public and non-governmental organizations of local and national importance for this purpose.

It is important to create incentives and opportunities to involve functional and infrastructural elements in these processes. We are talking about the creation and development of credit and financial organizations for investment support of foreign economic activity. An important aspect is the involvement in these processes of branches and subsidiaries of domestic banks abroad to attract external financial resources. Cooperation through an export credit agency with international financial organizations for the accumulation of foreign investment aid is also promising.

At the sectoral level, the opportunities of the investment sector should be used more widely. It could be important to involve leading foreign investment corporations in cooperation, as well as to create (in the strategic perspective) a domestic corporation of foreign private investment for investment and guarantee support of exporting enterprises of the real sector of the economy.

Another defined tool is to strengthen the participation of the insurance sector in minimizing risks and guaranteeing foreign economic activity, ensuring access of the real sector of the economy to financial and credit resources, including through the creation of insurance guarantee funds.

To date, alternative financial instruments, such as seleng, factoring, forfaiting, and crowdfunding, have not been widely used among enterprises in various sectoral sectors of the economy. Through selenium activities, industrial producers will be able to significantly increase the activity of use and renewal of non-current assets and external intersectoral partnership, investment and innovation cooperation. Factoring contractual operations allow to solve the problems of repayment of receivables for sold products, accelerate turnover and

optimize the structure of inventories, ensure timely reinvestment of capital and increase its profitability. Forfaiting operations are even more relevant for enterprises in foreign economic activity, which makes it possible to obtain loans from foreign investment institutions, use the potential of foreign direct investment funds, minimize currency and credit risks, reduce transaction costs and facilitate access to foreign innovation markets. In an effort to implement a variety of innovative projects, as well as reduce transaction costs for the organization of financing such projects, companies should conduct crowdfunding operations that involve attracting through online platforms of financial resources of a large number of individuals and legal entities.

4. Conclusion

The introduction of such an integrated approach to public policy will improve the system of resource support of domestic actors in the real sector of the economy in terms of European integration, and diversify and improve the structure of the export complex, improve conditions and environment for foreign trade, gain experience in effective public policy in the field of import substitution, strengthen Ukraine's European integration aspirations and strengthen the competitiveness of domestic producers in the common territory of the free trade zone with the EU.

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MARKET ANALYSIS AND NUTRITIONAL VALUE OF TECHNICAL HEMP PRODUCTS

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DOI: 10.31891/monograph/2021-10-23

1. Formulation of the problem

A balanced and nutritious diet is essential for the full development and life of man. However, with the development of the chemical industry, the nutritional value and quality of many foods is highly questionable. Therefore, the question arises of finding natural sources of food that are necessary and safe for humans, which should be available, nutritious and useful. Technical hemp is such a natural raw material with great potential for the production of food products for a wide range of applications. Therefore, the study of the biological and physiological value of cannabis for use in the food industry is relevant.

2. Analysis of recent research and publications

Scientists from Ukraine and around the world have devoted their research to the issue of using cannabis products in food production. Thus, Falendysh N.O., Yanyuk T.I. and Badruk Y.V. offer for use in the baking industry hemp flour and hemp oil [1].

Zhuravlyova L.A., Zhuravlyov A.P. and Terekhov M.B. investigated the influence of hemp oil on the quality of wheat bread from premium flour. It was found that the addition of hemp oil in the amount of 2% does not worsen the quality of bread, and indicators such as specific volume, porosity of the crumb, crust color, improve [2].

Matskiv O.O., Solod M.I., Vasylkevych V.O. and Ivasiv V.V. investigated the blending of linseed, mustard and hemp oil. They found that the use of a mixture of flaxseed, mustard and hemp oil in a ratio of 2:1:3 and 3:1:4 can increase the shelf life of the product and ensure optimal balance of the most important for human health NSCLC [3].

Mashta N.O. investigated the possibility of using in the production of processed cheese products from vegetable raw materials, in particular fat compositions based on hemp, palm and mustard oils, as well as mixtures of oat, rice and pea flour.

3. Materials and methods

The tasks were solved with the help of methods and means of theoretical research, which give a complete picture of the biological and physiological value of hemp seeds and stems, allow to formulate practical conclusions and recommendations for using their specific properties for food products for a wide range of applications.

4. Research results

On the basis of narcotic activity, there is a division of cannabis into Cannabis sativa L. (cultivated hemp) and Cannabis indica L. (Indian or hashish hemp). Cannabis, as a crop by its biological nature, has the ability to produce its own chemicals - cannabinoids, which are the basis of the drug. All this used to create great obstacles for the cultivation of hemp on an industrial scale, and for many years this plant, and together with the hemp processing industry, have fallen into deep decline. For a long time, new varieties of monocotyledonous cannabinoids were developed. Thus, scientists of the Institute of Bast Cultures (Glukhiv) managed to successfully breed many varieties of monoecious hemp and prove their technological value for the production of consumer goods based on hemp.

Recently in Ukraine the sown areas for technical hemp are gradually increasing. The ability to cultivate hemp under any conditions, providing the population with fiber products and vegetable fat, for many centuries has secured for it the glory of an indispensable culture [4]. In addition, technical hemp is an easily reproducible and highly profitable natural raw material. Occupying 3-5% of arable land in crops, they provide 45-50% of the profits from all crop production.

The main producers of hemp in the world are China, Chile, Europe, Korea, Canada, France [5]. Currently, technical hemp is processed or used in industry: Australia, Austria, Belgium, Bhutan, Great Britain, Hungary, Germany, Greece, Denmark, Egypt, Israel, India, Italy, Ireland, Spain, Canada, Cyprus, China, Korea, Latvia , Lithuania, Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Romania, Slovenia, Serbia, USA, Thailand, Turkey, Ukraine, Finland, France, Montenegro, Chile, Switzerland, Sweden, Estonia, South Africa, Japan.

China reserved the right to more than half (606 patents) of all know-how related to cannabis in the world. At that time, the French are the favorites in the production of hemp seeds in the world. The volume of hemp seeds grown by them

is about 59% of the world volume. In Asia in terms of hemp production, South Korea is second only China. In general, Asian countries control about 70-75% of the global market for hemp products. The area under hemp in the European Union over the past 20 years is about 15% of the world.

On the American continent, the main sown areas are concentrated in Canada, but the processing of hemp products is carried out in the United States. The third American leader in the production and processing of cannabis is Chile. Ukraine and Russia are not yet included in the world hemp statistics.

In Ukraine, technical hemp seeds are exported as seed and as raw material for use in Europe for the food and cosmetics industries. The main part falls on raw materials for industrial processing. In 2018-2019, the number of organic products increased: in 2018, such seeds accounted for 6% of the total mass of supplies, and in 2019 - 14% [6].

Hemp seeds are commonly used in the world as a source of edible oil, for baking bread and in medicine. Still unusually perceived candy, various types of tonics, vodka, beer, hemp cookies or cake. Cakes mixed with hemp seeds have until recently been a traditional food of the peoples of the East, southern Europe and Asia.

In North America, hemp seeds are used to make nut oils, bread, cookies, yogurts, pancakes, cereals, frozen desserts, pasta, burgers, pizza, salt substitutes, mayonnaise, cheese and a variety of beverages (milk, lemonade, beer, wine, coffee drink). The crushed seeds of industrial hemp are stored by canning or vacuuming. In Germany, pasta, chocolate, and sweets are added to the above list of products; in Great Britain - kozinaki on the basis of the crushed seeds of industrial hemp [6].

The use of salt-roasted hemp seeds is still in the customs of Ukrainians, Russians and other nationalities of the former USSR as a means of increasing potency [4].

From the research of domestic scientists it is known that hemp seeds contain fats (28-32%), proteins, phytin, glucosides, vitamins, other substances and, like no other plant material, hemp seeds contain the highest percentage of easily digestible fatty acids - linolenic and gamma. linolenic, which promote the formation of gamma globulin, which is part of the plasma protein fraction and contains bactericidal and antiviral antibodies.

Hemp seeds can be eaten or used to make a variety of foods, including hemp milk, hemp oil, hemp cheese substitutes, and hemp-based protein powder. Hemp seeds do not contain gluten, so they can take their rightful place in the diet of patients with celiac disease (a disease in which the use of gluten-containing cereals is contraindicated: wheat, rye, oats and barley) [4].

The effects of synergism are provided by a combination of concomitant cannabinoids, terpenes, flavonoids, a number of other therapeutically active substances contained in cannabis. But if we take into account a specific disease or "bouquet" of diseases, it can be argued that the effect of "ensemble" of different components of the plant, in most cases, can not repeat any of the extracts of individual elements [7].

Flavonoids have great pharmacological activity: they work well as antioxidants, anti-inflammatory, anti-allergic and anti-cancer drugs, as well as extremely effective antibiotics. A number of studies have shown that a diet rich in flavonoids can reduce the risk of cancer.

Hemp seeds contain essential oils and complete proteins, which are in an ideal ratio for human consumption. The most interesting thing is that this product can be eaten raw without any fear for the body, unlike soybeans. Hemp seeds are an analogue of flax seeds, but they have more Omega-3 and Omega-6 than any other nuts and seeds. The nutritional value of seeds is 553 kcal (per 100 g of product) (Table 1). Hemp seeds contain more than 10 amino acids, vitamin E, fiber, calcium, iron, magnesium and zinc. Is an indispensable tool for the prevention of anemia, strengthening the immune system and maintaining overall body tone.

Table 1. Nutritional value of hemp seeds

per 100 g:	
Proteins	31.56 g
Carbohydrates	23.45 g
Jury	48.75 g
Caloric content	553 kcal

Scientists who have been studying the properties of hemp seeds for 30 years have determined that it contains 20 amino acids, including 9 essential ones. The average content of amino acids in hemp seeds is shown in table 2 [8].

Table 2. General information about the content of amino acids in hemp seeds

Nomenclature of amino acids in hemp seeds	Content, % (relative to the total composition of hemp seeds)
Alanine	1.22
Arginine	3.35
Aspartic acid	2.97
Cysteine	0.39
Glutamic acid	5.31
Glycine	1.21
Histidine (irreplaceable)	0.90
Isoleucine (irreplaceable)	1.14
Leucine (irreplaceable)	1.88
Lysine (irreplaceable)	0.91
Methionine (irreplaceable)	0.57
Phenylalanine (irreplaceable)	1.14
Serine	1.60
Threonine (irreplaceable)	1.03
Tryptophan (irreplaceable)	0.39
Tyrosine	1.04
Valine (irreplaceable)	1.42

This unique composition of hemp seeds completely allows us to call this raw material Superfood [8]. As noted in [6], it is completely safe, as it is not modified, and no harmful chemicals are used for growing hemp. All because this plant has a huge vitality, which allows it to fight various pests and diseases.

European trends in healthy eating are driving the growing popularity of niche products such as flaxseed and hemp oils, flour, bran and protein from them. These goods are in demand among European consumers, and the EU market is quite large [9].

Hemp oil is a unique source of minerals, vitamins and essential fatty acids. Phosphorus, potassium, zinc, calcium, manganese, iron, sulfur, vitamins A, B, B2, B3, B6, C, D, E, antioxidants, proteins, carotene, phospholipids, phytosterols are part of its perfectly balanced composition.

Hemp seed oil has many unique properties that are not characteristic of any other oil (Table 3).

Table 3. Physico-chemical parameters of hemp oil

Indicator	Normalized quality indicators in accordance with TU U 10.4-3922410-001: 2017 [9]		
	refined	unrefined	
		first grade	of another grade
Acid number, mg KOH, no more	0.4	2.3	6.0
Moisture and volatile substances, %, not more	0.12	0.15	0.20
Low-fat impurities, %, not more	missing	0.10	0.15
Phosphorus-containing substances, %, not more	missing	0.30	0.80
Total ash, %, not more	0.05	0.05	0.15
Iodine number, g / 100, not more	145	145	145
Unsaponifiable matter, %, not more	1.0	1.0	1.0
Flash point (for extracted oil), °C, not lower	225	225	225

Rich in antioxidants, it prevents blood thrombosis, lowers cholesterol and promotes weight loss. One of the components of hemp oil - chlorophyll - gives the product a greenish tint. The main value of chlorophyll is that it prevents the development of cancerous tumors in the body [10].

Therefore, all over the world and in Ukraine, the production of hemp oil and a variety of food products (Fig. 1-4) is always appropriate and efficient [7].

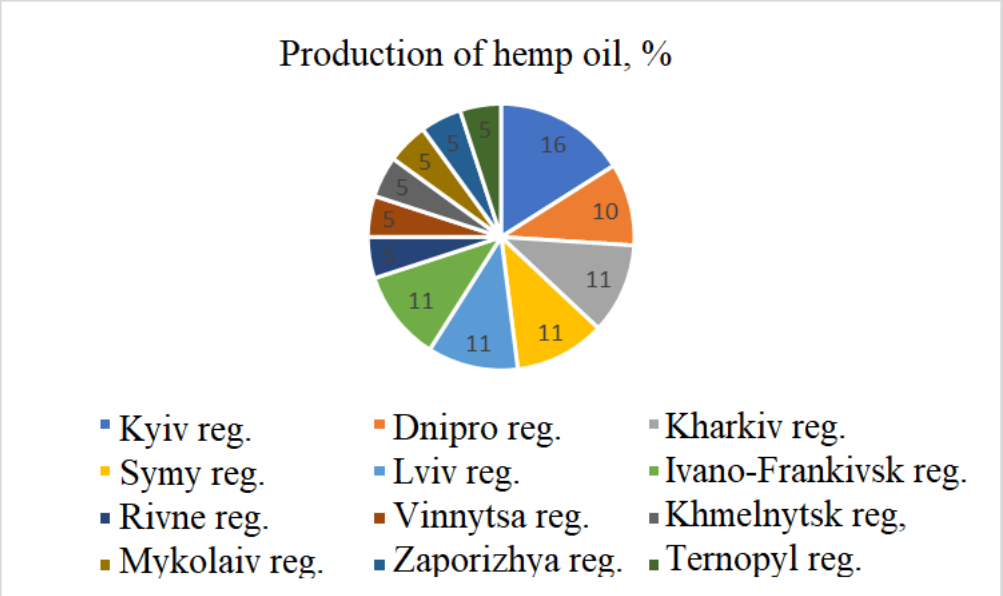


Fig. 1. Production of hemp oil

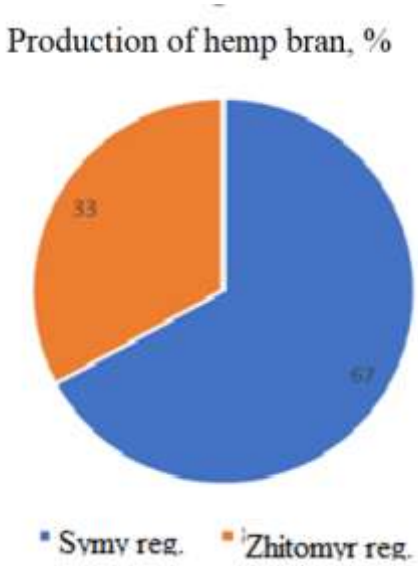


Fig. 2. Production of hemp bran

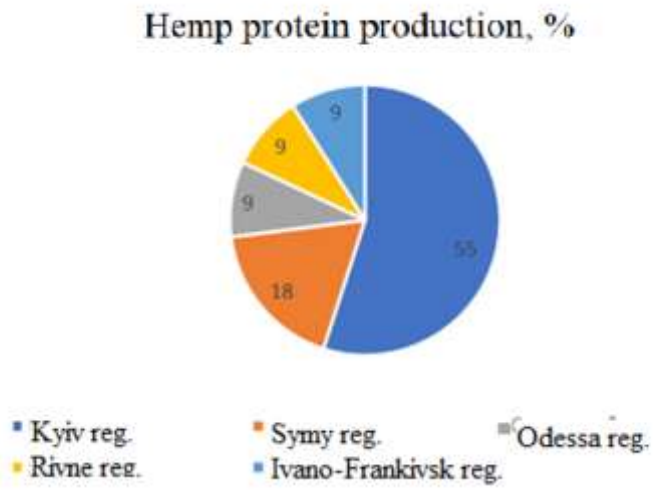


Fig. 3. Hemp protein production

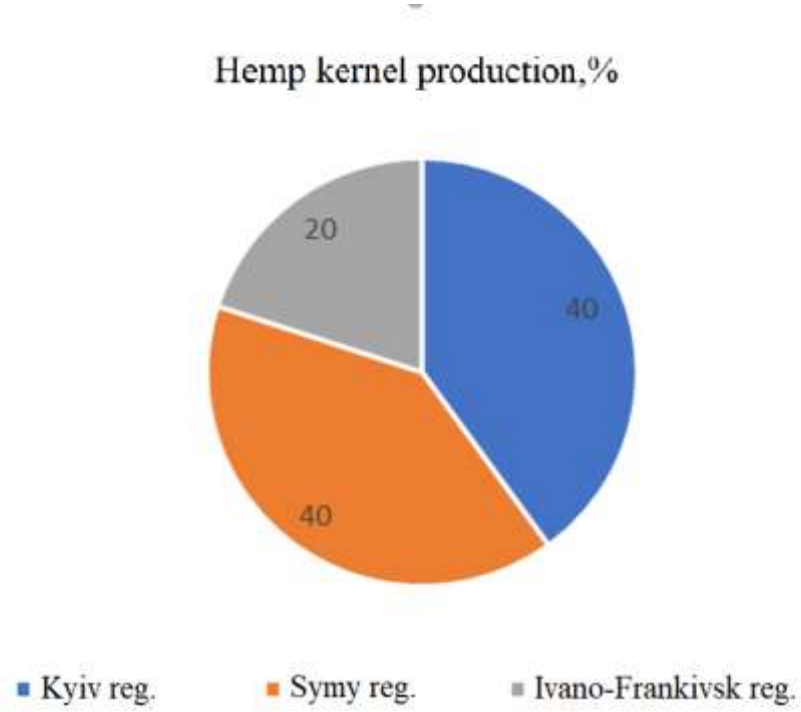


Fig. 4. Hemp kernel production, %

From hemp seeds produce various foods (Table 4) [11]. No plant other than technical hemp is a complete source of protein that is in a convenient form for human assimilation.

Table 4. Assortment of food products from technical hemp seeds

Country	Food hemp products made from industrial hemp seeds
France	oil, flour, protein, crushed seeds, muesli, snacks
China	oil, protein, flour, crushed seeds
Chile	oil
Canada	oil, flour, protein, crushed seeds, organic hemp seeds, organic hemp oil, cookies, hemp seed coffee, roasted hemp seeds, ice cream, hemp milk, snacks
Ukraine	oil, flour, "protein", crushed seeds, bran, halva, semolina.

The range of uses of hemp processing products in the world economy is steadily expanding, industrial technologies are being developed for the production of ingredients from hemp stalks for use in innovative industries.

One of the most promising areas of development of the nutraceutical market is the use of therapeutic properties of various elements of the hemp plant.

The rapid growth of the global market for nutraceuticals as dietary supplements, which include non-narcotic cannabinoids of cannabis can be divided into several key segments:

- foodstuffs which structure includes leaves and inflorescences of technical hemp;

- food products, the recipe of which includes leaves and inflorescences of technical hemp of therapeutic orientation;

- food products, the recipe of which includes leaves and inflorescences of medical hemp;

- food products, which include the "green mass" of legally grown psychoactive varieties of cannabis;

- food products, which include a full-spectrum isolate;

- food products, the recipe of which includes some cannabinoids taken.

Among the many positive properties of the stem of technical hemp are terpenes, which have a positive effect on human health through the endocannabiodine system, inhibiting the absorption of serotonin and, as a consequence, act as an active antidepressant. They also increase the amount of gamma-aminobutyric acid, which blocks nerve impulses and thus reduces anxiety.

Terpenes, cannabinoids and other phytochemicals provide cannabis with its unique medicinal effect, taste and smell. There are more than 50,000 terpenes found in nature, and a significant number of them have significant therapeutic properties.

Hemp plants are also a raw material for making various beverages.

Given the rapid development of the hemp beverage market in the United States and Canada, it makes sense for domestic producers of soft, low-alcohol, or alcoholic brands to pay attention to the production of various similar hemp-based beverages. Herbal teas from hemp raw materials are currently recognized as the first in the world for the sale of beverages from the hemp plant. Also gaining more

and more popularity in the world are such products as: juice from freshly cut hemp leaves, hemp milk, hemp chocolate, candies and other sweets.

Therefore, no wonder cannabis acquires the status of a strategic crop, the cultivation and processing of which is a priority of economic policy of governments of many developed countries and private business [12].

However, high competition on it until recently scared off Ukrainian exporters. The reduction of the import duty rate on plant products to 0% served as a catalyst for strengthening the export activity of national agro-industrial producers in the European market. Due to zero duty, their products have become more competitive in terms of price. Despite all the troubles and obstacles in national policy and current legislation on the cultivation of hemp, food production from hemp is gaining momentum not only around the world but also in Ukraine [Table 5].

Table 5. The main enterprises in Ukraine are processing hemp raw materials [11]

Region	Enterprises	Type of goods
Zhytomyr	PP Hemps	Textile ware
m. Kyiv	PP AlenGroup	Textile products, accessories
m. Kyiv	PE "HamperMix"	Thermal insulation materials
Kyiv reg.	FG "Tailor OP"	Oil, food
Poltava region	Agro-Hanf LLC	Textiles, accessories
Sumy region	Elifibre LLC	Seeds, oil
Sumy region	Marbut twine factory	Twisted products
Kharkiv	Kharkiv Rope Plant	Twisted products

Ukraine's foreign trade in cannabis products is still small, with exports exceeding imports, mainly due to Ukraine's focus on technical cannabis breeding and mainly supplying seed to other countries. Some segments of the market for technical hemp products are focused on the export of seeds and oil. As these domestic products are obtained at a high cost, the European market allows the supply of products at a higher cost and limits the export batch. In the European

market, hemp products are represented by many operators, so without a well-thought-out marketing strategy to take a place among them domestic producers will be difficult. Ukraine imports imported hemp products already completely processed, with high added value - oil and fiber.

Table 6. The main producers of food products from hemp in Ukraine

Name of Company	Product	Region
PE "BIGOVAL"	hemp and linseed oils, shampoos and soaps with hemp and linseed oil, meal, cake, drying oil	Kharkiv region
Agrosilprom LLC	hemp and flaxseed oil, fish feed	Dnipro
ELIFITO Research and Production Company	flaxseed and hemp oil, flaxseed meal	Ivano-Frankivsk
FG "Ekosvit"	Hemp foods - hemp oil, hemp protein, crushed hemp seeds, hemp flour, hemp salt, etc.	Sumy region
Desnaland LLC	Foods from bast crops - hemp and flaxseed oils, hemp and flaxseed protein, crushed hemp seeds, hemp flour, etc.	Sumy region, Hlukhiv

5. Conclusions

In order for cannabis products to enter the world market, it is necessary to create a powerful processing industry for oil, biologically active food additives, medical products and pharmacological drugs.

Because hemp seeds contain unsaturated acids that oxidize when they interact with air, their packaging should be carefully considered to preserve their properties and bring the value of the finished product to the consumer. Extending the shelf life of natural products by a few weeks is a very difficult process. 7 months is practically a hemp maximum [12]. Thus, in [9] a method of packaging

the finished product - sachet bags - was proposed to preserve the properties of hemp oil.

Therefore, in the further works not only the consumer value and efficiency of hemp seed food products will be more carefully studied, but also all stages and existing schemes of complex processing of hemp raw materials into food products. There is also the question of creating optimal and appropriate packaging to preserve the quality properties of hemp oil, dietary supplements, medical supplies and pharmacological drugs from hemp raw materials.

So, summarizing all the above, we can conclude: Based on the market research of hemp food products and their biological and physiological value, it can be stated that hemp seeds and hemp raw materials are a source of promising biologically active ingredient in health food technologies, and Ukraine has every reason to be a world leader in hemp industry. because our country has all the necessary resources, technologies and experience in growing and processing hemp.

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DIGITALIZATION OF UKRAINIAN ECONOMY: TRENDS, CHALLENGES AND THREATS TO THE DEVELOPMENT OF THE SOCIETY

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DOI: 10.31891/monograph/2021-10-24

The key indicators of the country's readiness for digitalization include the four most significant factors that characterize the level of digitalization of the country:

the level of digitalization of the economy;

digital coverage of households;

digital gaps;

intensity of state participation in digitalization [1, p. 117].

The Concept of Development of Digital Economy and Ukrainian Scociety for 2018-2020 it is stated that the main goal of digitalization is to achieve digital transformation of existing and creation of new sectors of the economy, as well as transformation of spheres of life into new more efficient and modern ones. Such growth is possible only when ideas, actions, initiatives and programs related to digitalization are integrated, in particular, into national, regional, sectoral development strategies and programs [2]. However, it should be noted that the Ukrainian government, in defining the goals of digitalization, made a serious mistake by confusing "digital initiatives" with "digital strategies". While businesses have been busy spending resources to digitize their wages, accounting, procurement, and sometimes human resources operations, many have missed out large-scale digital transformation. These problems were identified by COVID 19, which accelerated the use of digital tools. People immediately had to work remotely and they saw that the tools needed to work had been already created - these tools are not perfect, but they are constantly being improved. The world's technology giants, as well as smaller startups, quickly came to the fore with their solutions. This eased the situation for professionals who were able to continue working remotely.

International organizations annually conduct in-depth research to track changes in the trends of digital transformation in countries. The obtained results provide an opportunity to draw conclusions about the study of the experience of leading countries in the use of information and communication technologies. Thus, in The World Competitiveness Yearbook (WCY) 2021, innovation, digitalization, social benefits and social cohesion are key to economic performance. The ranking was led by Switzerland, Sweden, Denmark, the Netherlands and Singapore. Table 1 summarizes the results of the overall rating of global competitiveness of Ukraine and individual neighboring countries for 2017-2021.

Table 1. World competitiveness ranking of Ukraine and some neighboring countries

Country	2017	2018	2019	2020	2021
Polland	38	34	38	39	47
Russia	46	45	45	50	45
Romania	50	49	49	51	48
Slovakia	51	55	53	57	50
Hungary	52	47	47	47	42
Ukraine	**60**	**59**	**54**	**55**	**54**

Source: compiled by the author according to the data [3]

From the data in Table 1 we can see that Ukraine has improved its ranking position from 60th place (2017) to 54th (2021). Among the results of the neighboring countries, they all had better rating. Poland had the best position, but in 2020-2021 its position dropped down to 47th place.

The World Competitiveness Yearbook IMD (WCY) 2021 contains countries' ranking data by the following components: economic performance, government efficiency, business efficiency and infrastructure. For Ukraine, it is respectively 54th, 53rd, 50th and 51st place in the ranking. According to experts from the World Competitiveness Center, the economies with the highest performance are characterized by varying degrees of investment in innovation, diversified economic activities and state policy support.

For the fourth year in a row, the IMD International Competitiveness Rating measures the ability and willingness of countries to adopt and explore digital technologies as a key driver for economic transformation in business, government and society as a whole. The United States and Singapore came in first and second

place in the ranking, Denmark and Sweden - in the third and the fourth place respectively. The rating of the World Competitiveness Center positioned Ukraine in 58th place (Table 2).

Table 2. Digital Competitiveness rating of Ukraine

Index	2016	2017	2018	2019	2020
General	59	60	58	60	58
In terms of criteria:					
knowledge	44	45	39	40	38
technologies	60	62	61	61	59
future readiness	61	61	61	62	61

Source: compiled by the author according to the data [3]

Ukraine has the best position in the sector of knowledge, which takes into account the know-how needed to discover, understand and build new technologies, as well as such subfactors as talent, training and education, scientific concentration. This is the 38th place in 2020. Ukraine's position is slightly worse (59th) in the technology sector, which takes into account the general context that allows the development of digital technologies, as well as subfactors: regulatory framework, capital and technology base. Ukraine's future readiness for digital transformations is low - 61st out of 64. The country shows weak results in terms of adaptive attitude; business agility and IT integration (see Table 2).

One of the most important indicators of innovation and technological potential of each country is the level of technology development, the ability of the country's economy to develop in the context of digital transformation. The Portulans Institute and the World Information Technology and Services Alliance publish an annual report analyzing the network readiness index, a comprehensive indicator of the level of information technology development in the world. The authors of the study put forward the idea that there is a close link between the development of information and communication technologies and economic well-being, as today technologies play a leading role in developing countries, increasing productivity and competitiveness, diversifying the economy and stimulating business activity. It is assumed that public and private sector leaders to analyze

their policies and monitor their progress in the development of the information society should use the index. The experts calculated the Networked Readiness Index based on 62 different indicators, which were grouped under 4 categories: technological component, human factor, management skills and influence.

According to the Network Readiness Index in 2020, Ukraine ranks 64th position with an index of 49.43 and lags far behind European countries. Sweden (82.75), Denmark (82.19), Singapore (81.39), the Netherlands (81.37) and Switzerland (80.41) are in the top five. Of Ukraine's closest neighbors, the highest rating is in Poland (61.80) and Slovakia (60.78). Belarus and Moldova are after Ukraine and have corresponding index values of 49.16 and 47.09 respectively.

In terms of the components of the index, Ukraine has the best rank in management skills "governance" (58th position). And the lowest position - 79th - on "impact". In terms of technology, Ukraine ranked 62nd, and the human factor, “people” ranked 65th.

The European Union also identifies the digitalization of the economy as a goal of economic growth. The above mentioned is stated in the “Europe 2020” strategy. According to a study by the European Commission, an effectively functioning digital market can have a significant impact on economic development. Following the example of the European Union (EU), digitalization will increase the economic situation by 415 billion euros a year and create hundreds of thousands of new jobs. The growth rate of the digital economy of the United Kingdom of 5.4% is significantly ahead of the growth rate of GDP of 2% over the same period, the growth rate in China is as follows: 16.6% to GDP of 6.7% [5].

The Digital Economy and Society Index (DESI), which is an integral part of the study of digital indicators in Europe has a particular value for assessing the level of digitization. The DESI index covers five main areas: communications, human capital, Internet use, digital integration and digital public services. The International Index of Digital Economy and Society (I-DESI) displays and expands the EU-28 Digital Economy and Society Index, using 24 datasets to analyze trends and compare figures from 45 countries. Ukraine is not among these countries.

The DESI 2020 report, which is based on 2019 data, states that digitalization is growing in all EU member states. Finland, Sweden and Denmark were the leaders in the development. The last places in the ranking are occupied by Romania, Greece, and Bulgaria. In terms of the components of the index, the

situation is as following. Next-generation network coverage (NGA) in households in EU member states increased from 83% to 86%. The access of households to fixed broadband networks offering a bandwidth of at least 100 Mbps has increased (up to 26%). The 4G network, but 5G coverage still remains low (25%), covers almost the entire EU population (96%). There is an increase in the amount of people (up to 58%) who have basic digital skills. At the same time, a significant proportion of EU citizens still do not have basic skills in working with digital technologies, although most jobs require such skills. The labor market is experiencing a shortage of specialists in the field of information and communication technologies (ICT). In 2018, 64% of large enterprises and 56% of small and medium-sized enterprises (SMEs) faced difficulties in recruiting ICT professionals. 85% of EU citizens use the Internet at least once a week. In 2019, 38.5% of large companies relied on modern cloud computing services, and 32.7% used Big Data solutions [6].

As we can see, the level of digitalization has increased in recent years in all EU member states. However, it remains an important task for governments to give EU citizens access to digital competences. This will open up opportunities for the development of digital Europe.

The foundation for digital economy is a developed and efficient infrastructure. In the Concept of Development of the Digital Economy and Society of Ukraine, digital infrastructure is considered as a set of communications, technologies, products and processes that provide computing, telecommunications and network capabilities and work on a digital (non-analog) basis [2].

Digital infrastructure contains two multicomponent interconnected and complementary components: hard or information and communication technologies and soft or digital technologies. Each contains the relevant components that individually and together affect the acceleration of economic development.

A solid digital infrastructure is designed to provide access to digital technologies (connectivity) and conditionally includes the following key components:

fixed telecommunication infrastructure (main, distribution and local networks, traffic exchange points, etc.);

mobile telecommunication infrastructure (3G, 4G, 5G, radio and satellite technologies, Wi-Fi, etc.);

digital television infrastructure (terrestrial, cable, satellite);

LoRa radio infrastructure (long range frequency, unlicensed frequencies) for Internet of Things projects (sensors, sensors, etc.);

infrastructure of data processing and storage centers (so-called cloud or virtualized infrastructure);

cybersecurity infrastructure;

specialized infrastructures (special networks, video surveillance, related engineering systems) [7].

ICT development is determined by the relevant index (IDI), which is calculated by the International Telecommunication Union (ITU). The last calculation of this index was carried out in 2017. Ukraine ranked 79th. In 2018, the index was supplemented by three new indicators, such as: subscriptions to mobile broadband Internet traffic, the percentage of mobile phone owners and the percentage of people with information and communication technology skills. In 2020, it was determined for each country which additional indicators can be obtained. Among 8 indicators in Ukraine, fixed broadband indicators and the schedule of mobile Internet access are not available for monitoring.

It should be recalled that in 2011 the UN recognized the right to Internet access as a basic human right. This has given impetus to the development of various national programs and projects related to the spread of fixed broadband Internet access. In particular, in Ukraine, the government, represented by the Ministry of Digital Transformation, plans to provide the technical possibility of connecting to fixed broadband Internet access at a speed of 100 Mbps for 95% of the population of Ukraine by 2024.

It is worth analyzing the dynamics of the use of information and communication technologies (ICT) at domestic enterprises [8, 9]. Research shows that not all companies that participated in the survey use computers. There is even a decrease in the share of enterprises from the total number of enterprises from 95.4% (2017) to 87.9% (2019). In 2019 44532 companies used computers. This is 10.4% more than in 2017. In 2019, the highest share of enterprises that used computers was recorded in the field of water supply; sewerage, waste management (93.6%), supply of electricity, gas, steam and air conditioning (93.0%), processing industry (91.0%). The computers of the temporary accommodation and catering establishments are the least used. The bigger the business, the higher is the use of

computers. Thus, in 2019, 86.1% of small, 93.7% of medium and 95.0% of large enterprises used computers.

In 2019, the average number of employees (including full-time and part-time) who used computers decreased slightly. This is actually 33-35% of the total number of employees. This may be due to the general reduction in the number of staff in enterprises.

The development of computer technology has resulted in computer networks. Today, it is impossible to imagine the work of enterprises in certain industries without the use of computer networks. Their use gives each company numerous opportunities. The ultimate goal of the application is to increase the efficiency of the enterprise, which can be expressed by various factors: increasing the company's profits, improving the quality of employees, effective interaction between different departments of the enterprise.

In Ukraine, the number of Ukrainian companies that have access to the Internet is gradually growing. In 2019, this is 43,785 enterprises. Of these, 60.96% had fixed broadband access (20.6% of them with speeds of 100 Mbps and more), 30.6% - narrowband access and 23.6% - broadband mobile connection using portable devices. Accordingly, the average number of employees who used computers with Internet access is increasing. This is 1090 thousands of people, or 28.4% of the total number of employees.

In 2019, only 51.9% of enterprises used local area networks (LANs), of which 58.0% used Intranet and 8.1% Extranet. It is clear that the larger the company and the more complex its organizational structure, the more it uses the means of local networks. Thus, in 2019, 86.2% of large enterprises used LAN tools, of which the Intranet - 72.7%, Extranet - 30.8%. For comparison: 45.9% of small enterprises are covered by LAN, of which 55.1% - Intranet, 5.6% - Extranet and 69.1% of medium-sized enterprises used LAN, of which 66.5% Intranet, 13.3% Extranet.

Businesses use the Internet to work with websites that businesses are actively creating and using. At the end of 2019, 17,856 enterprises (35.2% of the total) had a website. Among small enterprises, 30.4% had websites, medium-sized enterprises 47.7% and large enterprises 68.3% of the total number of enterprises.

It should be noted that the forced quarantine caused by Covid 19 and the transition of a significant number of businesses online has significantly expanded the use of these services.

Thus, digital economy continues to grow at an incredible rate due to its ability to collect, use and analyze vast amounts of information (digital data). Digitalization is a recognized mechanism of economic growth due to the ability of technology to affect the efficiency, effectiveness, cost and quality of economic, social and personal activities in a positive way. It penetrates into all spheres of activity, into all countries and regions. Today in the world there is a huge gap between countries with weak development of Internet communication and countries with a very high level of digitalization. For example, in the least developed countries, only one out of five people use the Internet, while in developed countries, four out of five people have access to the Internet. In 2020, due to the pandemic, the global economy shrank by 4.4%. At the same time, digitalization has accelerated all round the world. The digitalization of the real sector of the economy is a major component of the digital economy and a determining factor in economic growth in general, including the digital industry itself as a producer of technology.

According to HBR 2020, Ukraine is one of the promising countries where the digital infrastructure is still limited, but which is rapidly becoming digital. This group includes China, India, Indonesia, Kenya, Vietnam, Bangladesh, Rwanda and Argentina. Based on the analysis of experts, it has been established that the economies of these countries ("successful breakthrough economies") should focus on such tasks as:

improving mobile Internet access, its accessibility and quality, for wider dissemination of innovations;

strengthening the institutional environment and developing digital legislation;

encouraging investments in digital enterprises, financing digital R&D, training IT staff and using applications to create jobs;

measures to reduce inequalities in access to digital tools by gender, class, ethnicity and geography (although access remains largely uneven) [10].

Digital transformation in the real sector of the economy allows to automate business operations, providing operational efficiency, such as reducing transaction

costs with an impact on productivity. Similarly, the digital transformation opens up new business opportunities, affecting employment and entrepreneurship. Digital transformation of business processes is aimed at ensuring that companies make decisions quickly, adapt their work to the requirements of the current moment and meet customers' needs.

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THE IMPACT OF COVID-19 PANDEMIC ON LITHUANIAN BUSINESS

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DOI: 10.31891/monograph/2021-10-25

1. Introduction

Countries, companies, and all other business entities are constantly being affected by a variety of factors. Some of them are predictable and easily dealt with, not causing much or significant damage. However, there are factors that fundamentally change the economic and financial situation of companies or the country as a whole. An example of this is the global COVID-19 pandemic, which already lasts for more than a year and has had a significant impact on the global economy.

The COVID-19 pandemic crisis and its impact are currently a particularly pressing problem. Although the period of this pandemic is short in terms of economic processes, it is already being studied quite widely. There is no country in the world that was not affected by the pandemic. The threat of the virus and the restrictions imposed by governments have led to a recession in global economic activity, unstable production and supply chains, a decrease in international trade and a decline in consumer and business expectations. To overcome COVID-19 pandemic, governments of most countries have decided to shut down schools, public spaces, and lock people down in their homes, also cross-border movement of the economy has been restricted as well (Wojcik, Ioannou [1]). These distractions, panic, and uncertainty about the future had a significant and negative impact on the global economy.

With the onset of the pandemic, a state of emergency was declared in Lithuania on the 26th of February 2020. The first cases of people with COVID-19 were reported in February 2020, and in March quarantine was announced which lasted three months. With the rapid rise in morbidity and mortality from COVID-19 at the end of 2020, a second quarantine was introduced in November. The pandemic crisis affected all Lithuanian companies and organizations to a greater or lesser extent. The slowdown or even suspension of companies‘ activities in certain sectors has had a negative impact on the financial results of these sectors. The introduction of quarantine and restrictions on doing business have negatively

impacted the financial condition of companies. According to the financial ratios of the Lithuanian economic activity sectors provided by the Lithuanian Department of Statistics, the financial results of companies engaged in accommodation and food service activities, arts, entertainment, and recreation activities decreased the most. The aim of this article is to investigate the impact of the COVID-19 pandemic on the Lithuanian business.

2. Review of research on the impact of the pandemic on national economies

With the restriction of business activities in the country, the closure of national borders, the introduction of universal quarantine and changes in the behaviour of the population, the country's economy is also changing significantly. Different economic sectors respond differently to a crisis caused by the pandemic. Although the crisis caused by the COVID-19 pandemic began more than a year ago, researchers from various countries have conducted a number of studies examining the impact of this crisis on economic sectors in different countries.

Stefano, Fabrizio, Santamaria [2] conducted a study on the impact of the COVID-19 pandemic on aviation, economy, and society. The study found that a global travel ban caused more than $ 3.3 billion in losses in the first quarter of 2020. More than 30 percent of workers have lost their jobs. Aviation business losses in the first quarter had an average of 0.13 percent impact on GDP. Suau-Sanchez, Voltes-Dorta Cugueró-Escofet [3], based on data from the International Civil Aviation Organization, found that in the first half of 2020 airline revenue losses ranged from $ 112 billion to $ 135 billion. Richard, Haiyan, Park [4] conducted a study analysing how the tourist-favourite Chinese cities Wuhan and Guangzhou, which were closed for 76 days, were affected during the COVID-19 pandemic crisis. The pandemic in the tourism sector of these cities caused as much as 96 percent annual negative change, which also affected the economy of the whole country. Yousef [5] found that at the beginning of the pandemic crisis, the stock market was in turmoil, due to sudden changes in stock prices. The authors note that stock prices were this low only during the 2008 financial crisis. The Dow Jones Industrial Average and SP 500 stock price indices fell more than 5 percent. Baldwin [6] analysed the impact of COVID-19 on cash flows in the economy. With the introduction of universal quarantine, households do not receive salaries, which reduces their consumption and the level of savings. Declined consumption is

reducing import demand, which in turn is reducing incomes for the rest of the world, so the country's exports are declining as well. Demand and supply shocks cause disruptions in domestic and international supply chains. A decrease in savings reduces investment and that has a negative effect on companies' capital stocks.

Shafi [7] investigated the impact of the COVID-19 pandemic crisis on Pakistani businesses. The study emphasizes that small and medium-sized businesses are very important to the country's economy, as they make up more than 90 percent of businesses and account for 40 percent of the country's GDP. By forcibly closing the country's borders, Pakistan lost a third of its annual revenue. Exports fell 50 percent. Ozili [8] investigated the impact of the pandemic on Nigerian companies. The study found that as many as 95 percent of companies were severely affected by the pandemic caused by the COVID-19 virus. Only 3 percent of companies were not adversely affected, and 2 percent of companies were not sure about the impact.

3. COVID-19 impact on financial condition of Lithuanian companies

In order to study the impact of the crisis caused by the pandemic on the finances of Lithuanian companies, we will assess financial condition of three sectors of economic activity –Accommodation and food service activities, Human health and social work activities, Arts, entertainment and recreation. These sectors were selected taking into account the availability of financial information and the fact that the activities of companies operating in these sectors were restricted after the introduction of quarantine in Lithuania. The analysis is based on financial data of all four quarters of 2019 and the first, second and third quarters of 2020. At the end of the first quarter of 2020, the first quarantine was introduced, which restricted the activities of companies belonging to these sectors. Year 2019 is analysed to show the financial performance of the sector before the onset of the pandemic and to compare it with the performance of the pandemic period. The third quarter of 2020 is analysed to show how the financial ratios have changed since the abolition of quarantine and compare them to the ratios of the third quarter of 2019. The calculations are performed based on the Financial ratios of enterprises provided by the Lithuanian Department of Statistics on the Official Statistics Portal [9]. Table 1 shows the ratios for assessing the financial condition. There are some limitations of the study. Lithuanian Department of Statistics does not provide complete information on quarterly financial ratios of all sectors. Information on

profit, income, expenses is provided, but there is no information on assets, capital, liabilities of economic activities concluding the sector. This limits the ability to calculate all the ratios in the table.

The first ratio assesses the ability of companies in the sector to work profitably. The second and third ratios belong to the group of short-term liquidity ratios. They are designed to assess the ability of companies to meet current liabilities. The fourth ratio assesses the company's dependence on borrowed financing sources. The fifth ratio assesses the efficiency of the company's accounts payable, and the sixth ratio assesses the efficiency of accounts receivable collection.

Table 1. Financial ratios

Ratio	Formula
1. Profit before tax margin, perc.	Profit, loss before tax/Sales income
2. Current ratio, coeff.	Current assets/Current liabilities
3. Cash ratio, coeff.	Cash/ Current liabilities
4. Debt to assets ratio, coeff.	Debt/Assets
5. Days accounts payable	Accounts payable/Cost of sales *90
6. Days accounts receivable	Accounts receivable/Sales income*90

Source: developed by the author

Tables 2, 3, and 4 show the results of the calculation of the financial ratios of the three sectors. The financial ratios for the first and second quarters of 2020 are in bold, as quarantine was introduced, and the activities of the analysed sectors were restricted during these quarters.

Table 2. Financial ratios of Accommodation and food service activities

Ratio	Quarter						
	2019 K1	2019 K2	2019 K3	2019 K4	**2020 K1**	**2020 K2**	2020 K3
1. Profit before tax margin, perc.	4,21	9,75	22,30	7,6	**-8,94**	**-11,52**	18,70
2. Current ratio, coeff.	1,46	1,49	1,67	1,4	**1,19**	**1,21**	1,46
3. Cash ratio, coeff.	0,49	0,54	0,61	0,61	**0,60**	**0,63**	0,86
4. Debt to assets ratio, coeff.	0,64	0,63	0,62	0,60	**0,59**	**0,60**	0,56
5. Days accounts payable	45,8	30,7	27,6	34,1	**40**	**60,8**	33,8
6. Days accounts receivable	8,54	5,82	5,55	4,72	**16,12**	**21,77**	13,74

Source: composed by the author on the basis of data from [9]

As we can see from the data presented in the table 2, profit before tax margin in 2019 grew rapidly during the first to third quarters. At the end of 2019, the ratio decreased to 7.6 percent. The quarantine that began in the first quarter of 2020 led to unprofitable operations in the sector. With a significant decrease in sales income during the first quarter of 2020 the ratio fell to -8.94%, and after the2020 sales fell by more than 50%, the ratio fell to -11.52%. During the third quarter of 2020, when quarantine was lifted, profit before tax margin rose to 18.70 % as sales started growing again. There was also a more significant increase in Days accounts payable and Days accounts receivable during the quarantine period. The values of the ratios show that during the quarantine period, companies were covering their obligations to suppliers less, and customers were also paying for goods and services less. After analysing liquidity ratios, no significant change was observed during the quarantine period. The values of the Current ratio and the Cash ratio show that the companies in the Accommodation and food service activities sector did not have liquidity problems during the analysed period. Although during the first and second quarters of 2020 the Current ratio decreased slightly, the calculated values show that companies were able to cover current liabilities with current assets. The values of the Debt to assets ratio fluctuated insignificantly during the analysed period and were not affected by the introduced quarantine. After analysing the values of the ratio, it can be observed that about 60% of corporate assets were financed by debt.

The results of the calculation of financial ratios presented in Table 3 show that the Profit before tax margin of companies in the Human health and social work activities sector were declining from the first to the fourth quarter of 2019. Following the introduction of quarantine in the first quarter of 2020, the Profit before tax margin fell significantly (from 9.75% to 1.81%) and during the second quarter, the sector's average Profit before tax margin became negative. During the quarantine period, the dependence of companies in this sector on creditors was growing. This is evidenced by the increase of the Debt to assets ratio to 0.57. Although the values of Current ratio and Cash ratio were sufficient throughout the analysed period, during the first quarter of 2020, they fell sharply. This indicates a decline in the capacity to cover short-term debts. There was also a significant increase of the Days accounts payable and Days accounts receivable ratios during the quarantine period.

Table 3. Financial ratios of Human health and social work activities

Ratio	Quarter						
	2019 K1	2019 K2	2019 K3	2019 K4	**2020 K1**	**2020 K2**	2020 K3
1. Profit before tax margin, perc.	15,26	14,55	12,28	9,75	**1,81**	**-1,13**	3,69
2. Current ratio, coeff.	1,94	2,91	3,03	2,89	**1,50**	**1,73**	1,78
3. Cash ratio, coeff.	0,92	1,44	1,39	1,19	**0,76**	**0,98**	0,72
4. Debt to assets ratio, coeff.	0,48	0,44	0,41	0,41	**0,55**	**0,57**	0,58
5. Days accounts payable	23,46	21,04	19,81	21,44	**49,68**	**40,21**	33,84
6. Days accounts receivable	33,92	30,59	31,35	28,81	**37,94**	**36,03**	22,78

Source: composed by the author on the basis of data from [9]

The values of the ratios show that the companies in this sector took longer to pay debts to suppliers during the quarantine period. The duration of buyers paying debts to companies has also increased.

Table 4. Financial ratios of Arts, entertainment and recreation

Ratio	Quarter						
	2019 K1	2019 K2	2019 K3	2019 K4	**2020 K1**	**2020 K2**	2020 K3
1. Profit before tax margin, perc.	4,12	3,67	7,31	5,44	**0,35**	**-3,68**	6,12
2. Current ratio, coeff.	1,76	1,68	1,78	1,87	**1,80**	**1,85**	1,72
3. Cash ratio, coeff.	1,03	0,85	0,92	0,99	**1,15**	**1,09**	1,05
4. Debt to assets ratio, coeff.	0,49	0,50	0,46	0,45	**0,44**	**0,48**	0,51
5. Days accounts payable	5,62	5,98	7,3	7,13	**8,20**	**10,07**	7,84
6. Days accounts receivable	3,65	3,67	4,48	5,16	**4,78**	**6,98**	5,72

Source: composed by the author on the basis of data from [9]

With the introduction of quarantine in Lithuania, the Profit before tax margin of enterprises of Arts, entertainment and recreation decreased from 5.44 % to 0.35 %. During the second quarter of 2020 with corporate income in this sector declining by almost 30 %, companies suffered a loss of almost 4 cents per euro of income. With the lifting of quarantine, corporate revenues have risen by almost 50 % and 6.12 %. Profit before tax margin was achieved. Unlike the sectors examined above, the ability of Arts, entertainment and recreation companies to cover short-term debts with short-term assets during the quarantine period has increased. This is evidenced by the growth of the Current ratio and Cash ratio. Rising Cash ratio values indicate that companies in this sector have increased their cash reserves. The Debt to assets ratio shows that Arts, entertainment and recreation companies are not dependent on creditors. During the quarantine period, this dependence remained virtually unchanged. Also, the quarantine period had virtually no effect on Days accounts payable and Days accounts receivable ratios.

Summarizing the calculations, it can be observed that the onset of the pandemic crisis and the introduction of quarantine had the greatest impact on the profitability of the analysed sectors. A particularly significant decline is observed in the Accommodation and food service activities. The main reason is the significant decline in income. Figure 1 shows Accommodation and food service activities income, gross profit, and net profit.

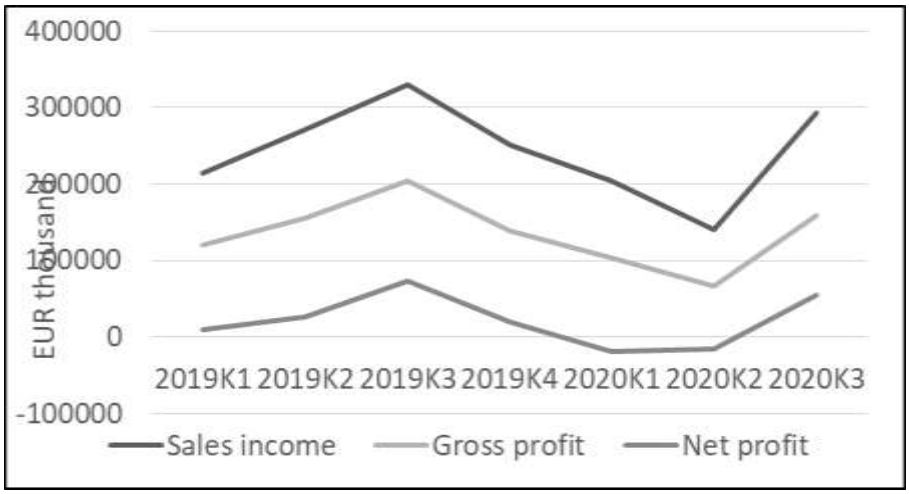


Fig. 1. Accommodation and food service activities sales income, gross profit, net profit

Source: composed by the author on the basis of data from [9]

The significant decrease in sales contributed to the increase of the Days accounts payable. The most significant growth (from 27.6 days to 60.8 days) is observed in the enterprises of Accommodation and food service activities sector.

The Days accounts receivable ratio also increased in the sectors analysed. Only in the Arts, entertainment and recreation sector was the growth of this ratio very modest. The largest changes in liquidity ratios during the quarantine period are observed in the sector of Human health and social work activities. The declining ratios of this sector is indicative of a reduced capacity to cover short-term debt. Despite the decline of these ratios, the liquidity of the sectors remained high. The almost unchanged Debt to assets ratio values of the Accommodation and food service activities and Arts, entertainment and recreation sectors suggest that the pandemic crisis and the introduction of quarantine did not affect this ratio in the mentioned sectors. Significant growth of the ratio in the sector of Human health and social work activities indicates an increase in dependence on creditors and increased risk.

The pandemic crisis has had a very strong impact on the Travel agency, tour operator reservation service and related activities sector of economic activity Administrative and support service activities. Although the profit of the economic activity Administrative and support service activities increased, the revenue of the sector Travel agency, tour operator reservation service and related activities decreased by more than 94 % (see figure 2).

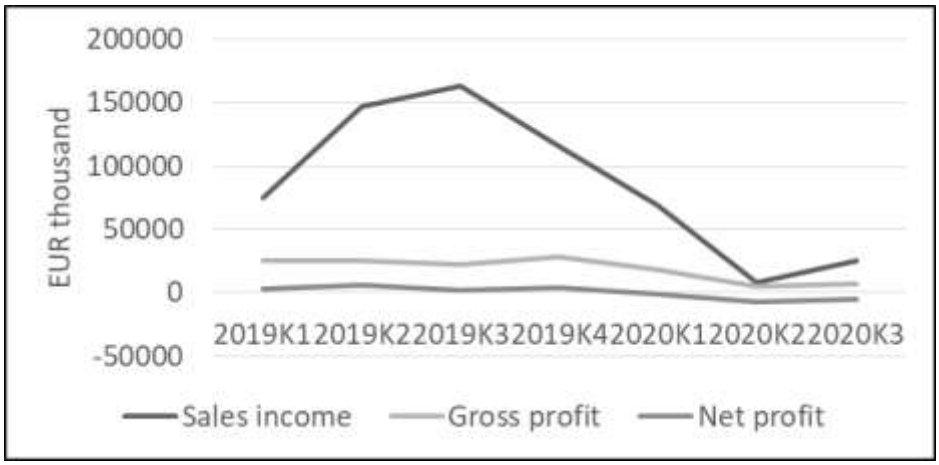


Fig. 2. Travel agency, tour operator reservation service and related activities sales income, gross profit, net profit

Source: composed by the author on the basis of data from [9]

As we can see from the figure, the profit of the companies belonging to the Travel agency, tour operator reservation service and related activities sector was more than 4 million euros in the last quarter of 2019, and in the first quarter of

2020, companies suffered a loss of nearly 1.5 million euros. During the second quarter of 2020, the loss already amounted to more than 7.6 million euros. Although after the lifting of quarantine in the third quarter of 2020 the sector's revenue more than tripled, the sector's loss was still more than 5 million euros.

The decline in revenue due to the COVID-19 pandemic led to an increase in the number of loss-making companies. Particularly high growth during the quarantine period is observed in enterprises of Accommodation activities. During the first quarter of 2020, the share of loss-making enterprises was as high as 87.3 %. During the first quarter of 2020, enterprises of Travel agency, tour operator reservation service and related activities that were unprofitable accounted for 83.7 % all enterprises in the sector.

4. Conclusion

The pandemic crises which states are facing have a definite impact on the economy of each state. During these crises, production, service provision are coming to a standstill in high-incidence countries, all of which are leading to economic instability. The decline is particularly marked in the countries with the highest revenues from tourism, as travel to other countries becomes very dangerous during a pandemic crisis.

The global Covid-19 pandemic that began at the end of 2019 affected the Lithuanian economy. The slowdown or even suspension of companies in certain sectors has had a negative impact on the financial results of these sectors. The introduction of quarantine and restrictions on business operations had a negative impact on the financial condition of companies and adjusted Lithuania's GDP growth scenario. Although Lithuania's GDP contracted by 4.2% in the second quarter of 2020, the Lithuanian economy is expected to begin to feel the first signs of recovery in the second quarter of 2021.

The results of the analysis of the financial condition of certain sectors of economic activity in Lithuania showed that the onset of the pandemic crisis had the greatest impact on the profitability of the analysed sectors, which became negative in these sectors. The negative profitability was due to a significant decrease in sales income. There is also an increase in Days accounts payable in the sectors analysed. The most significant growth (from 27.6 days to 60.8 days) was in Accommodation and food service activities enterprises. The other indicators analysed have hardly changed in this short period. Summarizing the analysis of

financial indicators, it can be stated that the enterprises of Accommodation and food service activities were most affected by the onset of the pandemic crisis.

Although after the end of the quarantine in the third quarter of 2020, the financial results of Lithuanian companies improved, the impact of the pandemic can be assessed and measured only after the end of the pandemic. The current situation suggests that the second significantly stronger wave of COVID-19 pandemic that began at the end of 2020, will undoubtedly have a much stronger impact on both the global and Lithuanian economies.

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MARKETING MANAGEMENT OF ENTERPRISES AND ITS TOOLS

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DOI: 10.31891/monograph/2021-10-26

Introduction

Mankind has long realized the importance of management as a special activity. As a branch of managerial knowledge, management began to form in the second half of the eighteenth century, and its development started in the early twentieth century in the era of industrialization and emergence of large-sized consumer resources and large-scale enterprises.

To distinguish marketing as an independent science in the management system, organizations required several historical stages of the management theory development. By the early 50's of the twentieth century the enterprise management was based on the use of budget control methods in response to changes in the current market situation. Later, the emphasis shifted to long-term planning, i.e. management, which is based on the forecast of key performance indicators of enterprises obtained as a result of analysis over the past long period. In the 60's of the twentieth century, the approach of strategic planning spread, when it is necessary to consider possible changes in the market (demand and competition) while developing planned indicators.

Modern systems of business management were formed as a result of the historical formation and development of management theory. Since the middle of the twentieth century, in the management theory and practice there have been widely spread marketing approaches and principles, according to which management of the enterprise should be based not only on the analysis and forecasting of market development and consumer needs, but the impact on them as well. The set of such approaches, principles, mechanisms and tools has become the basis for the formation of scientific concept of marketing management.

Analysis of recent research and publications

Theoretical and practical aspects of enterprise management that are based on the principles of marketing concepts with comprehensive application of marketing tools are widely represented in the works of O.M. Anisimova, I. Ansoff, H.L. Bahiiev, A.V. Voichak, P. Dixon, P. Doyle, P. Drucker, F. Kotler, J.-

J. Lamben, M.A. Aucklander, M. Porter, B. Santo and others. At the same time, despite a great attention of scientists to this issue, theoretical and practical aspects of the application of marketing tools to manage the activities of enterprises require further research and development.

The purpose of the article

The purpose of the article is to determine the nature, content and features of the use of marketing tools in the enterprise marketing management.

The main research

The concepts of "management of marketing" (or marketing activities) and "marketing management" are widely used in the modern scientific literature. Some authors use both terms simultaneously and actually identify them, considering marketing as a basis and as a subsystem of enterprise management, which determines the end result of its activities.

From our point of view, the concepts of "marketing management" and "management of marketing" are interrelated, complementary, but significantly different. Management of marketing should be considered as one of the functional areas of enterprise management, and marketing management as a management based on the principles of marketing and which applies to all activities of the enterprise [1-4]. Modern transformation of the market leads the enterprise management to comprehension of the need for widespread use of the concept of marketing in economic activities, to the understanding that a marketing approach will allow them to find their target market, their consumers and succeed. With this in mind, marketing management of enterprises is considered by us as a management that is based on the principles of marketing and with the comprehensive application of marketing tools.

Comprehension of marketing as a philosophy, concept, function and management style of the organization involves achieving the goals of the organization through maximum meeting the needs and active influence on their development. Marketing management is implemented at different levels of socio-economic system, scientific and philosophical knowledge.

The complexity of marketing management requires consideration of marketing in a combination of its three key levels:

1) marketing as a philosophical concept of economic activity;

2) marketing as a system of organization and management of business activity of the enterprise;

3) marketing as a tool of enterprise management.

Based on the marketing approach, it is necessary to apply a new functional organizational structure, mechanism and tools for managing business activity, which will be able to meet the needs of consumers, enterprises and society.

Marketing management of the enterprise as a management that is built on the principles of marketing is based on three main points [5]:

1. Information from the external marketing environment is the basis for making management decisions at the enterprise.

2. Constant market research determines the activities of the enterprise in the market.

3. Enterprise management is aimed at active influence on the needs and the market.

Marketing management of enterprises involves [6]:

- orientation of the enterprise towards the market needs;
- strategic approach of the enterprise employees;
- focus on commercial success;
- mobile response to the changes in the environment;
- support of competitive advantages;
- systematic and comprehensive approach to the management of the enterprise activities;
- program-target approach.

The general scheme of marketing management of enterprises includes input information on the state of internal and external marketing environment of the enterprise, management entities (enterprise management, management analysts, experts, consultants, innovators), management mechanism (goals, strategies, functions, resources, methods, tools, technologies, structure) and objects of management (economic activity, business processes, economic relations between market participants).

Marketing management performs general management functions that are market and consumer oriented. The main functions of marketing management include marketing analysis, marketing planning, motivation with marketing tools and marketing control.

Classical and modern concepts of marketing and marketing management of the enterprise require comprehensive use of marketing tools as key management tools.

Summarizing the views of scholars on the essence of the term "management tools", it should be noted that in the process of functioning of economic relations, throughout its history, the humanity has developed three fundamentally different tools of governance, i.e. influence on people and their communities, namely hierarchy, culture, market.

Hierarchy is understood as the main means of action, the relationship between power and subordinates, carried out through coercion and through control over the distribution of material goods. Culture includes social norms, guidelines, rituals, and patterns of human behavior created and recognized by society. The market is considered as a network of equal horizontal relations, which are based on the purchase and sale of products and services, on property relations, on the balance of interests of a seller and a buyer.

In the conditions of market relations (and exclusively in them) marketing tools begin to play a leading role in management. According to F. Kotler, marketing is a process in which companies create a certain value for customers and form close relationships with them in order to obtain a different value in return [7]. In the classical definition of marketing, it means the theory and practice of management decisions based on the analysis of factors of the marketing environment and comprehensive use of marketing tools.

Scientific systematization of marketing management tools originated when the term "marketing mix" (marketing complex) was used for the first time. In the general sense, marketing complex is a set of marketing tools, a totality of management tools that the company uses to influence the target market in order to achieve the expected response.

Although marketing has a fairly wide range of management tools, among all the existing set of marketing tools, the most important of them are identified, which ensure a close relationship between the company and its customers, form a set of measures aimed at influencing market participants.

In its classic form, a set of basic marketing tools are product, price, promotion and place (the concept of "4P") [8]. The main marketing tools are used

within the developed product, pricing, distribution and communication policies of enterprises.

Along with the transformational market changes in the XX-XXI centuries, there could be observed an evolutionary development of the "letter concept" of the marketing mix "4P", and as a result, there emerged new models, in which the basic tools of marketing were supplemented with new components or changed (Table 1).

Table 1. Alternative models of the marketing complex

<table>
<tr><th>"P" models</th><th>Non-"P" models</th></tr>
<tr><td>"4P"
Product, Price, Place, Promotion</td><td>"4A"»
Acceptability + Affordability + Availability + Awareness</td></tr>
<tr><td>"5P"
"4P" + Positioning</td><td>"4C"
Customer needs and wants + Cost to the customer + Communication + Convenience</td></tr>
<tr><td>"5P"
"4P" + Package</td><td>"4E"
Ethics + Esthetics + Emotions + Eternities</td></tr>
<tr><td>"7P"
"4P" + People + Process + Physical Evidence</td><td>"4R"
Relevance + Respond + Relation + Return</td></tr>
<tr><td rowspan="4">"10P"
"4P" + People + Personnel + Package + Purchase + Probe Public Relations</td><td>"4D"
Data base management + Strategic design + Direct marketing + Differentiation</td></tr>
<tr><td>"4V"
Variation + Versatility + Value added + Vibration</td></tr>
<tr><td>"SIVA"
Solution + Information + Value + Access</td></tr>
<tr><td>"7S"
Structure + Systems + Style + Staff + Skills + Strategy + Shared Values</td></tr>
<tr><td colspan="2">"2P+2C+3S"
Personalization + Privacy + Customer Service + Community + Site + Security + Sales Promotion</td></tr>
</table>

Source: formed by the author

A list of models of the concepts of marketing mix given in Table 2 is not exhaustive, as new models are emerging. However, in our opinion, almost all alternative models of the marketing complex are based on the classic model of marketing tools of the "4P" concept.

As a scientific discipline, methodology and practice, marketing has a wide and verified apparatus of methods, techniques and tools of marketing research, collection and analysis of market and internal information. Based on our proposed approach to understanding the marketing management of the enterprise and given the needs of practical application of marketing tools for enterprise management, it is suggested to divide them into tools for marketing support of enterprise management and tools used for its implementation (Fig. 1).

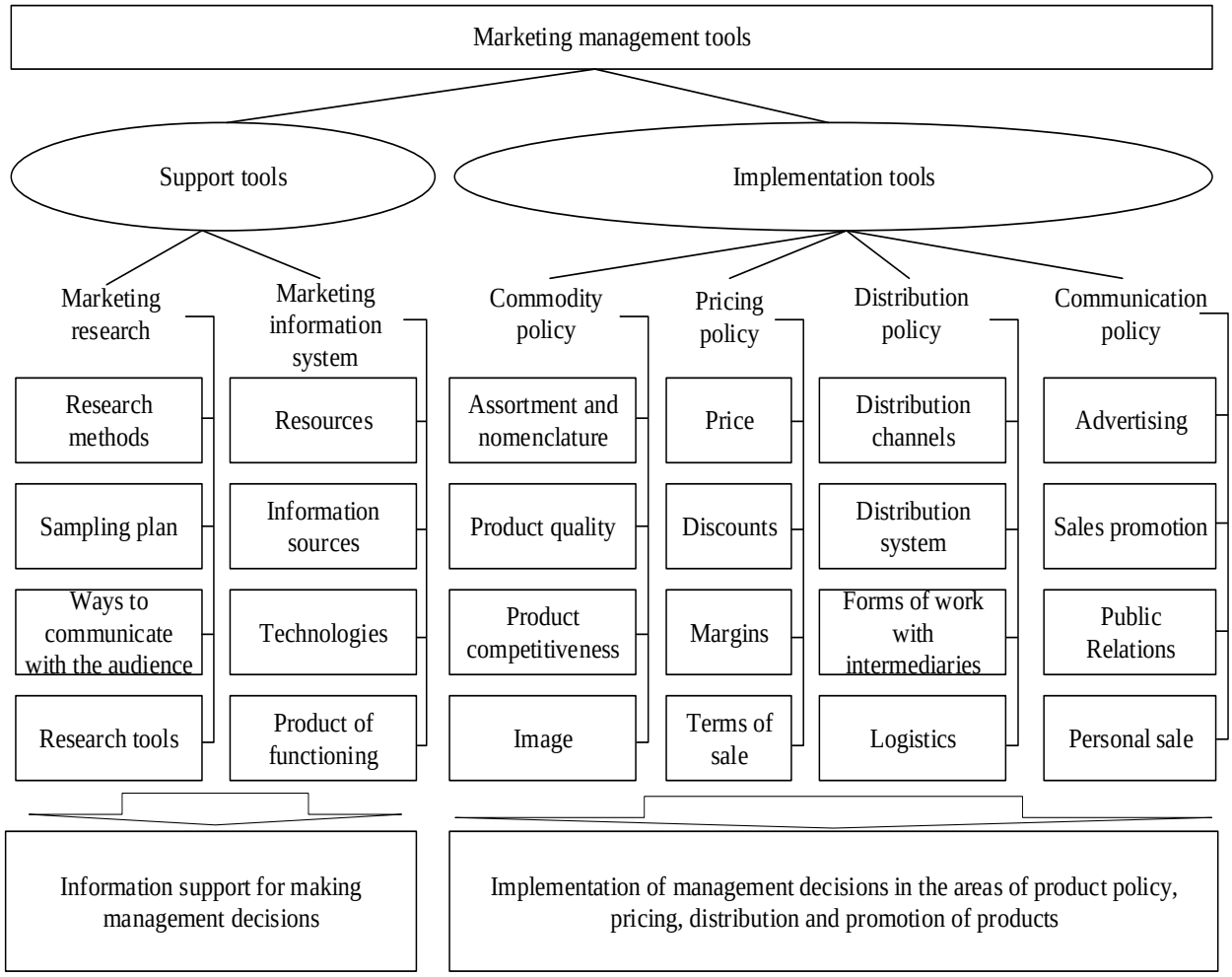


Fig.1. Marketing tools for enterprise management

Source: formed by the author

We propose to refer marketing research and marketing information system to the tools of marketing management support, while marketing commodity,

pricing, distribution and communication policies of the enterprise are suggested to be referred to implementation tools.

In recent years, along with the traditional marketing tools shown in Fig. 1, there are new, for example, Internet marketing tools, the effectiveness of which can be assessed in real time, as well as tools for marketing research of consumer needs and preferences, market trends.

When forming business strategies, companies widely use such marketing tools as methods of situational and portfolio analysis, segmentation, positioning, etc. With the help of marketing tools, the market situation is assessed and its further development is forecasted, i.e. marketing is a source of information for the formation of all levels of business strategies of the enterprise.

Marketers act as initiators, organizers and participants in the process of forming business strategies of the enterprise. At the stage of goal setting, marketing provides information about the marketing environment, strengths and weaknesses of the company and how they will affect the company's ability to achieve its goals, which makes them realistic and achievable. At the stage of planning activities by conducting marketing research and marketing analysis, the approaches of the enterprise operation are selected. Marketers, employees of analytical, economic, planning, scientific and technical and other services are involved in this activity. Marketers conduct marketing research and form recommendations for the choice of activities of the enterprise. At this stage, their recommendations are used to form the enterprise strategy and to develop plans for the strategic development of the enterprise.

At the corporate level, marketing provides identification of important factors of the external environment (unsatisfied needs, changes in the competitive environment, etc.), which must be taken into account when forming the strategy of the enterprise; at the level of structural units – a detailed understanding of market demands and means for the best meeting of these needs in a particular competitive environment; at the level of a specific product – making optimal management decisions by each individual elements of the marketing mix.

Marketing management of innovation and investment activity of the enterprise has been long carried out with the help of traditional marketing tools. However, changes in the market situation and approaches to management have forced the development of marketing as a concept and tool of management.

F. Kotler distinguishes the following reasons that no longer ensure the effectiveness of traditional marketing management and force it to develop [9]:

- today distribution of products is performed mainly by large companies that possess all the space on the shelves and decide who to provide it to and who not;
- despite the growth in the number of brands, the number of manufacturers is getting smaller. Each manufacturer has several brands for each market segment, which, in their opinion, provide them with greater protection from competitors;
- there has been observed a radical reduction in the life cycle of the product, in this regard, today it is cheaper to change the product than to repair it;
- thanks to digital and computer technologies, a new space for goods and services has appeared;
- when searching for excellent competitive advantages, companies create a large number of segments and niches, which, in its turn, leads to high market fragmentation;
- advertising has become oversaturated, which makes it difficult to attract the attention of consumers;
- novelty is the only way to attract consumers' attention.

All these reasons, especially the last one, motivate companies to increase economic and innovation-and-investment activity, which is considered not just as one of the possible goals, but as a critical condition for the existence of the enterprise. Since only innovations and their commercialization are considered to be a possible source of competitive advantage.

In the process of marketing management of the enterprise activities marketing tools solve the problem of profit maximization within the overall goal of increasing the value of enterprise assets [10]. Thus, effective implementation of a set of marketing actions with the use of marketing tools of management improves the company's position in the market, its financial condition and increases the cost, and thus increases its investment attractiveness.

Conclusions

Marketing acts as a philosophy of the enterprise operation, a system of tools for its sustainable economic development, which is implemented through the use of marketing principles, a holistic management system and implementation of the enterprise management process as a system of marketing management with a comprehensive application of marketing tools.

The use of marketing tools for enterprise management and analysis of its results can ensure the adoption of only those management decisions and the selection of those marketing tools that will have a positive impact on improving the efficiency of enterprise management.

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CREDIT RATING AS AN INDICATOR OF THE FINANCIAL POLICY DEVELOPMENT OF EU COUNTRIES

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DOI: 10.31891/monograph/2021-10-27

Introduction

In a highly dynamic environment, where changes in the markets occur in seconds, when the speed of transactions is constantly increasing and the transfer of information is instantaneous, the competition and the rules of the game are evolving, the position of the financial market investor becomes more difficult. In order to successfully conduct or manage a business, the investor, first of all, must be aware of the theory and management of credit risks, which underlies the formation of a credit rating.

Credit risk is the risk of losses incurred by the lender in the event of default by the borrower under the terms of the agreement. These liabilities arise from lending, trade and investment activities, payment and redemption of securities at own and foreign expense. Credit risk arises from the moment of making a cash deposit and grows according to the speculative degree, which depends on the form of investment [12, p.675].

Based on the economic category of credit risk, the credit rating, according to the International Monetary Fund, measures the relative probability of that an entity or side of financial transaction will be unable to meet its financial obligations, such as interest payments and principal repayment in time [9, p.88].

According to the position of Spuchakova, Valaskova and Adamko [13, p.676] credit rating includes an assessment of the risk of credit default, the risk of the guarantor or counterparties of derivative financial instruments. This risk is present in all sectors of the financial market, but is most important for banks, mainly through their lending and off-balance sheet operations, such as guarantees. Credit risk also arises through derivative financial transactions, securities lending, negotiations and repo transactions, and so on.

The service offered to determine the credit risk of banks, securities or insurance companies, public and restructured finances, in other words, all financial

institutions, including credit institutions of sovereign states, is a rating service provided by the largest credit rating agencies or rating agencies.

A rating agency is an independent company that assesses the financial condition of debt issuers and then assigns a rating that expresses an assessment of the issuer's ability to repay the debt. Potential investors rely on data and objective analysis of the RA in determining the overall strength and stability of the company or state [3].

The basis of the existence of rating agencies is the main problem of financial markets - the asymmetry of information. Markets are generally characterized by asymmetric information, which means that the true creditworthiness of the firm is the private information of issuers. The main purpose of RA is to reduce the asymmetry in available information on capital markets among investors and issuers of securities by publishing credit ratings.

The announced ratings of individual companies and sovereign states have far-reaching consequences, given the globalized economic relations between national economies at the macro level and the relationship between the financial and real sectors at the micro level. In other words, the purpose of the RA is to provide, as an intermediary, a far-sighted assessment of the relative creditworthiness of debt issuers and debt instruments, setting the expected framework of cooperation and trust that lenders have in borrowers regarding the creditworthiness of the latter.

Rating agencies play an important role in the financial decision-making process by providing market participants with information on the credit risk associated with various financial investments. They assess and publish the issuer's credit quality, i. e. its ability to return the money invested by investors. Borrowers typically use credit ratings to facilitate their own access to global capital markets because many international investors prefer rated securities (compared to unrated securities with a similar level of credit risk).

By requiring a minimum rating, investors and guarantors can limit the risk to their own assets - they are able to choose the desired degree of "danger" for their capital, providing it to borrowers at a lower or higher price, respectively. Thus, they help solve the problems of borrowers and serve the best interests of creditors.

Rating agencies provide a standardized assessment of potential risks and returns associated with alternative investments, according to creditworthiness

categories. They assign credit ratings to provide information on the probability of default, used for pricing and hedging of fixed income risk securities of corporate, municipal and sovereign issuers. Rating agencies provide market participants with an assessment of the relative creditworthiness of all bond issues by including all components of default risk in a single code - credit rating.

Although there are a number of rating agencies, the main ones being Moody's, Standard & Poor's (S&P) and Fitch, in 2019 the above companies accounted for approximately 96.4% of the credit rating market in terms of published credit ratings in the US and in the EU market - 93.2% [1, p.9]. Moreover, these companies account for 94.4% of the industry's profits. They also employ about 90% of the total workforce in the credit rating sector. These agencies assign credit ratings to issuers of debt obligations or bonds and to individual debt instruments issued by these companies. According to rating agencies, the issuers of securities may be companies, non-profit organizations or state and local authorities. Each agency has its own rating principles, according to which they assess the company's creditworthiness, which directly affects the loan rate that the issuing company will offer to bond buyers after their issue.

Taking into account the existing features of credit rating calculation, rating agencies - industry leaders (Standard & Poor's, Moody's and Fitch), using their tools to assess the risk of default of issuers or individual issues of certain securities, offer rating customers the following credit monitoring mechanisms:

1. a review that expresses medium-term forecasts (up to 2 years) and can be positive (indicating the possibility of rating upgrades over the next 2 years), stable (with a low probability of rating change) or negative (possibility of downgrading over the next 2 years) [11];

2. credit supervision, which is aimed at the short term and is carried out according to changes in certain macroeconomic indicators, which serve as the basis for calculating the credit rating (sometimes within 2 working days after the change). Moreover, during the credit supervision procedure, the company or the state does not have a credit review. It is important to note that the launch of credit supervision does not automatically change the rating position. Credit supervision lasts, on average, 70 days, during which, if necessary, the RA publishes a new rating;

3. simple rating change [11, p.643].

It should be noted that the debt crisis in the Eurozone has stressed the importance of monitoring sovereign credit risk in global financial markets. The recurring sovereign debt crises, such as the Latin American debt crisis of the 1980s, the Mexican and Russian debt crises of the 1990s, have recently inspired an ever-increasing number of sovereign credit risk studies. The fast-growing credit derivatives market offers a unique set of data to study the impact of sovereign credit risk, as they are linked to credit ratings and are easy to contract. As credit derivatives are securities, they can be used to analyze the impact of a credit rating on the development of the EU stock market.

Credit derivatives are generally used by investors to express a positive or negative credit assessment of an entity and, consequently, to accept or reduce the credit risk of bonds or loans of a sovereign or corporate entity. A significant market share of credit derivatives is given to credit default swaps, which account for approximately one third of contract volumes [2, p.25].

By definition, a credit default swap (CDS) is «an agreement in which one party purchases protection against losses that may arise as a result of a credit event of a reference entity before the date of repayment of the swap. The buyer of the protection pays periodic payments for such protection until the maturity date, if the credit event does not cause compensation for the amount of losses. If the latter occurs, the buyer of protection must only pay the contribution accumulated before the date of the credit event (standard credit default swap) and provide a loan obligation in exchange for payment of protection» [4, p.38].

The market price of KDS is quoted in principle positions and is paid annually, and is a certain measure of the credit risk of the reference entity (the larger the number of positions, the greater the credit risk). The market price of CDS, which is also called CDS spread or fixed rate, must be multiplied by the nominal value of the swap to calculate the regular payment payable under the swap contract [4, p.40].

The impact of sovereign credit default swaps (CDS) on the stability of financial markets has been the subject of much debate. Many believe that swaps are useful market risk indicators and valuable hedging instruments. Others believe that they may be speculative instruments, given that their prices do not reflect fundamental or actual risks, that is, they may abuse government funding that threatens fiscal sustainability.

In general, the authors [4, 14] found that SKDS provide signs of sovereign credit risk, which reflect the same economic and market conditions as secured bonds, with a small tendency to increase sovereign financing costs. Therefore, SKDS can create a useful hedging system to compensate for sovereign credit risk and thus can increase financial stability. In the context of their reliability as indicators of the market relative to the spread of bonds, SKDS, as a rule, react more quickly to new information in times of crisis, which is not manifested in equilibrium. It was found that for some countries during the previous financial crisis, SCDS spreads changed more than expected. SKDS can spread risks and exacerbate systemic phenomena through their connection with other markets; but so, do other financial assets, which makes it difficult to isolate their independent influences.

Given the significant impact of SKDS on the development of economic systems of the world, it should be noted that changes in the prices of the above contracts may be a decisive factor that determines the nature of the functioning of economic mechanisms [10, p.21].

Moreover, SKDS accounts for a third of derivative trading, mobilizing private funds to guarantee government bonds. The EU stock market is no exception, which is characterized by a high rate of private public debt insurance [12, p.239]. As economic cooperation within the union is the most natural among the member states of the Eurozone, the authors chose exactly 19 countries of the monetary union in order to confirm the existence of the impact of credit rating on the functioning of the EU stock market.

Paying attention to the subject of this study, it is important to emphasize that credit ratings are crucial elements in the formation of the price of SKDS. In other words, by means of spreads, credit rating has a significant impact on the development of national economies, demonstrating the level of risk for investors.

To confirm the above, the authors conducted a regression analysis of the spread of sovereign credit default swaps and the credit rating class of the Eurozone countries in 2019 (see Fig. 1, Table 1).

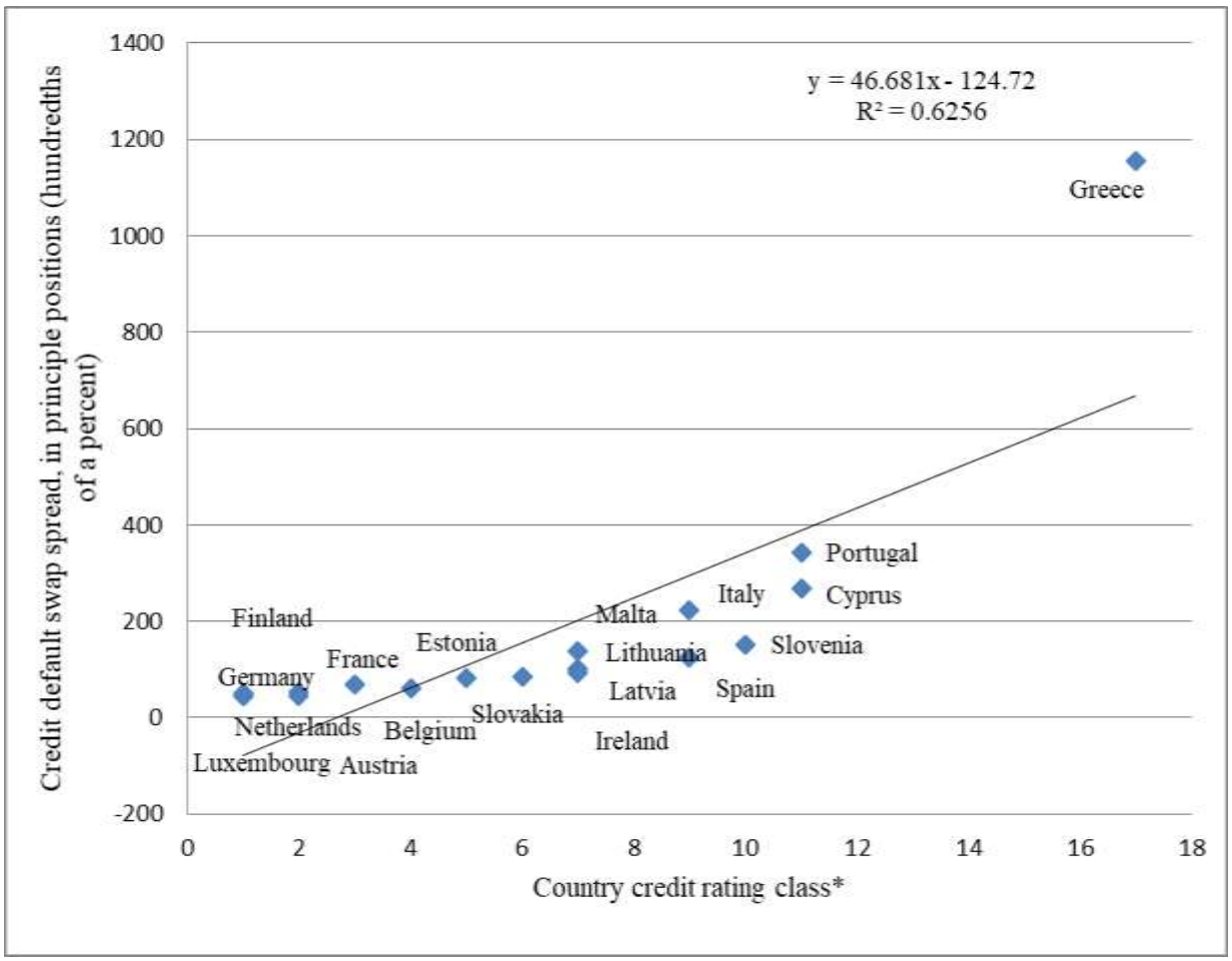


Fig. 1. Regression analysis of the indicators of the spread of sovereign credit default swaps and the credit rating class of the Eurozone countries, 2019
[5], [6] *- the number of a class is mentioned in order of rating reduction

After conducting a regression analysis of the above indicators, we conclude that they are significant (but not high) dependence - the approximation coefficient R2 = 0.6256 indicates a low degree of scattering of the random variable in the general population relative to the average. and the credit rating class of Eurozone countries is significant, but still not characterized as high (more than 0.75). This is due to the long-standing trend in the European Union to reduce the dependence of SKDS spreads on credit rating classes. Thus, in 2005 the coefficient of approximation R^2 was equal to 0.93, in 2008 - 0, 79, and in 2010 - only 0.65 [4, p.43].

Table 1. Spread indicators of sovereign credit default swaps and credit rating classes of Eurozone countries, 2019

Eurozone country	Moody's Rating	Credit default swap spread for the country	The serial number of the country according to its credit rating class
Austria	Aa1	52	2
Belgium	Aa3	60	4
Cyprus	B1	267	11
Estonia	A1	81	5
Finland	Aa1	45	2
France	Aa2	70	3
Germany	Aaa	44	1
Greece	Caa3	1155	17
Ireland	A3	102	7
Italy	Baa2	222	9
Latvia	A3	102	7
Lithuania	A3	94	7
Luxembourg	Aaa	45	1
Malta	A3	139	7
Netherlands	Aaa	51	1
Portugal	Ba1	342	11
Slovakia	A2	84	6
Slovenia	Baa3	152	10
Spain	Baa2	125	9

Source: developed by the author based on materials [5, 6].

The growing influence of factors other than credit risk in spreads is reflected in the decline in the credibility and accuracy of credit ratings during the global crisis. However, despite all the rules in place, credit rating is a determining factor in the formation of the investment image of sovereigns, and SKDS is such a security, which is based on credit risk assessment, which speaks of the role of rating as an indicator of EU stock market.

In order to further argue the impact of credit rating on the business activity of the EU stock market, it is necessary to choose an indicator that would characterize the union as a whole, without distinguishing countries on the fact of their membership in the monetary union. Such an aggregate category of stock market business activity is capitalization, which characterizes the total value of shares of all companies listed on European stock exchanges. The authors used the latest available statistics on this topic to systematize the historical movement of capitalization of the EU stock market in the form of a graph (see Fig. 2).

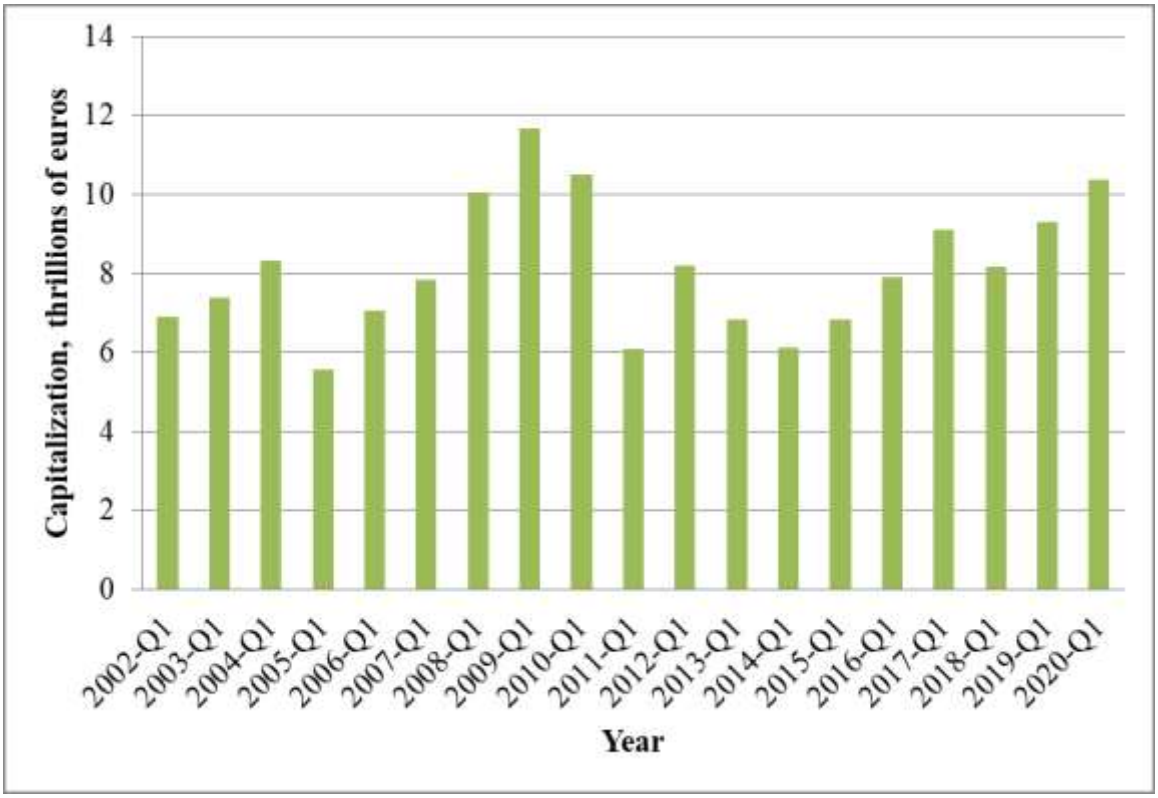


Fig. 2. Dynamics of capitalization of the EU stock market in the period 2002-2020. [7, 8]

Conclusion. Interpreting the data shown in the chart, the authors noticed a natural decline in the capitalization of the EU stock market during the global financial crisis of 2009-2010 and the crisis of the Eurozone in 2012-2014, accompanied by downgrades of the sovereign credit rating of some EU member states. In addition, the periods of the largest decline in capitalization fall on the years of providing European sovereigns with the lowest credit ratings, which indicates the relationship of the studied indicators.

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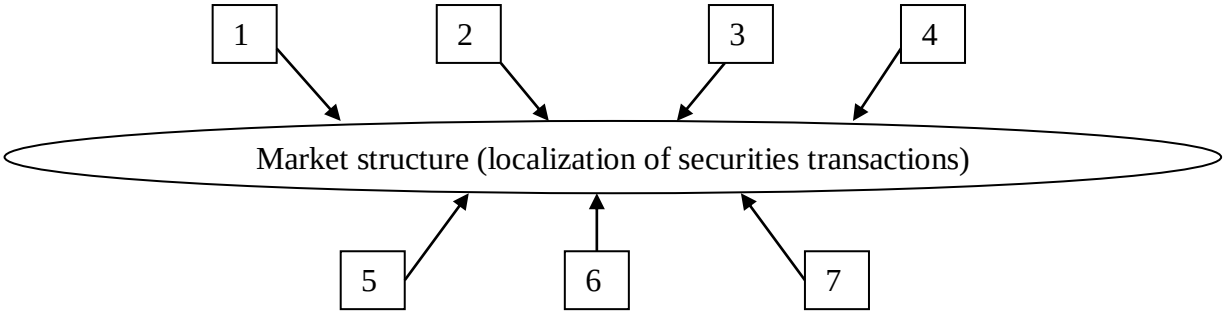
FEATURES OF STOCK MARKET DEVELOPMENT IN THE WORLD AND IN UKRAINE

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DOI: 10.31891/monograph/2021-10-28

The stock market is an area where the relationship of stock exchange, participants in the form of concluding agreements on the purchase and sale of securities and other financial instruments [9].

And the activity of the stock exchange is personified by operations with securities and documents-agreements, as well as with their circulation and placement of such objects as spheres of activity and reproduction (enterprises, banking institutions, etc.), objects, paintings, sculptures, jewelry, metals, etc.), as well as minerals (gold, platinum, oil and gas, etc.). It should be noted here that transactions with the circulation and placement of securities and financial documents form the material form of their relationship on the stock exchange and necessarily certify the legal right of the owner to the above objects.

In other words, the stock market is called the securities market. Schematically, the organizational structure of the securities market is shown in Figure 1.



1 – issuers of securities (business entities)
2 – investors who invest in securities
3 – professional market participants and stock exchange employees
4 – other subjects of relations in the securities market
5 – rights field
6 – emission mass
7 – investment mass

At persons directly involved in securities transactions

Fig.1. Organizational structure of the securities market

Based on the proposed organizational structure of the securities market, it is necessary to substantiate its essence in the modern economic system of the state. But mainly the securities market is a set of investment and financial entities and the system of relations of participants in market trades and transactions with financial instruments, as well as business entities and investors involved in these relations and concentrated and interacting in the field of exchange processes.

Economic relations are manifested in the interaction on the market of various entities - participants in securities transactions, stakeholders, business entities, government agencies. They differ not only in economic and organizational and legal functions, but also the degree of influence on the relationship of securities.

Among the market participants, first of all, it is common to distinguish stock market participants - issuers of securities (business entities), investors in securities, professional participants and self-regulatory market organizations (Figure 2) [6].

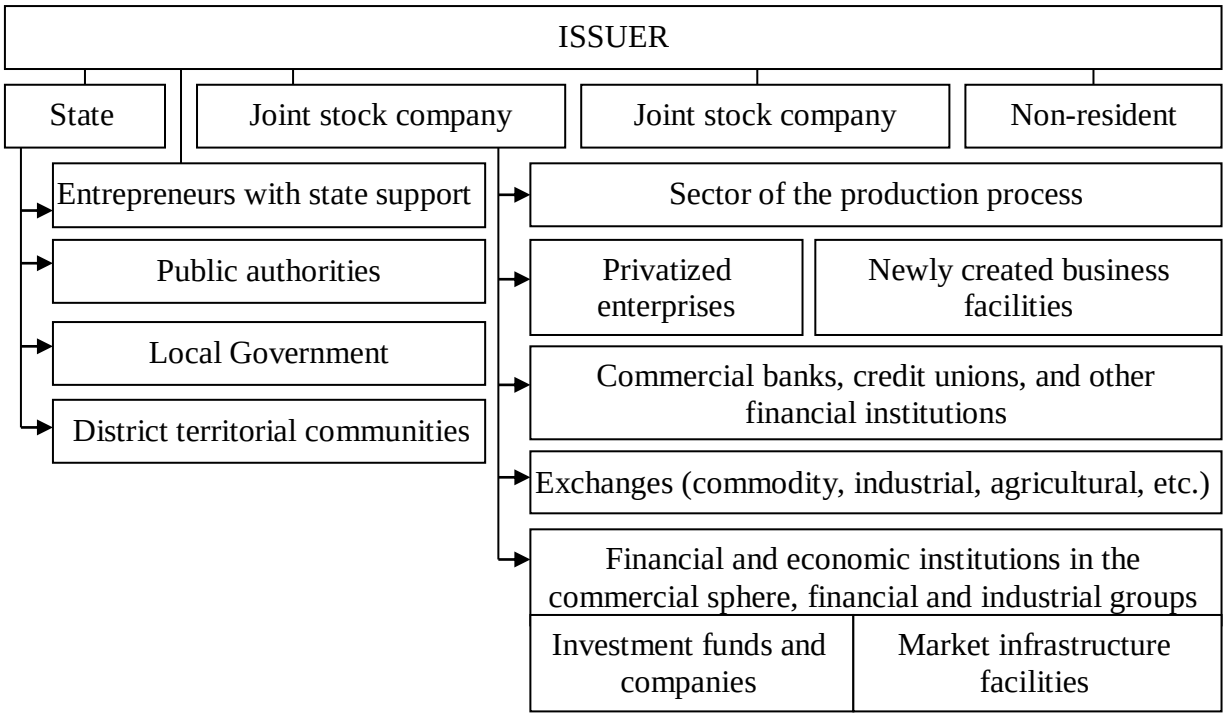


Fig.2. Classification of stock market issuers

By trading in the securities market, issuers and investors interact with each other in order to generate income and own benefits.

It is here that the synergetic result is the attraction of investment in entrepreneurial activity in order to achieve socio-economic effect. Investment

activity in the securities market is an activity of investment (money, assets, securities) by individuals and legal entities, including foreign ones, as well as the state, which is carried out through the mechanisms of securities circulation.

The organizational structure of the securities market is a set of interconnected financial formations of the market (issuers, participants, investors, government agencies) and relations arising in connection with the issuance and circulation of securities in the market, which are based on the rules of conduct in the market securities (legal field), quantitative indicators of issued securities (issue mass) and funds of market participants invested in securities (investment mass).

Each participant of the stock market in the implementation of exchange trading sets its own economic goals, and the synergetic result is to attract investment to continue its activities.

It should be noted that investment activities in the securities market means the implementation of investments in the form of legal force of specialized documents that contain information about the value and material properties of objects held by bidders in the stock market. These documents can be owned by both individual and legal entities, as well as the state, which also participates in stock trading and regulates relations in the stock market.

And the main principles of the stock exchange are [11]:

- a condition for competitive pricing of securities and other financial instruments by creating demand and supply for their purchase and sale;

- maintaining liquidity and volatility (turnover rate) in the securities market, along with compliance with equality and rules of conduct for all participants in stock trading;

- ensuring the transparency of the securities market through the disclosure of information that characterizes the market situation;

- ensuring that exchange traders and investors are informed about issuers and their securities;

- a application of effective technologies of electronic systems for concluding exchange transactions and execution of exchange contracts;

- ensuring the functioning of the stock exchange on a permanent basis;

- ensuring the protection of exchange traders and investors from abuse by establishing requirements for admission to trading, application of procedures for supervision, control and imposition of sanctions for violations.

And the development of the stock market in the leading countries of the world is accompanied by such terminological concepts for stock market operations as:

I. Percent rate is the amount specified as a percentage of the loan amount paid by the borrower for using it for a certain period.

II. Discount rate (discount rate) - the percent rate that charged by the central bank when accounting for government securities or providing a loan against collateral in the form of these securities. In the United States, the interest rate used by the Federal Reserve Bank provides short-term funds to depository institutions.

III. Repo rate – an agreement under which the seller undertakes to repurchase the security back from the buyer at a fixed price on a certain date in the future.

IV. Libor rate is the interest rate at which large banks place loans on the money market in London. Libor rates are set for different terms and for different instruments. Libor is fixed daily at 11 o'clock London time and is calculated as the average of the last ten quotations of sellers. Next, in addition, the list of interest rates in the stock exchanges of the world's leading countries should be disclosed (Table 1).

Table 1. Characteristics of interest rates in developed countries

Country	View of rate	Normative value
Australia	Cash rate	2,5%
Canada	Bank rate	1,25%
	Overnight rate target	1,0%
Europe Union	Deposit rate	0,5%
	Refinancing tender	0,25%
	Marginal lending rate	1,75%
Japan	Discount rate	0,30%
	Overnight call rate target	0,10%
New Zealand	Official cash rate	2,5%
Switzerland	3 month Libor range	0,00% - 0,75%
USA	Federal Funds	0,5 – 0,75%
	Discount rate	1,0%
United Kingdom	Repo rate	0,5%

In the world, the New York Stock Exchange NASDAQ and the London Stock Exchange are the leaders in the operations and scale of the stock exchange. And the London Stock Exchange is one of the oldest stock exchanges in the world.

The exchange was founded in 1801. Today it is the most multinational stock exchange in the world. The London Stock Exchange accounts for more than 50% of international stock trading.

The Frankfurt Stock Exchange is the largest German and one of the world's largest stock exchanges, founded in 1585. The main purpose at the time of creation was to set a single exchange rate for gold and silver coins, which were used in trade in the market square of Frankfurt. Today, the operator of the Frankfurt Stock Exchange is the Deutsche Börse Group. This is an organization with public law activities, which allows the most "transparent" and optimal organization of the bidding process. Today, about 90 percent of Germany's shares are traded on the Frankfurt Stock Exchange.

The Tokyo Stock Exchange was established in 1878, and today is one of the most important stock exchanges in the world. As a legal entity and a non-profit member organization, this exchange has quite large rights in the state in the field of self-regulation. About 80% of Japan's exchange turnover is accounted for by its share.

Its structure has changed several times, but there was no break in the auction, except for a short pause after the events in Nagasaki. Today, about two thousand Japanese companies and more than thirty foreign companies are represented on the Tokyo Stock Exchange. The main activity of the exchange is stock trading. This exchange is a member of the Federation of Stock Exchanges of Asia and Oceania.

The Moscow Stock Exchange is today one of the youngest exchanges in the world, and was established in 1997. It located in Moscow and currently among its shareholders – more than a hundred companies. The stock exchange is one of the three main exchanges in the country, the RTS and the MICEX, and is the largest commodity exchange in the Russian Federation. It took only thirteen years. The Moscow Stock Exchange is one of the main platforms of stock and commodity markets in Russia, providing the following types of services:

I. As an organizer of securities trading:

• Initial placement of securities.

• Secondary trading in securities.

• To provision of information and materials for exchange trading: quotations, estimated and market prices, trading volumes, etc.)

II. As the organizer of the auction on commodity groups: agricultural products, metals, energy carriers, raw materials, the industrial equipment, etc. The list of trade sections is updated regularly.

• Organization of auctions.

• Clearing services.

• Conducting specialized courses.

Only 10 countries account for more than 80% of the global capitalization of the global stock market and stock exchange transactions.

But it should be noted that the concept of "emerging market" does not always mean that we are talking about developing countries. For example, the group of emerging markets in 1994 included some Eastern European countries (Poland, the Czech Republic, Hungary, etc.) [8, p. 98 – 100].

The dynamics of stock prices is estimated using stock indices.

Here is general information about the main indices (Table 2), which are used in different countries. The stock market in a country is characterized primarily by the volume of exchange trading in securities, the number of securities traded on stock exchanges [7].

Securities transactions are one of the most important characteristics of the market that have the ability to provide changes in their supply and demand. But in this direction, Ukraine lags behind European countries by as much as 18 years. A separate example for comparison in Warsaw (Poland) is one of the largest stock exchanges in Central and Eastern Europe (Figure 3).

With such significant competitive advantages as a unique combination of different investors and the ability to place securities on different platforms by capitalization and trading volume, the WSE (Warsaw Stock Exchange) offers three platforms for the initial public offering of securities [11].

The main platform of the WSE is the EU-regulated market (market access is granted through the approval of the issuer's prospectus), where there is only a public offering (IPO / SPO); leader in the region of Central and Eastern Europe; № 7 in the world in terms of the growth rate of stock trading. And the New Con site (local and foreign companies) is № 1 in Europe in terms of the number of IPOs and growth rates among alternative sites in 2012.

The next platform - Catalyst - a market for fixed income instruments, which includes: corporate bonds; cooperative bonds; treasury bonds; municipal bonds;

secured bonds.

Table 2. Major stock indices

Countries and index	Number of shares	Base	The value on 2.07.2021
USA			
DowJones Industrial Average	30	-	5720.38
New York Stock Exchange Composite Index	All shares NYE (2128 in 1994)	1965 = 50	361,01
Standard and Poor's 500	500	1941-1943 = 10	673,61
Standard and Poor's 100	100	то же	653.79
NASDAQ Composite Index	4013	1971 = 100	1191.15
United Kingdom			
FT-SE 100 Index	100	1984 = 1000	3725,7
Japan			
Nikkei Dow Jones Average	225	-	22347,97
TOPIX	1235	1968 = 100	1699,43
France			
SBF 250 Index	250	1990 = 1000	1232,86*
SAS 40 Index	40	1989 = 1000	2111,80
Germany			
DAX Index	30	1987 = 1000	2572,25
Canada			
TSE 300 Composite Index	300	1977 = 1000	5061,46
Switzerland			
SPI Index	351	1987 = 1000	2123.40*
Gong-Kong			
Hang Seng Index	33	-	11084,43
All Ordinaries Index	520	1986 = 1000	4770,57*
Australia			
All Ordinaries Index	320	1979 = 500	2256,3
Korea			
KOSPI	714	1980 = 100	837,93
Italy			
MIB	320	1975 = 1000	9138,00*

Table 3. Capitalization index of shares of Ukrainian companies in the WSE (Warsaw Stock Exchange)

WIG-Ukraine									
Issuer	Branch	ISIN code	28.02.2019		31.05.2019		30.08.2019		deviation (+, -)
			Share, %	PLN	Share, %	PLN	Share, %	PLN	
KERNEL	Agricultural	LU0327357389	40,00	49,45	40,00	46,50	40,00	45,20	-4,30
ASTARTA	Agricultural	NL0000686509	25,06	29,90	22,12	24,60	21,87	22,80	-7,10
IMCOMPANY	Agricultural	LU0607203980	14,22	14,10	16,01	14,55	18,60	15,90	1,80
OVOSTAR	Food industry	NL0009805613	18,93	108,00	19,78	101,00	16,96	79,50	-28,50
AGROTON	Agricultural	CY0101062111	1,80	3,41	2,09	3,55	1,89	2,95	-0,46
COALENERG	Fossil coal industry	LU0646112838					0,67	0,45	-

Today, 11 Ukrainian companies have placed their securities on the main platform of the WSE, two companies - on the alternative site New Connect, as a result of which more than half a billion euros were attracted by Ukrainian companies. That is, the capitalization of shares of Ukrainian companies has increased so much that there is a need to launch the Index of Ukrainian Companies on the WSE - WIG Ukraine (since May 3, 2011) (Table 3). Here we should disclose the competitive advantages of the WSE, which include:

- Mutual information coverage of both markets;
- Understanding, on the part of Polish investors, of the peculiarities of doing business in Ukraine;
- Low cost of raising capital and payment for listing;
- Combination of investors with a high share of individual investors that generate liquidity in the securities market;
- The largest base of institutional investors in the CEE region, with a high level of capital investment. Today, the global stock market is developing rapidly and is a huge opportunity to invest profitably. Comments on the stock market and the efficiency of obtaining forecasts of the dynamics of the stock market, and qualitative reviews of the stock market, allow timely decisions by issuers of securities in the daily trading of securities, given the situation on world stock exchanges.

And with the functioning of the stock market in Ukraine, there must be a full range of information support, because the disclosure of information - a necessary condition not only for the successful placement of securities, but. and maintaining their liquidity in the process of further circulation in the stock market. Investors, both direct and portfolio, are interested in obtaining the most complete information about companies that bring their securities to the open market [1; 4, c. 240]. Shareholders need access to regular, reliable and comparable information that is detailed enough to enable them to assess the quality of management's management and to make informed decisions on valuation and share voting.

Issuers, in turn, understand that today increasing the level of information transparency facilitates the attraction of additional funds and increases the confidence of shareholders and potential investors, which ultimately leads to increased capitalization of the company.

The development of the Ukrainian stock market led to the appearance of Ukrainian stock indices in early 1997 [4]. These include the following indices:

1. PFTS - the index is the official indicator of the First Stock Trading System and is calculated on the basis of ordinary shares of enterprises listed in the PFTS. The index is calculated by the weighted arithmetic mean method and is calculated from 1.10.1997.

2. The Wood-15 index, calculated by Wood & Company Ukraine since July 1, 1997, which is based on the Paasche index. The index base includes 15 companies that occupy a leading position in the Ukrainian stock market.

3. Index SBPU-30, which was developed by specialists of JSC "Sofia-Securities". It is built on the principle of weighted arithmetic mean. The peculiarity of the index is that the calculation uses a currency index, which takes into account the current dollar exchange rate and the euro against the hryvnia.

4. The Inekodex index is the first Ukrainian industry stock index that reflects the current situation on the market of energy companies. It is calculated on the basis of the arithmetic mean of relative prices.

5. The IPI-U index has been calculated jointly by Interfax-Ukraine and Polar-Invest since January 1, 1999. The index base includes the most liquid stocks, and the listing is changed monthly. The peculiarity of this index is that it is calculated based on dollar stock prices.

6. The SOCRATES index is calculated according to the principle of the aggregate index. When calculating the market capitalization, only those shares that are traded on the secondary market are taken into account.

7. The KINDEX index has been calculated since September 1998 by KINTO. The index is market-weighted and it allows you to study the dynamics of prices of the most liquid stocks traded on the Ukrainian stock market. The composition of the index changes if companies cease to meet certain conditions (the spread between the best quotations of supply and demand should not exceed 100%; the number of quotations of both supply and demand should not be less than 5%). Figure 3 shows the model of interaction between objects and subjects of the stock market of Ukraine.

The main stock exchanges in Ukraine are: PFTS Stock Exchange (First Stock Trading System) and PJSC Ukrainian Exchange.

PFTS Stock Exchange is one of the largest organizers of securities trading in

Ukraine. Founded in 1996, PFTS is an organizer of trades in shares, bonds of domestic and foreign government loans, local loans, enterprises, treasury obligations of Ukraine, savings certificates and investment certificates. Here validation on the basis of a license issued by the National Commission on Securities and Stock Market of Ukraine (NSSMC) [4].

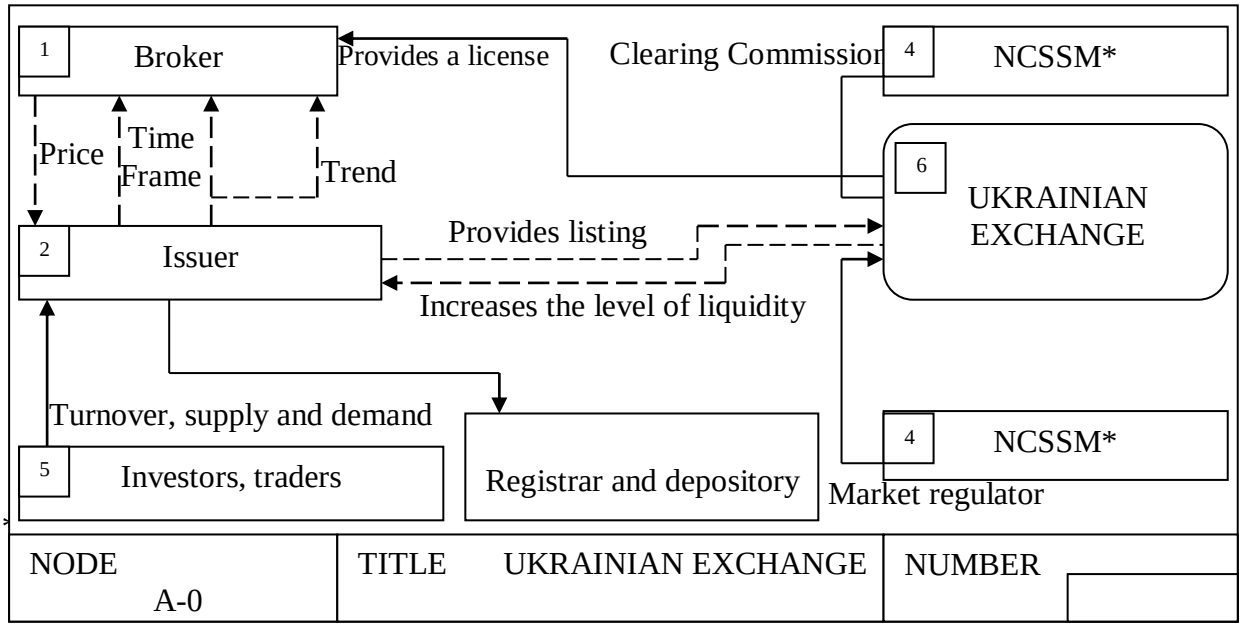


Fig.3. Objects and subjects of the stock market that are displayed in the BPwin software product

PJSC "Ukrainian Stock Exchange" is a stock exchange of securities of Ukraine, founded in May 2008 in Kyiv, where the constituent assembly was held and the authorized capital in the amount of UAH 12 million was approved. The Moscow Stock Exchange was the initiator of the creation and at the time of its creation UB owned 49% of the shares. The remaining 51% of shares were distributed among 21 Ukrainian companies [10].

In the next three years, Ukraine plans to create an integrated center of capital markets and commodity markets - the National Exchange for Trade in Capital and Goods (NEXT-UA). And the main structural units of NEXT-UA will include [13]:

- Universal Trading Exchange,
- Financial infrastructure company (depository, settlement and clearing center and trade repository),
- Arbitration Center,
- Advisory Board,
- Investor Relations Office.

It is expected that NEXT-UA will promote the integration of Ukrainian markets into the international ecosystem and the availability of better price targets for commodities. Businesses are also expected to receive hedging mechanisms through transparent capital markets, energy, agriculture and other products. This initiative will also promote the development of financial services based on international best practices and innovative financial technologies.

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DIGITIZATION OF PERSONNEL MANAGEMENT PROCESSES

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DOI: 10.31891/monograph/2021-10-29

1. Introduction

The desire of the Ukrainian society for new stages in the development of information technologies in the economy generates the need for large-scale modifications. Digitalization has an impact on almost all areas of activity, both individual enterprises and the entire industry as a whole. The personnel management system in this regard will not be an exception. At the same time, Digital-HR is a completely new stage in the development of the HR industry, which involves working with personnel at a completely new level, which requires the use of various kinds of innovative digital technologies. The practice of using information technologies indicates that their use significantly speeds up the collection, processing, transfer and use of information, simplifies communication with production personnel. The conducted research suggests that industrial enterprises that have implemented HR digitalization in their work have significant competitive advantages over enterprises that still use traditional paper technologies.

The history of the development of HR-management technologies makes it possible to distinguish four main stages.

1. *HR paper technologies.* At this stage, information flows are carried out independently one from one, reporting is at the lowest level.

2. *Technologies of early computer technologies*. At this stage, there is a movement of all the data arrays that were on paper media to hard disks of personal computers and to local information networks.

3. *Electronic information databases.* The first relational databases appear, the use of which makes it possible to connect various arrays of information with each other.

4. *The stage of web technologies.* At this stage, the transition to an electronic HR management system, active use of the Internet and its mobile applications is underway [1].

The sphere of digitalization of HR at Ukrainian enterprises is currently only at the initial stage of its inception. Less than 10% of them are currently at the stage

of modern digitalization, while about 30% still adhere to obsolete paper technologies [2]. Foreign enterprises are far ahead in this area.

Most foreign enterprises have fully digitalized their production and commercial activities in the field of personnel management. According to the results of the Deloitte study, today about 7% of enterprises use mobile information technologies for training production personnel, 10% for labor productivity management, 8% for time planning, 13% for recruiting and 21% for planning staff rest [3, 4].

Industrial enterprises that use the aging paper-based HR technologies face a number of challenges in recruiting and managing staff, among which are the following:

- great difficulties in the formation of a team of employees;
- low efficiency of personnel selection;
- outdated, ineffective methods of personnel search, which as a result leads to unnecessary expenditures of funds and time;
- low efficiency in the use of production personnel;
- the practical absence of a system for improving the qualifications of personnel, etc.

For a practical solution to these problems, it is extremely important to use new Digital-HR technologies. With their help, it becomes possible to make the process of recruiting and employing personnel much easier, to reduce the cost of wages, since automation reduces the number and volume of routine operations for collecting and processing information about potential employees, correspondence with them, etc.

2. Analysis of recent research and publications

Quite a lot of interesting studies by both Ukrainian and foreign scientists are devoted to the study and analysis of various aspects of the transformation and development of the processes of digitalization of the economy. In particular, Bey G.V. and Sereda G.V. the basis of their research was the identification of the characteristic features of the processes of digitalization of the Ukrainian economy in the field of entrepreneurship [5]. Bersin J. conducted a study of the current state and prospects for the development of the digital economy in the member states of the European Union and in our country. They managed to highlight the most important problems of digitalization in the Ukrainian economy [6].

Dlugopolskaya T.I. and Guk Y.V. analyzed in detail the reasons for some failures in the digitalization of the Ukrainian economy. To do this, he used a system of index calculations, based on the results of which certain recommendations were presented, the use of which can achieve a certain improvement in the current situation [7]. Zhukovska V.M. considered the problems of modernizing the modern economy of Ukraine, associated with the development of the digital component. Also, these authors investigated the current trends in the development of digital platforms [8], the formation and use of which also has certain problems today. Belyatsky N.P. and Podupeyko A.A. carried out a detailed analysis of the reasons for the unstable employment of personnel at industrial enterprises in the context of the digitalization of the economy [9]. Sand R. [10] and Lalwani P. [11] put the task of developing the content and tasks of the profession "accountant" in the context of digital agenda and the future of this profession.

Despite the fact that in modern scientific literature, a lot of attention is paid to the analysis of certain sections of the digital economy. Particular attention in this study was paid to the implementation of information technology in industrial enterprises. The authors point out that digitalization processes require changing the requirements for the functional responsibilities of information systems personnel and determining whether they have digital skills and competencies. This direction in existing research is not sufficiently disclosed, it requires further research and development.

3. Research results

Currently, in the field of personnel management of industrial enterprises, there is a rapid development of information technology, the criteria and methods for assessing the effectiveness of production personnel management systems are changing. The internal and external environment of enterprises and organizations is changing significantly. All this leads to fundamental changes in the field of enterprise resource management, and this is especially manifested in the production personnel management system [9]. At this stage of economic development of industrial enterprises, traditional models of production personnel management usually consist of several of the most important subsystems designed to perform certain functions (Fig. 1).

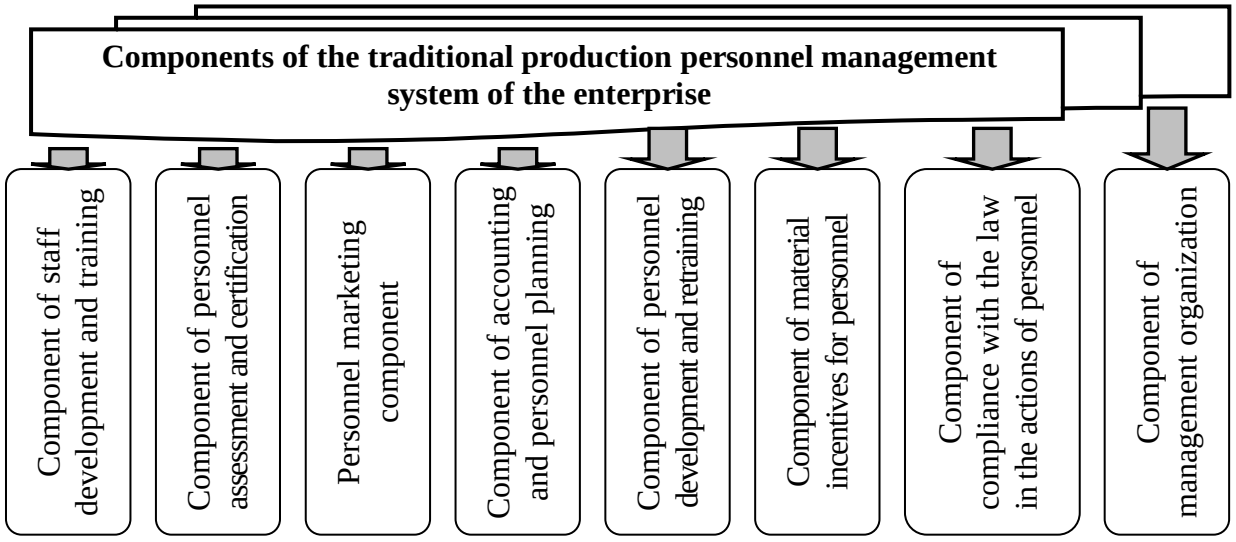


Fig. 1. The complex of components of the traditional personnel management system at an industrial enterprise

Any comparison of traditional and progressive (digital) concepts of production personnel management involves the identification and substantiation of the distinctive features of each of them (Table 1).

Table 1. Comparison of the distinctive features of traditional and progressive (digital) concepts of production personnel management

Name of distinctive features	
Traditional personnel management system	*Progressive (digital) personnel management system*
Human capital is the main resource for management activities	The combination of digital technology and talented programmers is the main resource
The staff receives unskilled (insufficiently justified) tasks	The management process is an intellectual activity
The division of labor takes place according to the functional principle	Management decisions are developed based on project activities
The main efforts are focused on the organization of management processes	The staff is an accomplice in the work to increase labor productivity
The work uses standard software products	Mobile applications are actively used, work is aimed at innovative solutions

In our opinion, the sensitivity of personnel to digital technologies should be assessed as the ability and readiness of each employee to adapt to possible changes in the work of the enterprise caused by the use of digital technologies, to perceive them and apply them in their work to solve problems of increasing labor productivity.

The strategy of digitalization of personnel management, in our opinion, should contain certain principles and directions for achieving the commercial goals of the

enterprise, as well as reflect the factors and conditions necessary for the implementation of this process. The goal of the digitalization of personnel management is the growth of the enterprise through the growth of labor productivity and the development of the potential of employees. The digitalization of personnel management processes requires the development of certain principles, the use of which makes it possible to form an effective process for the development, implementation and use of modern digital technologies in the field of production personnel management. Among them: a focus on increasing the productivity of the organization's personnel by stimulating the digital sensitivity of individual employees; focus on the continuous development of digital technologies; adaptability, i.e. the digitalization strategy must respond to possible external changes that are dictated by the actual conditions of the digital technology market and respond promptly to these changes (Fig. 2).

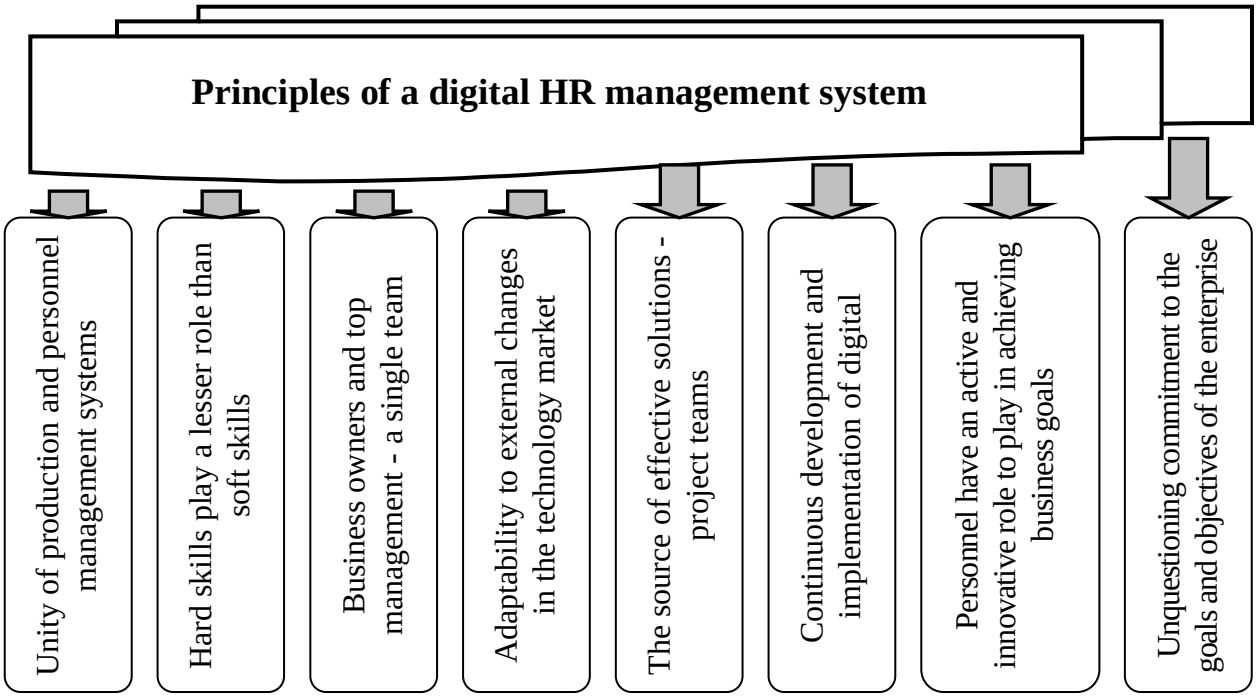


Fig. 2. Basic principles of digital transformation in the personnel management system

It is proposed to implement the Digital-HR strategy in practice in the context of several main directions [9]:

a) the introduction of information technology in the process of searching and hiring personnel of an enterprise: the use of mass social networks in order to find the necessary employees, analytical and cognitive methods of recruiting, the use of automated systems for recruiting employees in their work, the use of modern

technologies that allow remote interviews with potential candidates for vacant posts;

b) the introduction of information technology in the training and development of the most talented employees. This will provide real opportunities to quickly acquire the necessary skills, knowledge and abilities, independently draw up conditions and a training program, develop a base of existing opportunities in the field of education, intensify the practical use of mobile devices, applications for them, etc.;

c) the introduction of information technology in the management process: the introduction of management technologies using artificial intelligence, which provides an analytical study of the learning process itself and its results. It also makes it possible to predict the success of employee training, using the results of the analysis of the results of interviews, to determine the level of the enterprise's need for personnel training. There are real opportunities for the use of cloud technologies in order to effectively use network resources and combine them into a single local educational network. The practical replacement of paper circulation of documents with electronic document circulation is also becoming a reality. The development of platforms for information analysis and forecasting of the level of labor productivity, as well as the degree of use of the production personnel of the enterprise to increase it;

d) increasing the digital competence of employees of the HR department, implementing information policy in the system of advanced training and training of the company's personnel;

e) implementation of digital workstations, digitalization of the working environment: using the company's own databases to search, buy and use information on various enterprise projects, develop an integrated digital platform based on the experience of personnel, provide feedback between personnel and top management of the company , providing staff with real opportunities to provide remote work.

The indicated directions of the digital transformation of personnel management make it possible to determine the essence and significance of the Digital-HR strategy, the implementation of which in practice will ensure the effective functioning of Digital-HR in the above directions.

It seems important and necessary to consider the key trends in the field of personnel management, which, in our opinion, have a significant impact on the development and degree of use of Digital-HR in industrial enterprises. It is proposed to take into account the following types of trends that directly affect the development and improvement of Digital-HR:

a) the presence of prerequisites for conceptual changes in personnel management at enterprises, the transition to VUCA - a new environment for talent management and personnel planning. VUCA stands for:

- Volatility (volatility, instability, instability, volatility) - the situation changes quickly and unpredictably (based on these changes, you cannot predict the future situation or plan actions);

- Uncertainty (uncertainty) is the "place" where major disruptive changes happen. And the past in a given place is not a predictor of the future: determining what is to come is extremely difficult;

- Complexity (complexity) - a "place" where many difficult to understand facts, causes and factors add up to problems;

- Ambiguity (ambiguity, ambiguity, uncertainty) - a “place” where it is difficult to answer the questions “who, what, where, when, how and why”;

b) a radical change in the place and role of the HR department. Transforming it from a support unit into a business partner of the enterprise, making the fundamental decisions that affect the business success of the enterprise. Creation of such conditions at the enterprise when HR-managers ensure sustainable development and long-term prosperity of the enterprise through the use of the most modern information technologies in human capital management. The HR business partnership model in recent years has been an original trend in the HR management market. The purpose of introducing the position of HR-business partner is to reduce the time spent on solving a particular problem. Ideally, we should talk about a special project manager, the use of which increases the efficiency of the implementation of HR processes. This proposal is of particular importance for large enterprises with a voluminous structure;

c) there is a need to take into account the characteristics of the generations of personnel when choosing methods and management tools. According to the existing theory of generations, the distinctive features of the employees of

generation "U", which in the near future will make up about 40 ... 45% of the labor market, are:

- striving for self-realization;
- high level of digital sensitivity;
- informal communication style;
- requirements for a free work schedule;
- work automation;
- openness in communications, etc.

All this inevitably leads to a change in the paradigm of human resource management in accordance with existing needs, needs and interests;

d) the interest of production organizers (employers) in the automation of all functions performed by the personnel management department is progressively increasing. The development and implementation of programs for automating the processes of recruiting and training personnel provides real opportunities to eradicate routine work and focus on more important tasks that require attention and creativity.

So, digitalization can provide industrial enterprises with a lot of advantages [1]. The obvious advantages of digitalizing production personnel management are:

- a significant reduction in labor intensity, cost reduction and an increase in the efficiency of HR processes in comparison with the work of a living specialist;
- release of labor resources by reducing the time for employees to carry out various business processes. This creates opportunities to release workers to perform other, more important tasks or reduce their total number, while maintaining the pace and volume of work performed;
- reducing the distance in the manufacturer - consumer system. When using digitalization, the consumer uses the manufacturer's services without a personal visit to the enterprise. This allows, firstly, to improve the reputation of the enterprise; secondly, to keep the consumer in touch for a sufficiently long time; thirdly, it provides the consumer with the opportunity to purchase the goods of the enterprise, regardless of its location;
- increasing the efficiency of personnel management processes by increasing the efficiency of each employee who does not spend his working time on many operations transferred to the digital field. Various kinds of digital technologies are

also important, which monitor the quality of the work of the personnel, keep track of their working time, and check the effectiveness of its use by each employee;

- the level of product quality increases, the cost of production decreases. Note that this advantage is not manifested in every enterprise, since it is not always possible to influence the technological content of production processes even with the help of digitalization;

- acquisition of additional competitive advantages by the enterprise and its products. Digitalization can help a company quickly and efficiently get an additional competitive advantage that other market participants who are engaged in the same field of activity do not have. Note that the lack of digitalization, on the contrary, can lead an enterprise to obtain the status of a market outsider and, as a result, to crisis phenomena at the enterprise;

- long-term wide automation of production and management decisions. Digitalization is the foundation for the development of innovative solutions in the field of information technology, which allows you to completely eliminate the prerequisites for control and personal participation of management in certain business processes.

The digitalization of management processes, as an effective tool for improving the production and commercial activities of an industrial enterprise, has not only positive characteristics. It also has certain disadvantages that can cause negative consequences if you do not pay attention to them in time. In our opinion, such disadvantages include:

- excessive costs of the enterprise for the development and implementation of digitalization projects. Note that digitalization does not always provide a real increase in the company's income. Therefore, it is imperative to make a detailed and comprehensive analysis of the task, determine the expected income from digitalization and compare it with the real costs of its implementation;

- the presence of significant difficulties in the implementation of digitalization projects. It is quite easy to break the existing and, possibly, efficiently operating mechanism. However, the consequences of this action can be unpredictable. Therefore, it is necessary to substantiate in detail the digital reform of each business process and predict what the final results can lead to a radical change in business processes when they are transferred to the digital sphere;

- the possibility of leakage of commercial information. Information leakage risks increase significantly with the massive introduction of digital technologies. Ensuring the required level of security will inevitably lead to a significant increase in the cost of digitalization projects. And this can cause direct and indirect damage to the image of the enterprise, its consumers and other stakeholders, as well as the entire business as a whole.

4. Conclusion

The results of the study allow us to conclude that the effective functioning of Digital-HR causes fundamental changes in the field of personnel management, in the structure and nature of the functioning of the modern market for various types of goods and services, suggests a real need to develop the activity of enterprises and organizations in the field of information technology. The main attention in the formation of the information environment of the enterprise is placed on the creation of the information infrastructure. At the same time, it should be noted that a very important role is played by the creation of a system and the necessary culture of using Digital-HR, i.e. formation of information (digital) competencies among employees. Therefore, when forming a strategy for the information development of an enterprise, special attention should be paid to the used and projected production personnel management systems. Hence, it follows that the most important task that determines the effectiveness of personnel management in the context of the widespread use of digital technologies is to ensure the effective work of personnel and increase their labor productivity, only in this case it is possible for the enterprise to switch to an innovative path of development and use of its digital activity. In our opinion, the practical use of the Digital-HR strategy will allow enterprises to use fundamentally new information approaches to the management of labor potential, workplaces at the enterprise and the system of labor relations in their production and commercial activities. All this is possible if industrial enterprises introduce modern systems of information (digital) technologies into the basis of their activities, which will provide them with an innovative way of improvement and development.

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PSYCHOLOGICAL PECULIARITIES OF MOTIVATION IN MASTERING A FOREIGN LANGUAGE

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DOI: 10.31891/monograph/2021-10-30

Introduction

The specificity of motivation to master a foreign language is determined by the peculiarity of the discipline "foreign language", which differs from others by its aspects. First of all, this specificity lies in some modification of thinking itself. While teaching a foreign language, the teacher tries to think in that language. The characteristics of a foreign language is manifested in its "irrelevance", the teacher should find the "subject", fill the foreign language with the content in accordance with the requests and interests of students. This feature of a foreign language is associated with another one, namely: the "infinity" of a foreign language as a subject of study.

Learning a foreign language is a study of a foreign language culture. A foreign language culture competence is commonly understood as everything that can bring learners the process of its mastering the educational, cognitive, developmental and educational aspects. Knowledge, skills, abilities, motivation are the elements of the content of foreign culture which are correlated with such aspects of learning as perception, cognition, development, education. In this sense, the components of a foreign culture can be defined as learning objectives [1, p. 156].

The process of a foreign language mastering enriches the worldview of students, because they receive information about its original country – customs, foreign culture, learn more about their native language by comparing different linguistic phenomena, forms, thus expanding their philological background. Working with reference books develops a culture of mental work, develops special skills for the rational implementation of educational tasks, and it is a prerequisite for the development of the need for self-education. Mastering a foreign language promotes the development of all types of memory, thinking, especially abstract, as well as such mental operations: synthesis, analysis, etc., it has a positive effect on the development of abilities such as phonemic hearing, language forecasting,

imitative abilities, it promotes the development of imagination and creativity of the students [2, p. 41-44].

The analysis of recent sources and publications

The problem of motivation and attitude to a foreign language is widely described in the works of such foreign authors as: Ellis Rod, Brown H. Douglas, R. C. Gardner [5], W. E. Lambert, D. Wilkins, S. Krashen [7], P.C. Smyth. R. Gardner and W. Lambert studied this problem very thoroughly. They identified two major groups of motivation: instrumental and integrative. Instrumental motivation implies the desire to master a foreign language for certain practical purposes, such as getting a job, reading foreign newspapers or texts, passing an exam or receiving a promotion in hierarchical degrees. This category also includes more negative factors, such as fear of failure and so on. Integrative motivation is the desire to master a language in order to understand and communicate with the people in their native language.

It was originally thought that those who were taught with integrative motivation mastered the language more successfully than those who had instrumental motivation. The recent studies by O. Burcu, G. Carol, M. Degang, W. Huitt, E. Leigh, C. Taylor questioned this statement. It is believed that now these two groups are not completely independent on each other, as it was previously reported: the motivation of the learner may include elements of both the first and the second types, and that indicates the complexity of the problem of motivation.

Presentation of the main research material

During our survey we referred to the psychologist O. Leontiev who sees in the creative nature of language one of the characteristic features of a foreign language in general and a foreign language in particular. All the personal characteristics of the learners are especially evident in the process of foreign language learning, and their connection with the successful of learning feedback is more clearly visible as well. Finally, the peculiarity of a foreign language comprises no fragmentary knowledge of any certain aspects of a foreign language itself but has an independent value, only a holistic knowledge of a foreign language gives an awareness of its usefulness [1, p.127-130].

According to I. Zimnyaya, the main conditions for creating the necessary motivation to master a foreign language are the following:

1) the formation of cognitive and communicative needs;

2) the content of educational material, which has for learners educational, developmental and general educational value;

3) the implementation of personal-activity approach.

The first one states that a foreign language, just like a native language, is a means of communication.

Communication requires a motive, a need that has to be formed. The second states that when this need is formed, it is necessary to offer the learner an appropriate subject-semantic content that would satisfy this need. And the third means that the learner is at the center of learning with all his individual psychological features, it is from the standpoint of the learner, the purpose of the lesson is determined. The personal-activity approach assumes equal relations between the teacher and the group of learners, the teacher and the learner as communication partners [3, p.130-131].

According to N. Kuzovlyova, the attitude to the subject itself consists of two components: the interest in it and the awareness of its importance. As a rule, mastering a foreign language is not colored by personal content, which sharply reduces its significance and interest in it. N. Kuzovlyova divides internal motivation in mastering a foreign language into three types: communicative (provides linguistic intent and situational interest), operational-instrumental (provides procedural interest) and cognitive (provides cognitive interest in the subject). External motivation includes socially conditioned (related to the civic motives of students' awareness of social necessity, obligation, that form the content of education) and personality-conditioned motivation (which provides awareness of the need to know a foreign language for future work or study).

If we consider professional intention as a motivating factor, it can be a part of the motives of each type of aforesaid motivation. P. Kozyk combined all the motives in the process of foreign language learning into four groups: a) motives based on the social and personal significance of the subject; b) motives related to a certain type of foreign language and speaking activity; c) socially determined motives; d) motives, which are based on the consciousness of the necessity to learn a foreign language beyond the connection of personal motives of another order [4].

According to S. Grigoryan, awareness of the goals of foreign language learning is not always a solid motivating tool that can support the cognitive activity

of learners at the appropriate level. This activity can be supported by the functioning of procedural, relevant motives (based on the cognitive interests of learners to the studied language). S. Grigoryan identifies two types of motivations that motivate the process of a foreign language learning. On the one hand, these are the needs that come from the psychological model of the individual (goals, requests, perspectives), on the other hand, they are cognitive interests arising from the internal model of educational activity. He describes another important type of motivation, specific to learning a foreign language, namely – the functioning of social motivation based on the need for communication [4].

R. Gardner combined a number of components in the form of a model of motivational characteristics. Although this model was developed on the example of French as a foreign language, its categories are not limited to any language; they can be applied to any foreign language learner. Gardner distinguishes four main categories:

1) the attitude to people who speak the studied language;

2) attitudes related to the study of a foreign language;

3) motivational indices;

4) generalized attitude.

The first component includes attitudes towards the community and people who speak the studied language. The second component includes the attitude to the language learning process itself, so to say the learning situation: how the learner perceives the language learning process in the course and the personality of a teacher, what is his parents' opinion about his learning this language. This category also includes the assessment of feelings of anxiety during language classes; the more confident and free the learner feels, the more successful he will be during his knowledge acquisition compared to those who feel anxious during classes.

The first category relates to the learning situation, the second understands the relationships that develop during the learning process. The third category concerns the motives for learning a language, its goals and includes the intensity of efforts made to learn a language. In this model, R. Gardner does not mention instrumental motivation, because, in his opinion, integrative motivation is crucial. This category includes both initial factors, so to say those that occur before the start of training, and those that occur during the training process. The fourth group of variables according to R. Gardner's scheme is a generalized attitude that

includes a general interest in foreign languages, the need to achieve and interest in a particular language. Thus, Gardner's scheme includes general personal characteristics that may have a positive or negative impact on foreign language learning.

R. Gardner's model demonstrates that abilities cannot be considered the only characteristic of a language learner, no less important role belongs to the affective aspect, so called motivation and attitude to a foreign language, which means something more than just a desire to learn the language. The affective aspect includes many components that together make up the overall orientation of the relationship in the complex. This scheme appears to us incomplete. It does not reveal those aspects of the relationship that determine and precede the process of study of a foreign language, and it does not distinguish them from the attitudes that arise in the process of language learning. There is no distinction between more stable, affective personality characteristics from direct affective reactions to language learning, here we mean the situational attitude.

These problems have to some extent been covered in the works of foreign authors who have studied such aspects as:

a) affective conditions that precede the study of a foreign language (initial affective attitude);

b) affective conditions that arise in the process of language learning;

c) finally, the affective conditions that are the result of learning.

R. Gardner and his group paid much attention to the initial attitude to the language. Interest in the affective aspect in the learning process is reflected in some recent experimental approaches that attempt to reduce the negative attitudes of learners when encountering a new language. Finally, very little is said by researchers about motivation as a goal or learning outcome. Affective learning outcomes should not be neglected in determining the goals of language teaching. The question of interest to researchers is the relationship between the affective state with which the learner approaches the study of language, and the level of his achievements. A closer relationship corresponds to a higher level of achievement. Those who are taught by showing a positive attitude learn more successfully, but those who are taught to learn well have a positive attitude towards language. Moreover, recent studies show that the attitude factors studied so far are more important in the early stages of learning than in the later ones. On the other hand,

the experience of successful language learning at the initial stage of learning leads not only to its successful further study, but also to a more positive attitude towards it [6, p. 25-36].

The study of the affective aspect was prompted by the belief that the cognitive aspect is not the only one that matters in language learning. Some authors state that the affective component makes no less, and sometimes more, contribution to language learning than the cognitive skills represented by aptitudes or abilities. Thus, J. Schuman argues that affective and personal states are like an engine of cognitive skills that sets them in motion. According to his vision of empathy, the flexibility of the language "I" are factors necessary for the "inclusion" of language tendencies, abilities and other cognitive skills [4].

Many of the ideas used in the study of the affective aspect are to some extent a combination of observations based on common sense, psychological theorizing, and empirical findings. However, little has been done to observe and record the recording of emotional and motivational states in those learning a foreign language during their studies. At the same time, research in recent years has led to the belief in the importance of the emotional component in learning a foreign language.

Investigating the problem of motivation and attitude to a foreign language, in some cases use the term "learning" a foreign language, in others – "mastering" a foreign language. We need to distinguish between these concepts and determine their psychological meaning. S. Krashen introduced the terms "mastering" a foreign language and "learning" a foreign language to distinguish between the conditions in which the process of language acquisition takes place, namely: in the language environment of native speakers or in terms of learning it in the audience [8].

In the natural language environment there are opportunities for constant use of a foreign language in different conditions, in situations where the learner must interact daily with a new language as a natural means of communication, with the possibility of mastering a language other than mastering the native language in childhood. In this situation, a foreign language is a means of ensuring the social integration of the learner into a new social environment. In the classroom, as a rule, a foreign language is studied intentionally, specifically and in a more analytical aspect, ie through systematic study and intentional practice under the guidance of a teacher. However, such a distinction between the concepts of "mastering" and

"learning" a foreign language as such, which takes place either only in the natural language environment or in the audience, may ultimately be conditional, although it is impossible to disagree with the fact that during classes opportunities mainly for language learning, and in real conditions more opportunities for mastering a foreign language.

However, even in a language environment, it is not a mastery but a foreign language learning, for example, in cases where immigrants live in ethnic areas, communicate with their mother tongue and have minimal contact with the language of the country of residence, when the immigrant is forced to learn relatives, friends and colleagues, sometimes with the help of books and other teaching aids. The process of learning a foreign language in the classroom can be seen as creating artificial conditions for learning a language. This study can be simple and informal, when a learner of a foreign language uses the help of a friend in everyday, ordinary environment, or it can be systematic and intentional, for example, in the classroom using the appropriate program [9].

The differences between learning a foreign language in the audience and mastering it in the language environment are not decisive, both of these conditions can be considered as a whole, that is, ideally both of these ways should complement each other. It is worth remembering that the information obtained from a foreign language in certain conditions is perceived and assimilated by those who are taught, differently and may not correspond to their individual characteristics. Making differences between these conditions for learning a foreign language, we believe that we should not be harsh in favor of only one or only the other. In real life, the conditions for mastering a foreign language are far from ideal. Immigrants in a country may not find a person who can help them learn a language, and in a situation of artificial learning a foreign language in the classroom, those who are taught are far from the language environment, native speakers and do not have the opportunity to use a foreign language for outside the classroom, to test their knowledge in practice, although in this case the learner may come into contact with a native speaker, which is an undeniable advantage, because neither a teacher who is fluent in the language nor any technical means can to fill the lack of direct interaction with the native speaker of this language [10].

We are convinced that the definition of the concepts of "mastering a foreign language" and "learning a foreign language" should be based not on the conditions of language acquisition, but on the quality of this acquisition. Mastering a foreign language, in our understanding, is an active form of knowledge, the ability to use a foreign language in real conditions in a communication situation, while learning a foreign language is often the acquisition of language forms - vocabulary, grammar, etc., and usually inability to use language in a communication situation.

In this case, in distinguishing the terms "learning a foreign language" and "mastering" a foreign language, we tend to take the view of N. Shevchenko, who defines the term "mastering" a foreign language as the ability to adequately form and formulate one or another imaginary content with language, and the study or assimilation – as any form of activity of the subject to master a foreign language as a means and means of expression [8]. When learning a foreign language in the classroom, it is necessary to take into account the conditions in which learning takes place. Among the various factors influencing the acquisition of a foreign language, we can name such as the social context, the personality of the learner, the language environment and learning conditions. It is the conditions of learning that are easiest to change and adapt to the social and linguistic environment and characteristics of everyone who is taught. Motivation of mastering a foreign language is very important here, which should be the object of close attention in the learning process.

During the study of a foreign language in the classroom feature of the motivation of educational activities. It is unremarkable that the study of this subject, both in school and in higher education, takes place without pronounced motives for its study, in the absence of the need for a foreign language as a means of communication. Foreign language is not included in a number of special disciplines in higher education and, accordingly, the question arises about the motivation to master it. In the process of learning a foreign language in university, according to the scientist, the motivation of educational activities does not take any significant changes compared to the initial level. Moreover, the vast majority of students do not have motives related to the process of learning a foreign language, with the subject itself. These motives do not appear in the majority of students while studying at a higher educational institution. Basically, the motives for learning a foreign language in higher education are motives of a broad social

nature, related to the need to use a foreign language in future professional activities and for general education, so to say here we can talk about motives that are "understood" rather than real acting. At the same time, the importance and necessity of learning a foreign language in the military in a non-language higher education institution is emphasized by many authors [10]. The following main functions of a foreign language as a subject in higher education are distinguished: as a means of forming a professional orientation; educational function, general educational function.

I. Zymnyaya as a task of learning a foreign language identifies the following: 1) formation, development, education of socially active personality; 2) systematic increase and deepening of professional competence of students; 3) improving the general culture, the culture of language behavior, language communication of those who are taught. This task is correlated with the general and educational goals of education [3].

Conclusion

The specificity of a foreign language as a subject in a higher military educational institution is that its study is not directly related to the life plans of students and cadets, and they are not always aware of the feasibility of its study; there is no clear justification of the goals and set of skills that must be possessed by a specialist in accordance with the qualifications, students and cadets are dominated by formed in high school negative attitude to a foreign language as a very difficult subject that is virtually impossible to learn [10].

In view of all the above, the question arises about the formation of a positive motivation to master a foreign language in order to increase the effectiveness of educational activities in this discipline and improve training in general. In conclusions we may state that many authors assign a special role to the communicative approach to learning a foreign language. The only structure of motives in the process of a foreign language learning is considered optimal in that case when the leading role belongs to the direct communicative activity of the studied language. So, the communicative orientation in foreign language classes can increase the motivation to learn a foreign language.

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DUAL EDUCATION AT THE NUWEE: SUCCESSES AND PROBLEMS (ON THE EXAMPLE OF THE SPECIALTY «AGRICULTURAL ENGINEERING»)

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DOI: 10.31891/monograph/2021-10-31

Introduction

Dual form of education is a relatively new trend for educators and students. Acquisition of higher education in dual form involves vocational education of applicants in educational institutions and apprenticeships at the enterprise (organization, company, etc.) based on an agreement on joint organization of the educational process in dual form.

The combination of theory and practice, the experience of scientists with the experience of practitioners helps to improve the efficiency and quality of training at universities.

The concept of dual education originated in Germany [1], which experience is used in many countries of the European Union. In Ukraine and in the world the works of Pankratova O. [2], Ruvennnyi I.Ya. [3], Soloviyov S.V. [4], D. Rodikov [5] and many others are devoted to the problems of dual education.

The authors [6] proved the global recognition of the dual education system on the example of the vocational education system. Scientists emphasize that this is the most common and recognized form of training, which combines theoretical training in an educational institution and industrial training in the enterprise. The practical (production) part is about two thirds of the training time, and the theoretical part is about one third of the training time.

The system of such organization of training is widely practiced in Germany, Austria, and Switzerland. In Germany in particular, dual education has been introduced into the legal framework and is being implemented with the involvement of chambers of commerce and industry. The dual education system proves that the business prepares specialists of the required qualification and invests significant funds in this process. Businesses predicts the need for specialists, and future students choose their career while still in school.

A German school graduate, who wants to get an economic or engineering education, does not start with choosing a university, but with finding a company

that will take him to study or internship. If the graduate successfully passes an interview, the company enters into a contract with him for training. The curriculum is formed with the participation of employers and stakeholders, who, in addition, have the opportunity to distribute the load of educational materials within the disciplines of one specialty. In the production the teachers are employees of the company (instructors and mentors).

The analysis of the current handbooks, didactic and scientific works showed that all the authors confirm the prospects and reliability of the dual education system. Such conclusions are explained by the fact that this system meets the interests of all participants in the educational process: students, businesses, employees, the state.

The company has the opportunity to prepare personnel to satisfy their needs, and who will best meet certain requirements.

Such a system of education motivates young people to study indeed.

Taking into consideration the experience of Europe, in particular Germany, a pilot project of dual education programmes has also been introduced in Ukraine. In particular, the National University of Water and Environmental Engineering became a participant in this project.

The aim of our research is to analyse the process of introducing a system of dual education at the NUWEE on the example of students of the specialty 208 "Agricultural Engineering".

Presenting main material

The introduction of the dual education system started with a careful selection of partners - employers according to the established criteria, among them are:

- availability of an agreement with the National University of Water and Environmental Engineering;
- availability of material and technical base;
- availability of high-class specialists with higher education who are ready to the teaching and mentoring work with students;
- the company has vacant positions that can be offered to applicants for higher education in dual form; the company must confirm its interest in future employment of the applicants.

Taking into account the above requirements, the following agricultural enterprises were selected:

1. Private enterprise "Autoland Company".

Private enterprise " Autoland Company " was established in the village of Zdovbytsia, Zdolbuniv district, Rivne region. Main company activities are as follows: import of new agricultural machinery of foreign production (Versatile, PLA) and used machinery of foreign production (John Deere, CLAAS, Lemken, Kuhn, Kinze, Horsch, Kverneland, etc.).

Over the years, the company has created an operational training service centre for: combines, tractors, farm machinery. This company has fast and efficient delivery of spare parts for all types of machinery and equipment, as well as the ability to order spare parts from the catalogue. Production of rape tables for any combines, hydraulic hoses of high and low pressure to all types of equipment and facilities is carried out.

The company specialists conduct professional training of machine operators, and thus, they have significant experience in organizing of educational and training work.

- 2. MAANS Company, Zdolbuniv, Rivne Region.

The main activity of the enterprise is: designing and manufacturing of reapers, carts for reapers, spare parts and other consumables for agricultural machinery.

The company currently employs more than 150 people. MAANS has at its disposal modern and functional production facilities with an area of 9000 square meters. Highly qualified engineering and technical staff, as well as installed modern equipment for cutting, bending, stamping, heat treatment, milling, welding and grinding of metal make it possible to organise practical training for applicants of higher education.

3. "SBE Ukraine Volyn" LLC.

The main activity of this enterprise is the cultivation of grain and oilseeds. The enterprise is equipped with modern facilities and equipment. It is part of the "Viliya" brand group of companies.

In addition to these enterprises, two more agricultural enterprises were selected in Rivne region, which activities and the level of material and technical base meet the requirements for partnership in the organization of dual education. But, unfortunately, they didn’t meet the created list of criteria for selecting mentors from the company.

Within the framework of the project on introduction of the dual form of education in the specialty 208 "Agricultural Engineering" mentors must meet the following criteria:

1) work as the staff of the partner employer at the main place of work;

2) have higher education in the specialty;

3) to be skilled workers, have experience of relevant practical work in the specialty for at least two years;

4) can control the implementation of the individual curriculum;

5) showed a personal desire to become mentors for students implementing a dual form of education.

The selection of students was based on criteria defined by specialists of the relevant university department. Below there is a list of criteria:

1) to be applicants for higher education in the specialty of 208 "Agricultural Engineering";

2) to show a personal desire to get education in a dual form;

3) want to increase the level of practical training at industrial enterprises;

4) do not have academic debts;

5) to be ready to conclude an employment agreement with the employer-partner and increase the level of training at the enterprise;

6) agree to work in a position offered by the employer-partner and in accordance with the working conditions offered to them;

7) after graduating from university to be ready to get a job at a partner employer enterprise on a permanent basis.

In order to comprehensively assess the process of introducing dual education, we conducted a survey of teachers, students and specialists of partner companies.

Below there are generalized results of teachers' survey, who presented their attitude to the introduction of a new form of education in Ukraine.

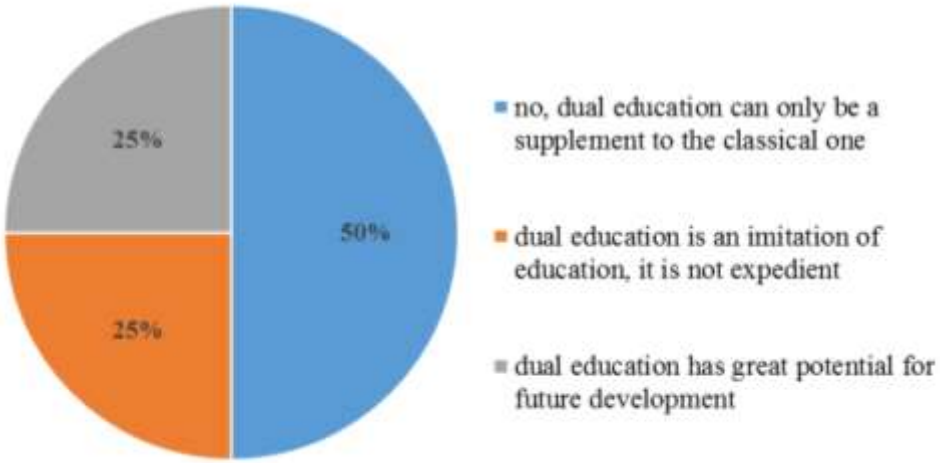


Fig. 1 - Results of a teachers' survey. The question was: "Do you consider dual education as a separate form of education in the future (in the perspective of development and improvement of dual education)? »

Students, who participated in a programme of the dual higher education, received a high assessment of their knowledge from teachers. It proves the prospects and feasibility of introducing this form of education in Ukraine. (Fig. 2).

The survey was conducted among students, too. Moreover, both students studying in the dual form of education and those, who receive classic higher education were covered. Some results are given below.

The obtained results prove that applicants for higher education highly appreciate the dual form of education, considering it promising. In this form of education, students see the possibilities to gain practical experience and they consider it a good start to their future careers.

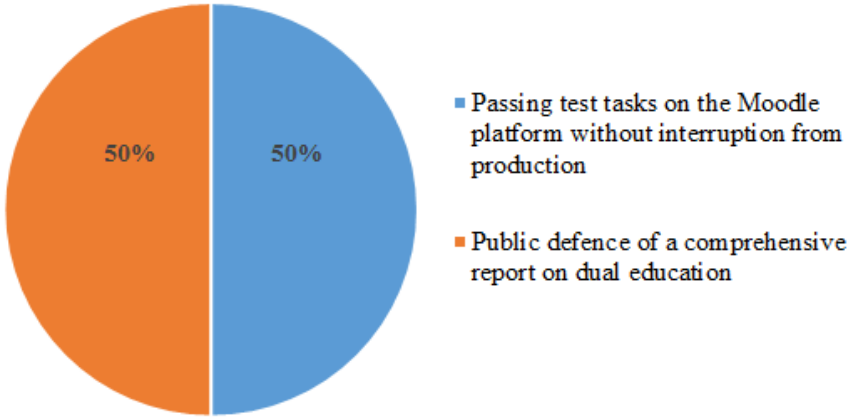
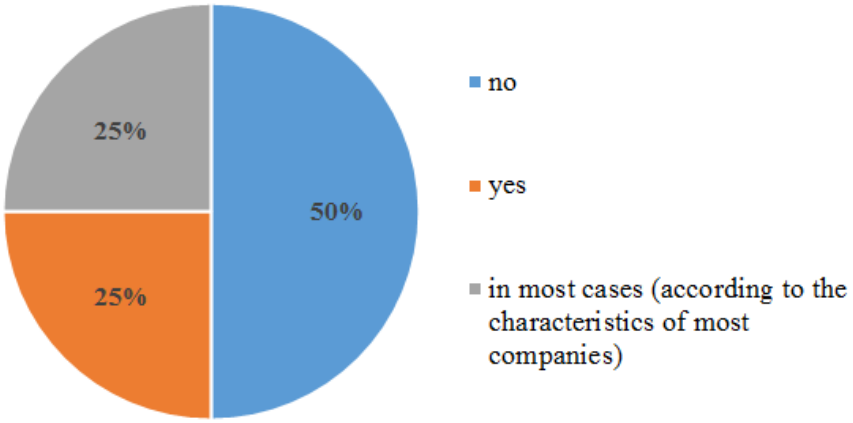
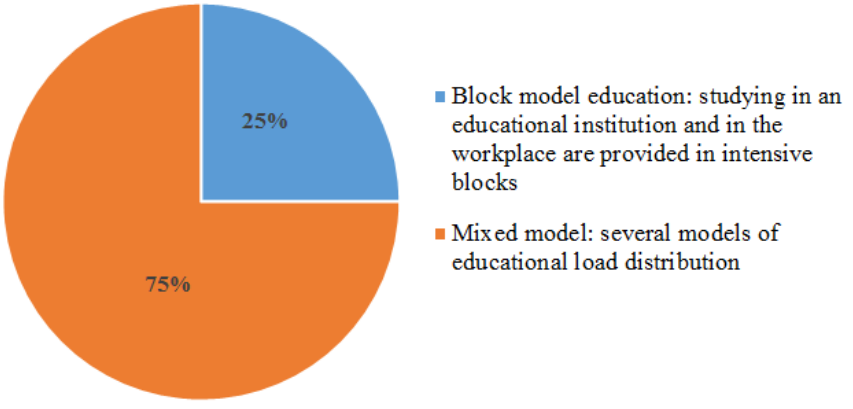
We can see that 50% of teachers do not consider this form of education as a great prospect and regard it only as a supplement to the classical one. At the same time, the majority of respondents positively perceive the parallel acquisition of knowledge and practical skills by students in enterprises and suggest that the specialists of the partner company can form 50% of the total assessment of student knowledge.

The survey of higher education applicants revealed a significant problem, which is the negative attitude to the fact that students, who study in a dual form of education, do not lose the right to receive a student scholarship.

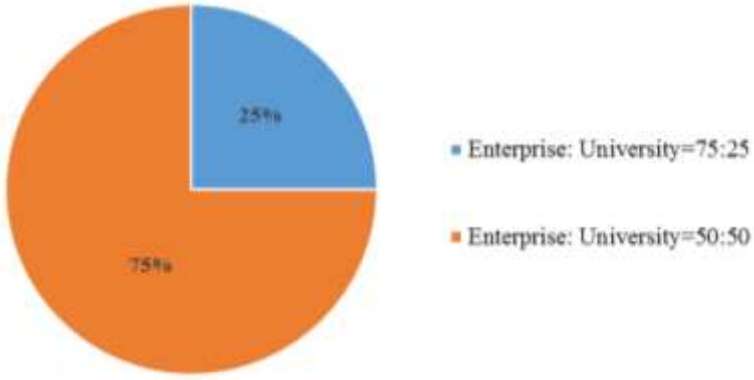
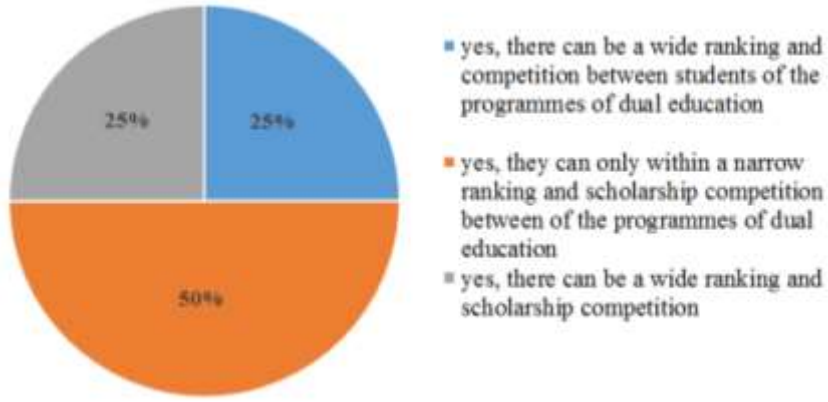
This problem needs to be solved. In particular, we proposed to create a separate scholarship fund for applicants for higher education, who study in a dual form of education.

A number of difficulties were also identified by teachers and partner companies (Fig. 2).

Table 1. Suggestions of teachers on the organization of dual education at the university

Question	Survey results
1	2
Which form of knowledge and competencies assessment of the dual student do you support?	
Is it necessary to change the schedule of the educational process for students of dual education compared to students of classical full-time education?	
What model of organization of dual education in your specialty is the most appropriate in terms of future work at enterprises?	

Continuation of table.1

1	2
You agree that the partner company evaluates the results of dual education of the student in the following ratio of the overall student's knowledge assessment, %	
What is your opinion on the issue: can dual-education students apply for a scholarship fund?	

Thus, the analysis of the implementation of the pilot project results on the organization of dual education revealed both the positive aspects of this form of education and the problems that need to be solved. But, as the analysis of the development of dual education in Germany has shown, its development requires the support of the state and the creation of a legal framework.

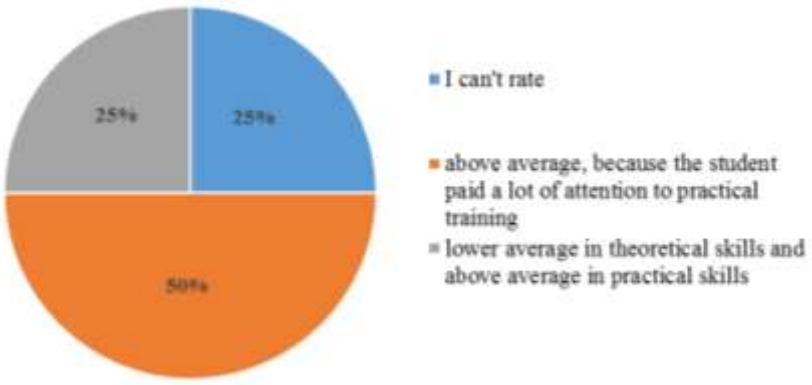
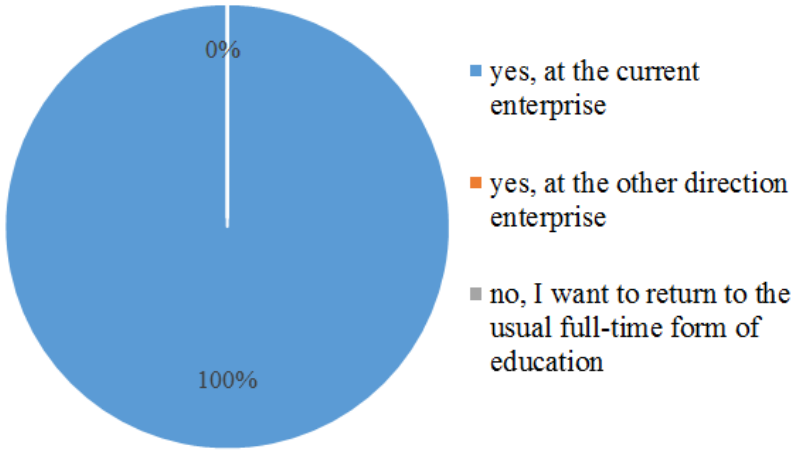
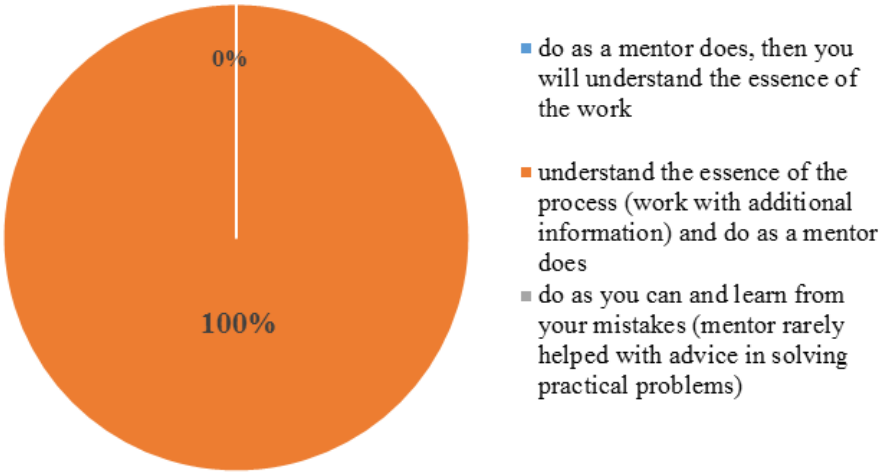
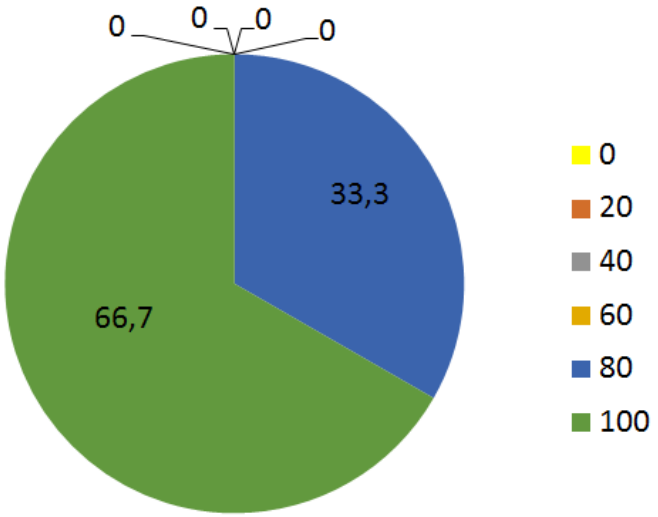


Fig.2. Results of the students' knowledge assessment, who studied in dual form of education (The question was: "How do you assess the level of theoretical training of students of dual form of education compared to fellow students of classical full-time form (after dual education) in your discipline? ").

Table 2. Survey results of students receiving higher education in dual form

Question	Survey results
Do you plan to continue dual education?	
How was your practical training at the enterprise established?	
Please estimate in percentage, how dual education has met your expectations in the terms of practical skills acquisition within your future specialty (when considering the prospects of changing jobs)	

With this in mind, a list of suggestions to the Ministry of Education and Science of Ukraine to increase the effectiveness of dual education has been formulated. Here are some of them:

1. To encourage higher education institutions to expand the contingent of students in the term of the dual form of education.
2. To promote the active implementation of cloud learning platforms and services for teaching students in dual form of education.
3. To monitor the organization of dual education in different HEIs in order to identify the positive and negative aspects of dual education with further generalization to improve this process.
4. To consider admission to dual education.
5. To legislate the dual form of education, as not all companies have the clear understanding of its implementation.

The companies that agreed to participate in the project on the introduction of dual education have gained new interesting experience in the field of vocational training of young professionals. According to the survey of practitioners, when working with students there were many questions and difficulties, the solution of which requires elaboration and discussion. The survey results also show that the key issue for all partner companies was the selection and encouragement of mentors, who need to perform their professional duties and train students at the same time.

Conclusions.

In Ukraine there is a gap between the knowledge acquired at universities and the requirements of professional practice. Dual education is aimed at preventing this problem by forming a highly qualified and competitive specialist. The introduction of dual education in Ukraine requires the involvement of state structures to this process and the development of a number of legislative acts.

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CURRENT TRENDS AND FEATURES OF TOURISM DEVELOPMENT AMID PANDEMIC

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DOI: 10.31891/monograph/2021-10-32

In 2020 the tourism industry faced a serious challenge in its development - a severe crisis associated with the rapid spread of a new species of coronavirus COVID-19 around the world. The outbreak of coronavirus infection COVID-19 began in December 2019 [1]. The first cases of pneumonia of unknown origin were found in residents of Wuhan, Hubei Province, central China. The disease was associated with the local animal and seafood market. On December 31, 2019, the Chinese authorities reported an outbreak of unknown pneumonia to the World Health Organization [2]. On February 11, 2020, the disease was named the new coronavirus pneumonia COVID-19.

World GDP contraction is 3%. On average, developed countries economy shrank 6.1% in 2020. In the US it was 5.9%, in the Eurozone 7.5%, in Japan 5.2%, in Mexico by 6.6%, in South Africa by 5.8% in Russia by 5.5% [3]. Tourism has been one of the sectors most affected by the COVID-19 pandemic. Tourism accounted for 7% of world trade. Every tenth inhabitant of the planet was attracted to this sector of the economy through a complex production and distribution network. The travel industry has been threatened by consumer uncertainty.

According to the Unitee Nations World Tourism Organization UNWTO in 2020, the decline in export earnings from international tourism exceeded 730 billion US dollars. This is more than 8 times the losses caused by the global economic and financial crisis of 2008-2009.

Modern tourism has covered almost all countries of the world. Out of 195 countries, more than 150 countries were involved in tourism. World tourism has shown steady growth. According to the UNWTO, the number of arrivals worldwide by 2030 should have been 1.36 billion people, i.e every fifth inhabitant of the planet could travel. Globally, tourism revenues accounted for about 10% of GDP.

The coronavirus pandemic and the introduction of anti-epidemic measures by various countries have accelerated the transformation of world tourism. Many organizations are working to increase the testing capacity and track the contacts of

the infected people.

New security standards are being introduced by airlines, airports, catering establishments and hotels. Forms of hotel work are changing. Coffee machines and coolers have disappeared from public areas. You can stay in the spa, hammam or gym for up to 30 minutes.

The COVID-19 coronavirus pandemic has been the most serious challenge for the tourism industry since its inception. In the current extreme conditions of the tourism business, the support and development of the tourism industry takes place in conditions of uncertainty and risk. The nature of this uncertainty is due to the fact that the dynamics of tourism is generated by internal stochastic processes, which are usually not available for direct observation and only their external manifestations in the form of events that have already occurred are recorded.

Conceptual principles of tourism susentation in a pandemic have not yet been developed and are manifested in the form of proactive actions, which should be preventive in nature, i.e tp prevent the spread of viral infection [4-7].

Coronavirus constraints combined with changing realities have forced the tourism industry to change rapidly. As a result, several notable trends have emerged [8-10].

Marketing tools of tourism in a pandemic note the focus on domestic tourism with increasing rental of scooters and bicycles. The demand for city and sightseeing tours has increased, there is a trend of eco-tourism development, removal work, participation in private trips.

The systematization of technologies to support tourist attractiveness, features and focuses, and the developed management tools is executed by the author and presented on fig.1.

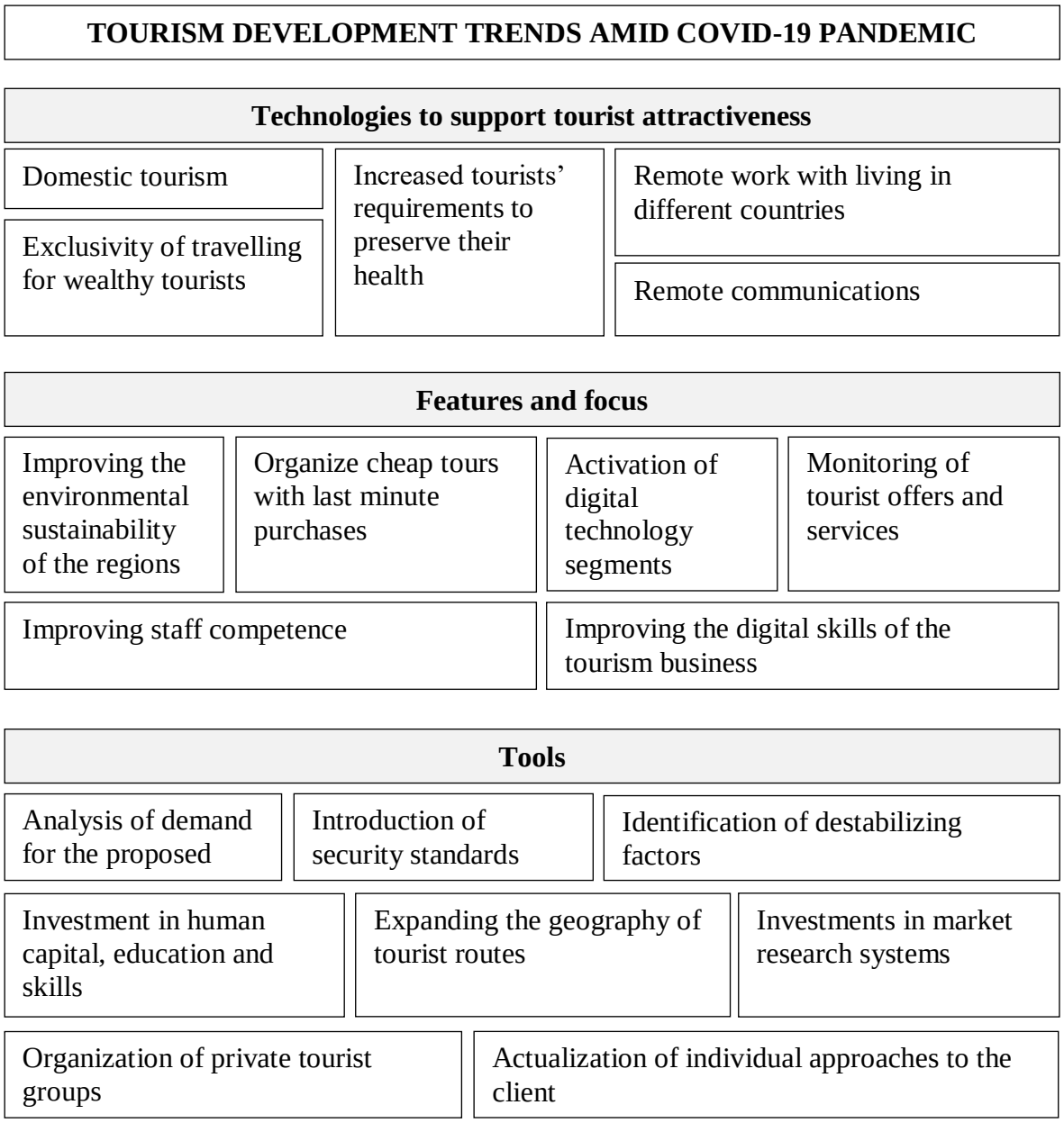


Fig. 1. The main trends in the development of tourism in a pandemic, features and tools

At the present stage of development of trends in the tourism industry there are a number of features of its operation:

- the tourist attractiveness of the proposed trips has been preserved in its original form, although their implementation has been transformed to take into account modern realities and limitations,

- there is a trend of tourism development in the form of remote work with moving and living in different countries for a period that significantly exceeds the duration of the usual tour,

- the requirements of tourists to preserve their health during the trip have sharply increased; great attention is paid to disinfection, observance of distances, wearing protective clothing, etc.

- demand for travel has shifted depending on customer income. The wealthiest clients prefer the exclusivity of travel with charters and a limited audience

- there are a number of cheap tours with last-minute purchases

- there are incentives for the development of domestic tourism and improving the environmental sustainability of regions

- there is a need to improve the digital skills of the tourism business. The segment of digital technologies in tourism is becoming more active. Methods of remote communication continue to develop

- promising acquisition and organization of investment in human capital to acquire the necessary competencies.

The health and safety of tourism in the context of the coronavirus are identical concepts supported by information, training and the provision of workers with appropriate protective equipment and equipment to perform their work. The increased risk of transmitting the infection is especially true for cleaners, domestic hotel workers, and transport workers.

Direct physical contact, insufficient ventilation, eating in public areas, moving to work on public transport contribute to a higher probability of COVID-19 outbreaks.

The definition of security is presented as a formative, dynamic, economic, social, legal and educational system to ensure danger prevention. Security can be both relative and necessary, however, it should be borne in mind that in the real situation, these concepts are present simultaneously and they correspond to the mandatory assessment of the risk of extreme unforeseen situations.

Structuring the conditions for ensuring the safety of tourists in a pandemic is presented in fig. 2.

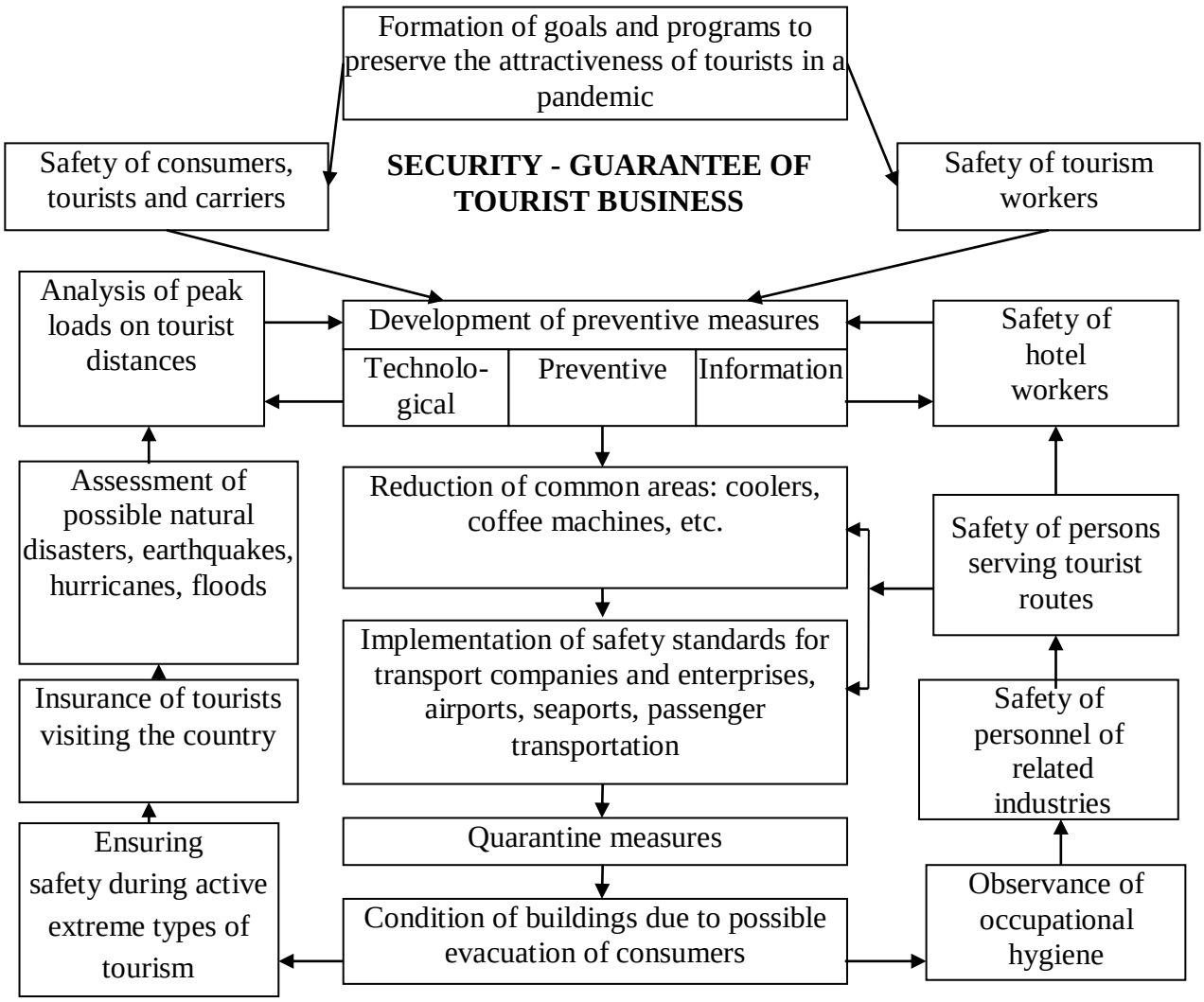


Fig. 2. Structuring the conditions for ensuring the safety of tourists in a pandemic

The Law of Ukraine "On Tourism" provides a system of guaranteed safety of tourists and the procedure for selling tourist services, taking into account the possible various risks that may cause unpleasant, unexpected consequences and harm to the health of tourists and their property. Public authorities and local governments in their job descriptions, within their powers must take appropriate measures.

Persons who organize the use of tourist resources must ensure compliance with the requirements of environmental protection and cultural heritage, as well as comply with the requirements of minimization or cessation of harmful effects on the environment, as well as to compensate for possible damage.

While ensuring the safety of tourists in a pandemic, an important role is played by the nature of the staff's views: their desire to either stabilize what has been achieved, or to radical innovations.

Equally important for compliance with standard and special safety conditions in the hotel industry are issues of occupational health. Occupational health studies issues related to working conditions and their impact on the human body. Hygienic and treatment-and-prophylactic procedures are being developed, which are aimed at improving and preserving the health of employees, increasing their efficiency and productivity. This is due to the fact that human activity directly depends on the conditions of implementation and features of the technological processes used. In turn, deviations from the normal conditions of functioning of processes and their possible violations cause a negative impact on the human body.

An effective solution to the problem of hotel security requires an active approach based on the analysis of the operation of the facility, identification of the most dangerous areas, preparation of possible scenarios and adequate action to prevent them.

There are a number of examples of gaining competence in the field of tourism and hotel restaurant business by studying both abroad and in Ukraine.

The Academy of Hotel and Restaurant Business in Poznan (Poland) provides the necessary knowledge to work as a chef, bartender, restaurant and bar manager in accordance with international standards in the tourism and hotel business. The curricula of the Academy are characterized by constant updating of programs, which is aimed at acquiring knowledge in line with the latest trends and innovations. Graduates work in travel agencies, companies, hotels, restaurants, rest homes, government and local government.

In the Czech Republic, the specialty "Tourism Management" is studied at the University of Hradec Králové and Mendel University in Brno. The specialty "Tourism and Regional Development" is studied at the Higher School of Economics in Prague and at the University of Masaryk. Specialists in this field are in demand for organizing and holding mass events, concerts, congresses, banquets. Students study the disciplines of healthy living, nutrition and gastronomy, equipment use, computer science, micro and macroeconomics, management, marketing and foreign languages. Due to language skills, graduates are often offered vacancies in the international companies. The basic disciplines studied by a specialist in this profession are: basics of hotel business; gastronomy; basics of tourism; design; equipment in the hotel business, hotel and restaurant reservation and accounting systems; hotel marketing; event management, etc.

Ukraine also teaches students in related specialties.

The crisis caused by the COVID-19 pandemic has destroyed the economy of the tourism sector, leading to unprecedented consequences for jobs and businesses. Tourism is one of the sectors of the economy that has been hit hard by the pandemic. Global recessions and risks of use for tourism products.

Particularly exacerbated structural inequalities in the tourism economy-fragmentation, participation in the tourism business of small and medium-sized businesses, excessive dependence on seasonality, segmentation and internal heterogeneity. In these conditions, new mechanisms to support the industry become especially relevant.

Tourism intersects with various areas of politics, health care, transport, ecology, economics, and foreign affairs. It is necessary to improve the conditions and coordination mechanisms by considering the sustainability of relations as a guiding principle for the resumption of tourism.

It is necessary to direct the policy of tourism recovery to accelerate the digital transformation and strengthen the relationship between tourism and the environment, to develop a policy of investing in technology, green infrastructure and value-added jobs.

Many countries have fiscal policies to support tourism enterprises by suspending taxes on the social security system. In Germany, travel companies are allowed to defer tax payments until the end of 2021. In South Korea, the government issues discount coupons that can be used to offset tourism costs.

Measures aimed at supporting tourism business companies will be especially important in the near future. These include: maintaining the company's liquidity, reviewing taxes and fees, protecting consumer rights, improving the digital skills of tourism business workers, creating mechanisms for crisis management.

In countries such as Portugal, Barbados, Singapore, Chile, free online training and retraining courses for tourism workers during self-isolation are organized. In Chile, the SIGO program provides technical assistance to tourism entrepreneurs in organizing business start-ups and digital management.

In Ukraine state aid to the tourism business is aimed at supporting small and medium-sized enterprises. This fact forces domestic airlines to seek a way out of the pandemic crisis on their own. Of the 11 planes of the Ukrainian low-cost carrier, 7 were converted for cargo transportation, another 4 planes are used for

irregular special flights, on which Ukrainians are evacuated from different parts of the world.

This is especially true for small and medium-sized tourism businesses. Now these companies are in a particularly vulnerable position, because they were forced to close all non-core production and had to minimize operating costs. The costs of the crisis are higher for small businesses due to their limited resources.

The COVID-19 pandemic has shown that cities can adapt quickly and need to be better prepared for the future. Urban tourism is one of the main trends in the development of tourism during the pandemic, educational and tourism projects for schoolchildren and new travel formats, teleconferences with foreign partners.

Commitment to international cooperation can serve as a platform to overcome the effects of the pandemic to ensure the survival of tourism businesses through large-scale government support.

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ROBOTICS IN UKRAINE

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DOI: 10.31891/monograph/2021-10-40

1. Introduction

The market for robotics and smart sensor sensors is one of the largest among the markets for advanced production technologies in the world.

The main players in the robotics market are manufacturers and integrators. According to The Robot Report, more than 340 companies around the world produce industrial robots.

Integrators are engineering firms that design, build and install robotic systems, as well as resell or distribute to other companies. Some of these companies are partners for robot manufacturers, other companies advise and offer robotic solutions, after comparing robots from different manufacturers and choosing the most appropriate solution. According to The Robot Report, there are more than 345 integrator companies worldwide [1].

2. Analysis of the structure and indicators of the world robotics market

According to Research and Markets, the global market for industrial robots (excluding the cost of components, software, and systems engineering) in 2018 reached a volume of 16.9 billion dollars [1]. It is expected that the average annual market growth rate in the period from 2019 to 2024 will be 12%, and the volume will reach 31.7 billion dollars. According to the volume of shipped products in 2018, 420 thousand robots are installed in the world. This figure, according to experts, will grow at a rate of 12.7% per year and reach 774 thousand robots in 2024.

The volume of the global market of industrial robotics in general in 2018 amounted to 45.7 billion dollars. According to analysts, in 2024 this figure will reach 69.8 billion dollars. with a growth rate of 7.8% per year.

However, at the end of 2019, Research and Markets adjusted the estimate

and forecast, according to which the volume of the industrial robot market in 2018 amounted to 48.7 billion dollars, in 2024 the volume will increase to 75.6 billion dollars at an average annual growth rate of 9.2%, according to the new forecast. According to analysts, the key driver of the market will be the reduction of skilled workers in production, which will lead to increased automation and popularity of collaborative robots (Collaborative robot is an automatic device that can work with humans to create or produce various products).

At the end of 2020, according to the International Federation of Robotics (IFR), the number of industrial robots installed in 2018 amounted to 422,271 units, and the market reached 16.5 billion dollars. (excluding components and systems engineering) (Fig. 1). Sales of industrial robots in 2019 decreased in quantitative terms by 12% compared to 2018, from 422 to 373 thousand units. The total number of robots in operation was 2.7 million units.

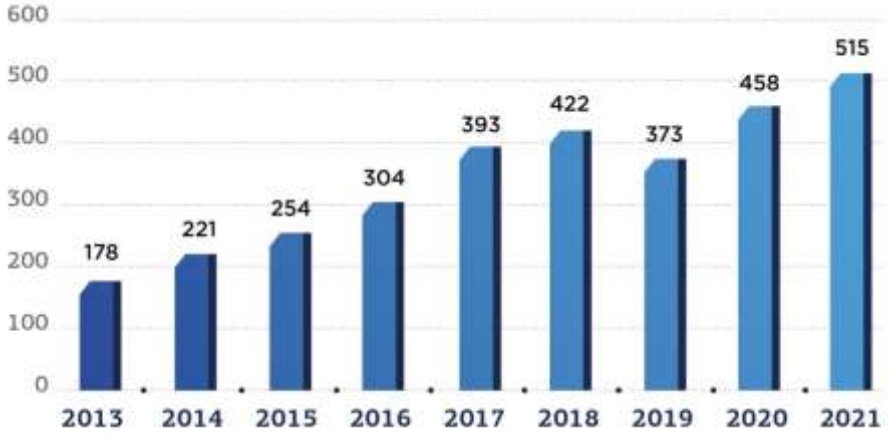


Fig. 1. Number of installed industrial robots in the world (2013 - 2019 years, 2020-2021 years - forecast, thousand units)

Source: IFR Press Conference: https://ifr.org

According to IFR, the largest number of industrial robot installations falls on the countries of the Asian region - 285 thousand units in 2019. Deliveries of industrial robots to Europe in 2019 amounted to 26.8% of the level of deliveries to Asia or 74 thousand units, and deliveries to America - 19.4% of deliveries to the Asian region or 54 thousand units. (Fig.2).

The average number of robots in Europe - 114 units, America - 103 units, Asia - 181 units, the average number of industrial robots in all countries - 113 units [2].

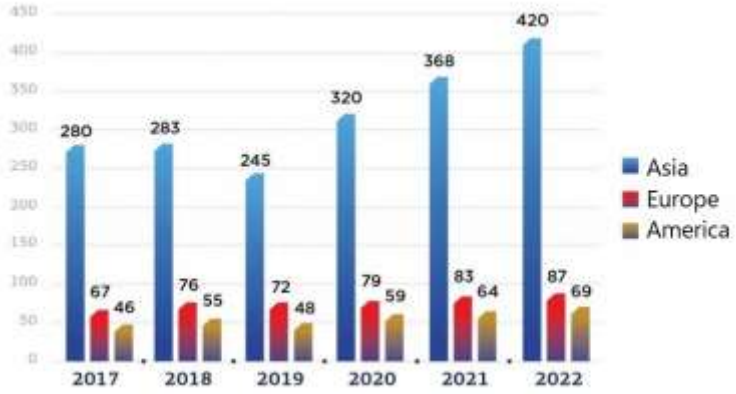


Fig. 2. Annual statistics on the installation of industrial robots in different regions of the world (2017-2019 years, 2020 - 2022 years - forecast, thousand units)

Source: IFR Press Conference: https://ifr.org

3. The main material

The general classification of robots is given in fig. 3. There are other classifications based on weight, size, other design features, industries, etc.

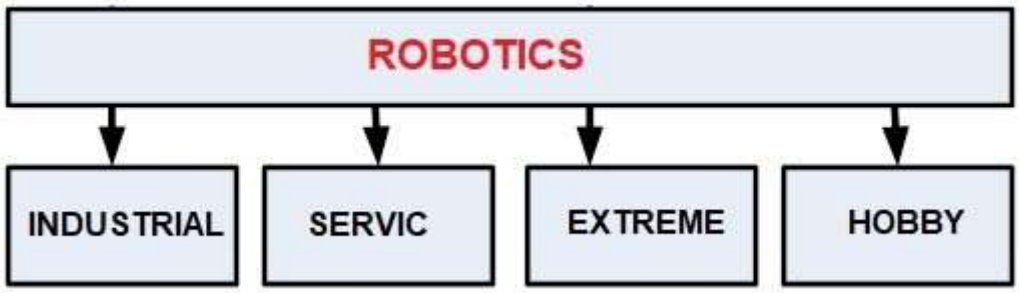


Fig. 3. Classification of robots

Functional definition of the STA robot - from the words Sense, Think, Act. The device can be called a robot provided that the following conditions are met [2]:

Sense: The robot has the ability to perceive the world around it with the help of sensors. Such sensors can be microphones (sonar), cameras (all areas of the electromagnetic spectrum), various electromechanical sensors (accelerometer), and more.

Think: The robot has the ability to interpret (understand) the signals it receives from sensors that observe the physical world, build and adapt patterns of behavior and make decisions depending on the chosen patterns of behavior. This ability can be realized in different ways: on-board computer robot, "intelligent"

cloud, or a person who controls the robot via remote control or tactile interface.

Act: The robot has the ability to influence the physical world in any effective way.

In Ukraine, one robot per 20,000 employees [3]. Robotic systems are available at large plants owned by large international companies: Henkel, Philip Morris, Procter & Gamlbel, etc.

Companies with Ukrainian capital approach robotics with caution. If we talk about the industries that are leading in robotics, then in Ukraine we can note the metallurgy and food industry, as well as logistics and agriculture.

An example of complex automation in the heavy industry of Ukraine can be considered the plant "InterpipeStal" - the only modern metallurgical plant built in independent Ukraine from scratch. Almost everything is automated here: special software monitors the condition of the equipment, and production processes are controlled by the MES system. This year, Interpipe NTZ will open an automated section for the production of railway wheels for export markets. The line will include machines for finishing machining wheels with a robot-manipulator loading and unloading.

Nova Poshta is actively using new technologies in logistics. Last year, the company opened the Kyiv Innovation Terminal (KIT - a sorting center with a high level of automation), and in the spring of this year - a similar center in Khmelnytsky.

There is a point example of the use of robotics in medicine: last year the Vinnytsia clinic Innomed acquired a robot surgeon DaVinchi. With its help operations are already carried out.

And in the agricultural sector of Ukraine, robotics is mostly limited to unmanned aerial vehicles (UAVs), they are used mainly in fieldwork [4].

As a rule, robots are involved in physically heavy work: this technique allows you to minimize injuries, speed up production processes and improve product quality. And production management systems - to control production processes, equipment operation and minimize the likelihood of errors due to "human factor".

Thus, the number of downtimes and accidents decreased at Interpipe plants after the introduction of the Smart.EAM module. In the production of wheels, the number of accidents decreased from 2% to 0.3% of working time, and direct losses

(defective products due to emergency shutdown of equipment) - from 2000 to 300 units per year "[3].

In addition, automation and robotics allow you to effectively manage human resources. For example, KIT employs about 800 people, and if the processes were not automated - the current volume of the sorting center would require at least 1,200 people. "But we do not aim to significantly reduce staff. On the contrary, we are constantly evolving, opening new offices and innovative terminals, so we are looking for people "[3].

Farmers use drones to monitor crops, create field maps, various area measurements, etc. And a robot surgeon helps to perform minimally invasive operations.

Military theory, in contrast to practice, has frozen at the level of the wars of the last fourth (ordinary war) and fifth (nuclear war) generations. Now in military theory, development and research have begun, and in military practice - intensive testing of the concepts of the sixth generation of wars, to which the most developed countries may be ready at the turn of 2025-2030.

In the wars of the sixth generation, the decisive role will no longer be played by a large number of ground forces, not nuclear, but unmanned high-precision conventional strike and defense weapons, weapons based on new physical principles, and information weapons. The wars of this generation will be radically different from the previous fourth in that they will be conducted in a contactless manner.

In the development of the theory of wars and martial arts, the study of armed conflict today there are new concepts of information, network and network-centric wars, which determine the principles of the general nature of action on the enemy, from social and information to material.

The world is entering not only a new military-technical revolution, but also a revolution in military affairs. A new, colossal leap in the development of armaments, and consequently in the forms and methods of armed struggle and war in general.

The state's readiness to wage sixth-generation wars at a high technological level makes it possible to determine its military potential and, accordingly, to predict the results of military conflicts with other states.

Tactics as a theory and practice of preparation and conduct of combat by all-

military units, units and subdivisions are constantly evolving. The main factors that determine the development of tactics are changes in weapons and equipment, organization of troops and methods of combat.

The most important promising weapons and equipment include high-precision weapons systems, the basis of which is the use of guided and homing ammunition (missile, aircraft, anti-aircraft and artillery); weapons of kinetic and directed energy (electronic, magnetic guns, high-frequency radars, combat lasers); military robots (UAVs, sappers, scouts, etc.).

Most of these innovations, in particular, ground unmanned combat systems (NBBS), require ground forces as the most "contact" and bearing the greatest losses in a war of any type.

In Ukraine, of the large number of declared developments of the NBBS, the most complete are the developments of private companies Robotics, Robonirs, Ukrainian Armored Vehicles (Synergy), Infocom, and our developments NU "LP" (Fig. 4).

Unlike other companies, NU "LP" proposed a project "Department of combat (shock) robots (VUR)" (rather than a separate robot), which includes a "flock" of NBBS. Their operation is provided by: commander, mobile robot operators, driver, observer-driver, repairman and security guards. The compartment when moving is placed on three tractors with trailers. Tractors are equipped with KUNGs to accommodate personnel. The trailers transport mobile combat operations, as well as the necessary equipment. One of the tractors can be used as a repair and evacuation vehicle.

4. Conclusions

Three possible scenarios of robotics development for the next 10 years are considered, which are determined by such factors as technology readiness and demand [5].

The first scenario is associated with an increase in the number of individual solutions and the lack of new options for mass use, which leads to the design of target robotic systems, the initial prices for which are quite high.



а) б)



в) г)



д)

Fig. 4. Military work from companies: a) Robotics; b) Robonirs; c) Ukrainian armored vehicles (Synergy); d) Infocom; e) NU "LP"

In the second scenario, the robot is considered as a standard automation device. In this scenario, the market will be dominated by several solutions that are easy to install, configure and integrate. An example would be a courier robot, a stand-alone pick-up robot or a robot for charging electric vehicles. As a rule, the

options for mass use in this category are not particularly difficult.

The third possible scenario is Google World, in which a breakthrough in artificial intelligence, adaptability and connectivity will lead to a number of intelligent modules capable of handling complex and dynamic situations. The software will be a key factor in success and will be dominated by large-scale development companies.

Until recently, it was considered that replacing people with work in production is economically viable only if the average hourly rate of an employee exceeds $ 3 (the average wage in the industry in Ukraine - at $ 2, 5). But in the world, the value of time and quality of the made production comes to the fore.

At the global level, the trend towards job automation is quite clear. According to a study by the McKinsey Global Institute, the leader in replacing manual labor in the world will be agriculture, which employs the largest number of workers. Europe is more active than other industries in automating the processing industry.

Jobs, as they become robotic, will be redistributed within the service sector, moving to other areas. With some this has already happened, others will appear over time, as the production of goods becomes more automated. But there are also jobs that may never be mechanized. For example, care for the sick and elderly, work with children in preschool institutions.

Advanced technologies in the field of robotics [6]: new materials, new energy sources, the interaction of groups of robots and humans, alternative navigation methods for extreme conditions, machine learning and AI technology for robots, human-machine interaction, manipulative robotics, sensory and environmental perception reality, robot simulators using ML / RL technologies, new principles of drive mechanisms, methods of robot production and technologies of end-to-end design of robotic systems.

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FRICTION BRAKE UNITS IN RAIL VEHICLES - ASPECTS OF OPERATION

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DOI: 10.31891/monograph/2021-10-41

Abstract. The use of friction linings and pads in friction brakes of rail vehicles need now to take a milestone towards the adaptation of composite synthetic materials in order to reduce noise, which is required by EU directives and the legislation of the Member States adapted to them. This is also necessary due to the acceleration of changes in the management of organic materials in the circular economy, which using their unique properties, are an irreplaceable alternative in other sectors of the economy, and their price is gradually increasing. The article aims to analyze the key aspects of the use of friction brakes in railways and is an introduction to research in this field.

Key words: railway, friction pair, wagon, friction brake, composite materials, friction lining, brake shoe

1. Introduction

The first documented studies of friction elements come from the end of the 19th century. The intensive development of railways in the second half of the 19th century contributed to the foundations of many of today's mechanics, such as material fatigue and fracture mechanics. A particularly important aspect of the research on rail vehicles was their deceleration and stopping at a designated point. The first brake blocks used in railways (now more often called brake shoes and linings) were tested as early as 1860, the materials used for this type of brake blocks included metal, leather and gutta-percha; tests were also carried out on other organic and inorganic materials (such as porcelain, basalt or concrete).

For general use, cast iron shoes have been implemented. In the 1950s, composite brake shoes underwent numerous operational tests, however, causing three times faster wear of wheelset rims compared to cast iron shoes and as a result of applying a metal layer to the surface of the insert - they did not become widely used.

The return to the concept of using composite materials for the production of synthetic composite inserts took place in the 1990s. Currently, the most common ones in use are thermosetting organic resins, rubbers, friction modifiers and various types of fibers [1]. The requirements for both composite and cast iron brake shoes are generally defined as enabling the train to stop in all conditions [2, 3], but due to the necessity to comply with the requirements of the European Union Directive 2000/14 / EC [4] and 2002 / 49 / EC [5] it became necessary to reduce the noise generated at the interface between railway wheels / brake discs and brake shoes / linings, which is a significant problem in carriages not equipped with electrodynamic / recuperative brakes, allowing for energy recovery to the network, minimizing costs , but also the reduction of noise caused by braking at the contact of the friction pair lining / shoe - disc / wheel [3, 6, 7]. Currently, despite the attempts made by many companies in the field of introducing plastic inserts on the market, which may lead to the reduction of noise emissions; The vast majority of cast irons, organic composites and sintered metals are still used for brake shoes / linings [8, 9].

This work describes the effect of heat generated in the process of friction of the brake shoe against the vehicle wheel and the friction lining against the brake disc in rail vehicles on the braking efficiency of rail vehicles, as well as on the wear processes of individual components and their causes.

2. Thermal conductivity in friction brakes of rail vehicles

Composite brake shoes and linings are characterized by lower thermal conductivity compared to the most commonly used cast iron. Organic composite shoes and linings act as natural heat insulators; however, despite this feature, they are a commonly used alternative to synthetic composites [8, 9].

Initial and control tests of brake blocks should be performed in accordance with the EN 16452: 2015 + A1: 2019 [10] standard and the UIC 541-3 [11] sheet. As stated in the above-mentioned standard, inserts made of both organic and sintered materials during preliminary tests determining the applicability of a given material should be subjected to chemical composition analysis. In the case of sintered materials, the following are also analyzed: macrographic structure and high temperature stability, which is the result of energy balance in the friction pair. The standard indicates that each individual batch should be subjected to quality

tests in terms of hardness, friction coefficient and material density. It should be noted that the coefficient of friction in the preliminary tests should be determined with greater accuracy than in the control tests. Correct definition of the friction coefficient allows to accurately determine the properties of the temperature field necessary for the analysis of thermal effects in the friction pair during braking [12, 13]. Initial tests of the friction coefficient and the influence of temperature are performed on specially designed dynamometric stands [3, 8, 14]. An exemplary position of the type is presented in Fig. 1.



Fig. 1. Sample dynamometric stand – [15]

Calculation of the temperature of the brake friction elements is the subject of many scientific studies [16, 17, 18], but in most cases - the influence of the friction coefficient to a constant value during braking is simplified, which in the described friction pairs cannot take place due to the presence of variable slips depending on the speed, and moreover, the temperature itself will also affect the friction coefficient [8, 19].

Stabilization of the braking force is currently based on the feedback in automatic systems regulating the pressure pressing the brake block [2], which allows not only to regulate the braking intensity, but also to extend the service life of the brake blocks. Yevtushenko et al. [19, 20] proposed the use of a graph of five

experimental curves which present the dependence of the friction coefficient on temperature and the temperature gradient. Belhocine and Bouchetara [21] showed that thermal gradients depend on the heat dissipated by friction and the heat convection coefficient. In [19], the influence of structural changes and process intensity on changes in the friction coefficient was negated. Sawczuk et al. [2] indicate, however, that any changes in the geometrical structure of the brake-disc friction pair may lead to braking deceleration. However, changes in geometric structures are inevitable when the temperature of the brake disc during braking can reach up to 600 ° C. A drastic increase in the temperature of the friction pair dissipates a large amount of energy on the friction surfaces and may occur a phenomenon known as "hot spots". These contact areas are characterized by high stresses resulting from strong thermal gradients, which often leads to the formation of fatigue-thermal cracks, plastic deformation and tribological surface damage [3, 21, 22].

Originally, brake insert analyzes were only performed using analytical formulas such as those described by Milošević et al. [16] and Belhocine and Bouchetara [21]. Formula (1) characterizes the thermal power generated on the contact surface, and formula (2) describes the heat conduction through the friction pair in the transient equation.

$$q(r) = -\frac{\mu F_N \omega r}{A} \quad (1)$$

$$\rho C_p \frac{\delta T}{\delta t} + \nabla(-k\nabla T) = Q - \rho C_p u \nabla T \quad (2)$$

Formulas (1) and (2) constitute a theoretical introduction to the problem of heat propagation in the friction pair disc / wheel - brake shoe / lining. Solving the problems of heat propagation and analyzing its sources is most often performed by FEM/FEA simulations.

The study of the influence of temperature distribution and its conduction is based on numerical models created on the basis of experimental studies [8, 9, 16, 21, 23, 24]. An exemplary numerical analysis of the braking process presented in [16] is shown in Fig. 2. Experimental tests allowing to determine the properties of the material for the friction insert are performed on dynamometric stands designed

for this purpose, using thermocouples [8, 9, 22, 24], a pyrometer or thermal imaging cameras [22].

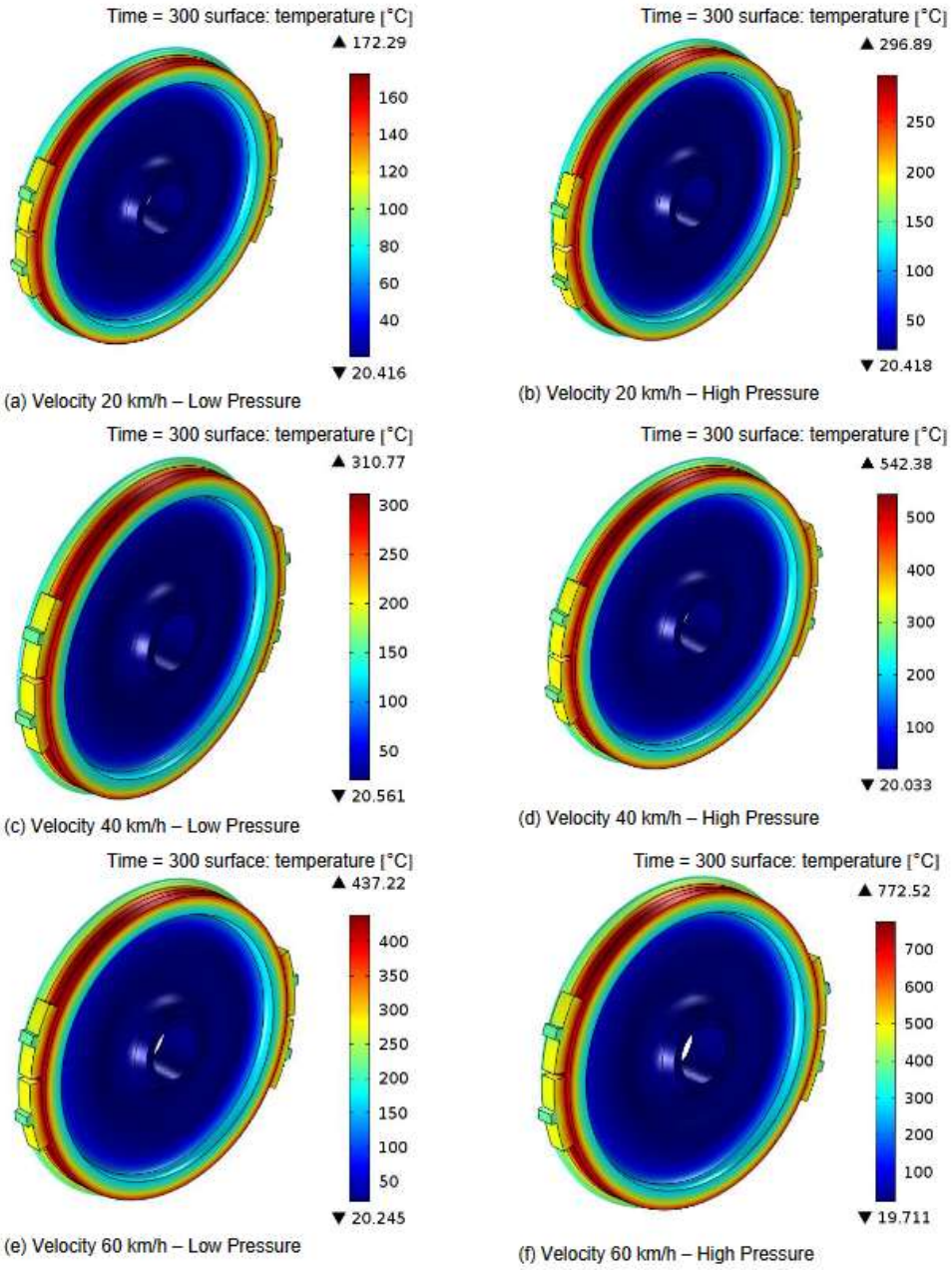


Fig. 2. The thermal distribution on railway wheel after t=300s – [16]

An example of the temperature measurement on the brake disc is presented in Fig. 3. The temperature measurement during the test is based on monitoring the heating areas, but the problem remains to determine the emissivity of the disc, which is not only unknown, but also changes during the tests [22]. It is worth noting that the formation of cracks can be recorded with a thermovision camera only on the friction surface, while the subsurface damage of the top layer [25], which can be detected by, for example, eddy currents [26, 27], are also significant.

Subsurface damages most often result from wear and fatigue of the material [28], and the fatigue may worsen at a faster pace along with increasing skidding [29].

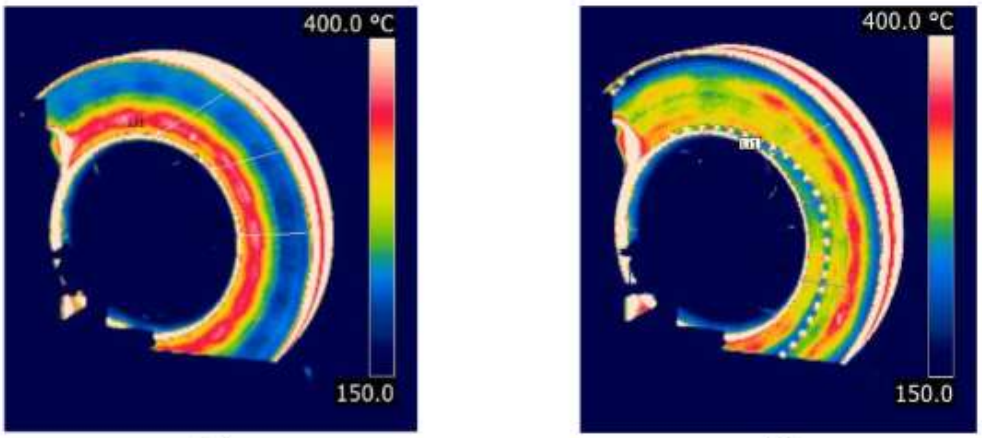


Fig. 3. Temperature distribution on a disc at the moment braking ended from a speed of 200 km/h: (a) classic (smooth), (b) perforated on the friction surface – [2]

3. Wear of friction brakes on rail vehicles

The material composition of composite shoes and linings, both organic and synthetic, is a strict secret of the producers. According to various sources [22, 29] it contains at least 20-30 different components, for example the OMC insert consists of steel and mineral fibers and particles of copper, brass, graphite and minerals embedded in a phenolic resin matrix [22]. On the other hand, FR20H.2 friction linings are made of thermosetting resin, synthetic elastomer, metal and organic fibers and friction modifiers [2]. Considering the diversity of composites, whose composition remains a secret of their manufacturers, it is not possible to analyze the group of composites intended for testing within a single test point. This creates a problem for the acceleration of the brake pad market, as every company is forced to make similar mistakes, and the new product results are the product of many prototypes undergoing - or not; subsequent research stages in accordance with the EN 16452: 2015 + A1: 2019 [10] standard and the requirements set by the client. The monopolized market limits the possibilities of implementing innovations as dynamically as in the automotive industry.

Brake linings are exposed to a strong influence of vibrations due to the influence of friction in the structure of various clamping forces and elasticity of the friction material. At low stresses, the influence of vibrations will not lead to fatigue wear, which results directly from the Wöhler diagram, but in the case of sudden

braking, the number of cycles increases drastically and is uncontrolled [30]. An example of a worn brake block is shown in Fig. 4.



Fig. 4. Used friction brake blocks from railway wagon – [31]

The fatigue wear of brake blocks is mainly influenced by vibrations in rail friction brakes. The most widely used model to reflect vibration is the stick-slap model based on mass, stiffness and damping parameters. The variety of composite materials used for friction linings causes large gaps between the effects of the stick-slap model [2, 14, 30, 32, 33, 34, 35]. The consequence of this type of vibration is also a change in the friction coefficient as a function of velocity, but it is also influenced by the wear of the friction pair [2, 8, 19].

4. Conclusions

Analysis of the use of friction brake materials in railways; showed that the vast majority of research focuses on the thermodynamic aspects of friction pair modeling. The frictional aspects of the friction pair are defined as a parameter

resulting from the thermal aspects of the tested materials. On the other hand, the tendencies to the formation of vibrations resulting from the stick-slip contact, which is also the frictional aspect, are included in a small part of the analyzed literature resources. The frictional aspects occurring in the described braking process can still be determined by the measure of ignorance, especially in the case of variable friction conditions in the work performed by the lining - disc and shoe - wheel pairs. However, it seems possible to try to determine experimental curves based on thermal parameters, speed and friction with a sufficiently large number of tests for a given material.

The testing of materials for friction elements is a challenge due to their extensive structure and high research costs. Many companies decide not to launch new products from the above-mentioned reasons, which also limits market opportunities. Nevertheless, it is possible from a research and not purely commercial perspective; obtaining the appropriate number of data to determine the boundary conditions for the study of synthetic composites with a similar chemical composition, which, however, requires a multi-faceted analysis of the collected material, geometric and dynamic data.

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PROCESSING MAPS AND CONSTITUTIVE MODELLING THE HOT WORKING BEHAVIOUR OF HIGH MANGANESE AUSTENITIC STEELS

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DOI: 10.31891/monograph/2021-10-42

Abstract

Depending on the conditions of plastic forming (deformation), the properties of the deformed metals and alloys are determined by different plastic deformation mechanisms and thermally activated processes on which deformation parameters have influence. The phenomena accompanying the plastic deformation can be revealed experimentally during tensile, compression or torsion tests. As a result of these tests, known as plastometric tests, the strain hardening curves (during cold deformation) or flow curves (during hot deformation) are obtained, which are representing the relationship between stress and strain. The selected axial symmetric compression test broadly reproduces the actual conditions of a wide range of plastic working processes, including free forging and hot rolling. For optimum planning of a process for new material or for optimization of a production process control in terms of quality and performance of already existed material, the so-called processing maps can be used. They are used in hot deformation processes such as forging or extrusion for various metals, alloys and composites. These maps are the visualization of the so-called efficiency of power dissipation η. Some researchers had already built a material model describing the behaviour of the material during hot plastic deformation in which it considered the workpiece as a power spreader throughout its processing system. The model consists of a part dissipating power J, by the so-called dynamic metallurgical processes and heat G. Dynamic processes include, for example, dynamic recrystallization DRX, recovery dynamic DRV, dissolution or particle growth. The effect of component J on the flow curve is the efficiency of power dissipation η. The processing maps indicate areas where there are the dominant mechanisms of removing the effects of strain hardening, such as dynamic recovery and recrystallization. For their "construction" flow curves are used. They can be used

to minimize the number of metallographic studies, as they can indicate interesting processing domains of optimum plastic working. In summary, to precisely control the production process, a good knowledge of the material's behaviour (the relationship between stress, strain, temperature and structure) is needed.

Mathematical model of the material

Most of the semi-empirical constitutive models are based on the model developed by Sellars and Tegart (1966/1990) and modified by Garofalo. This equation is used to describe the high temperature deformation, which describes the strain rate in relation to the flow stress and the absolute temperature:

$$\dot{\varepsilon} = A * F(\sigma) * \mathrm{Exp}\left(-\frac{Q}{R*T}\right), \text{ where: } F(\sigma) = \begin{cases} \sigma^{n1} \\ \mathrm{Exp}(\beta * \sigma) \\ [\mathrm{Sinh}(\alpha * \sigma)]^{n} \end{cases}.$$

Here A, n1, α, β, n are materials constants. Q is the hot deformation activation energy in kJ* mol^{-1}. The stress σ is shown as a function of temperature T, strain ε and strain rate $\dot{\varepsilon}$. By taking logarithms of both sides of the three possible equations, it is possible to acquire the material constants. The values of n1 be β can be acquired from the slope of the parallel and strain lines from the ln σ - ln $\dot{\varepsilon}$ and σ-ln$\dot{\varepsilon}$ plots. The value of comes from this relation: α = β/ n1. The slope of ln $[\mathrm{Sinh}(\alpha * \sigma)]$ versus ln$\dot{\varepsilon}$ yields 1/n and the slope of ln $[\mathrm{Sinh}(\alpha * \sigma)]$ versus 1/T the activation energy Q. The last material constants ln A is found from the interception of ln $[\mathrm{Sinh}(\alpha * \sigma)]$ versus ln $\dot{\varepsilon}$. Usually, the Garofalo equation is fitted at the strain corresponding to the peak stress or at the strain where the steady-state of the material is reached. There are some literature positions describing that this equation can predict the creep behavior under transient and steady-state deformation.

The connection between the true stain φ and strain ε is:

$\varphi = \mathrm{Ln}\frac{1}{1-\varepsilon}$, where: $\varepsilon = \frac{h_0 - h_1}{h_0}$. H is the sample high before "0" and after "1" the deformation.

The Zener-Hollomon Z parameter, which binds temperature with strain rate, is also possible to implement. The equation looks as follow:

$$\sigma = \frac{1}{\alpha} * \mathrm{Ln}\left\{\left(\frac{Z}{A}\right)^{1/n} + \left[\left(\frac{Z}{A}\right)^{2/n} + 1\right]^{1/2}\right\}.$$

The Zener-Hollomon Z parameter can be "connected" with the grain size D_0through:

$$\varepsilon = A * D_0^B * Z^C,$$

where: A, B, C are materials constants. To determine these parameters the information about initial grain size is needed, for example through metallographic studies.

The methodology for determining the coefficients can be found else wares [1-6]. A large part of the researchers presents the coefficients in the above equations as deformation ε dependent. They usually use the 5th or 6th grade polynomial [4, 5]: $n_1, \beta, \alpha, A, n, Q = f(\varepsilon)$, for example:

$$n_1 = a_5 * \varepsilon^5 + a_4 * \varepsilon^4 + a_3 * \varepsilon^3 + a_2 * \varepsilon^2 + a_1 * \varepsilon^1 + a_0.$$

A "standard" material model can be extended to phenomena occurring after plastic deformation, which include: metadynamic recrystallization and/ or recovery, static recrystallization and/or recovery or grain growth. These phenomena must be taken into account in processes where between two deformations, the effects of strain hardening were not removed. The following equation can be used to describe the degree of static and/ or metadata recrystallization [5]:

$$X = \frac{(\sigma_{01} - \alpha_1 * Logt) - \sigma}{(\sigma_{01} - \sigma_{03}) - (\alpha_1 - \alpha_3) * Logt} * 100\%.$$

The recrystallized fraction X can be described by the half recrystallization time $t_{0.5}$, and the n parameter (Avrami exponent):

$$X = 1 - Exp\left[-0.693 * \left(\frac{t}{t0.5}\right)^n\right].$$

The equation represents a "S" (Avrami)- like curve, which is created by fitting the $t_{0.5}$, and the n parameters to the results from stress relaxation test.

Another way to determine the recrystallized fraction X, or generally the fraction effects removing the strain hardening in the material, is the softening fraction E. The data is mostly obtained from double hit compression or double torsion tests

[5]. The share of softening (recrystallization) is determined from the following equation:

$$E = \frac{\sigma_{fmax} - \sigma_{f2}}{\sigma_{fmax} - \sigma_{f1}} * 100\%.$$

The indexes by stress values σ are corresponding to flow stresses determined from the flow curves from each hit in the double hit tests. The σ_{fmax} is the maximum σ value obtained in the first deformation.

The method of determining the above equations is well described, for example in [5]. Both methods can also be used to assign the start and finish of a precipitation process. Metallographic examinations are necessary to correctly identify the mechanism (phenomena) after the deformation.

Processing maps

The "construction" of the processing maps can be found anywhere [3-6]. The efficiency of power dissipation η is defined as follows:

$$\eta = \frac{J}{J_{max}} = \frac{2*m}{m+1},$$

where m is the coefficient of sensitivity for strain rate:

$$m = \frac{Log\ \partial\sigma}{Log\ \partial\dot{\varepsilon}}.$$

The input data consists of points (from set σ, T, $\dot{\varepsilon}$, ε) that are usually joined with the 3th grade polynomial, obtained from plastometric tests (like hot compression test) or mathematical models (for example Garofalo). Through the many years of the research areas with the most important dynamic metallurgical processes (dynamic recovery, recrystallization and superplasticity) were correlated with the value of the η-parameter. Therefore:

- dynamic recovery DRV: if $\eta < 0.33$;
- dynamic recrystallization DRX: $\eta = 0.33 \div 0.55$;
- superplastic forming SPF: $\eta > 0.60$.

In recent years the processing maps have been designed as an overlap of two maps: efficiency of power dissipation η and of the so-called instability parameter ξ. The "Prasad" instability parameter ξ is defined as follows [3]:

$$\xi_p = \frac{\partial \mathrm{Ln}[m/(m+1)]}{\partial \mathrm{Ln}\,\dot{\varepsilon}} + m < 0.$$

The instability parameter ξ divides the map into the following areas:

a) stable, when ξ> 1;

b) metastable, when 0 <ξ<1; and

c) not stable, if ξ<0.

The process performed in the stable or metastable area is intended to provide a product without internal or external defects [1-5]. The described instability parameter ξ is unsatisfactory, as indicated by the results published by Sun 6]. In the area classified as stable (un-shaded area) the cracks occurred on the surface of the samples during deformation what contradicts with an area of the not stable process (ξ<0; shaded area). Murphy defined a new "instability parameter ξ":

$$\xi_M = 2 * m - \eta < 0.$$

In addition to the mentioned cracks, there may be such internal mechanisms of material "destruction" as: flow localization, adiabatic shear bands or cavity formation. There is a possibility that they are not fully taken into account by the parameter defined by Prasad [3]. Therefore, in addition to external examinations, it is important to carry out metallographic examinations of selected samples based on the received maps.

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GRAIN REFINEMENT OF MAGNESIUM ALLOYS

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DOI: 10.31891/monograph/2021-10-43

1. Introduction

Magnesium is an element that makes up 2.74% of the earth's crust. It is found in most countries in the form of various compounds and minerals. Currently, the main problem of the automotive industry is to reduce the fuel consumption of the engine and consequently also to reduce the amount of CO_2 emitted into the atmosphere. One of the ways to achieve this goal is to reduce the weight of the car, hence the tendency to increase the amount of magnesium alloy elements in its construction.

Currently, around 85% of the cars produced in Europe have a steering wheel made of magnesium alloy. In addition, BMW makes extensive use of magnesium alloys for housings and brackets. It was also the first company to introduce a magnesium-aluminum crankcase for a water-cooled engine in series production. Magnesium and its alloys are characterized by a tendency to form a coarse-grained microstructure in castings combined with high grain size heterogeneity. The coarse-grained microstructure of the cast metal is unfavourable, because of the difficulties associated with possible plastic processing and the lower mechanical properties of the finished products.

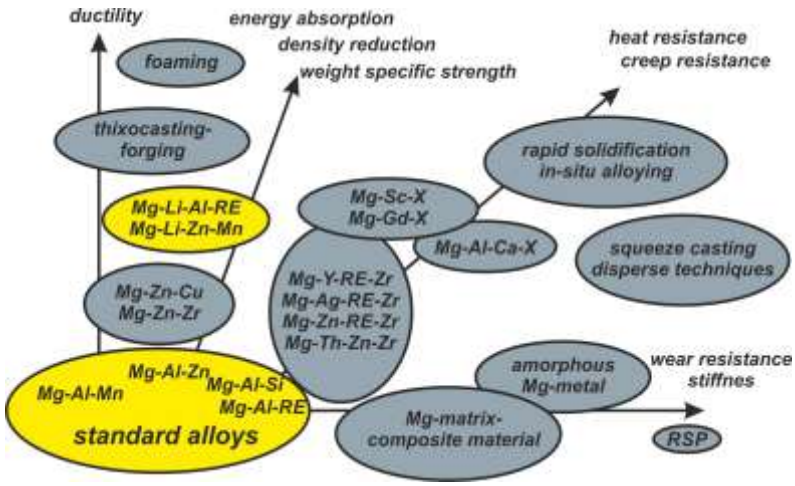


Fig.1. Directions of alloy development [2]

Currently, research is being carried out on grain fragmentation by introducing the following elements into liquid magnesium alloys: Sr, Si, Ca, B, rare earth metals, and the compounds AlN, MgO, TiB_2 and TiC to form crystallization nuclei. Expect for strontium, which is effective only in pure magnesium, or magnesium alloys with Al < 1%, they cause a significant reduction in the grain size of magnesium alloy castings. However, they are not used on an industrial scale [1-11].

In presented work, the application of grain modifiers such as TiBor and AlSr in 0.2% wt. on Mg-12Li-1.5Al single β-Li phase and their influence of structure and mechanical properties were reported.

2. Material and experiment

Within the framework of present work, the alloys of magnesium with lithium and aluminium and with grain refinements such as TiBor and AlSr have been melt, cast and investigate. As main components used in experiments, magnesium with technical grade (min. 99.5% Mg), aluminium 3N8 (99.98% Al), lithium (99.9% Li), and refinements in the form of cement containing titanium and boron (AlTi5B) and strontium (AlSr10) were utilised. Melting and casting of alloys were carried out using laboratory vacuum induction furnace VSG 02 from the company Balzers. Melting temperature was approx. 700÷720°C and the melting time approx. 5 min., which, taking into account the strong bath stirring electrodynamic eddy currents in enough for the complete homogenization of the melt. Grain refinements were introduced at the end of the melting process from the vacuum containers. After placed of grain refinements in the alloy, melts kept in the liquid state for 2 minutes, followed by the casting. Alloys were cast by gravity into the cold mould of graphite to give rod-shaped ingots with dimensions ø20x100 mm. Ingots were characterised by a homogeneous, fine-grained structure and not found to the occurrence of casting defects. The chemical composition of achieved alloys is presented in Table 1. Measurements of chemical elements content in the obtained solutions were made using the inductively coupled optical emission spectrometer with inductive coupled plasma (ICP OES) OPTIMA 5300V, manufactured by PerkinElmer. The samples were taken in a mixture of nitric (V) and hydrochloric acids with the addition of hydrofluoric acid.

Table 1. Chemical analysis of the Mg-Li alloy

Analysed alloy	Elements [wt.%]									
	Li	Al	Si	B	Ti	Sr	V	Ca	Fe	Mg
Mg-12Li-1.5Al	12.00	1.80	-	-	-	-	-	-	-	Balance
Mg-12Li-1.5Al+0.2 TiBor	12.00	1.75	0.040	0.0021	0.0091	-	<0.001	-	0.0012	Balance
Mg-12Li-1.5Al+0.2Sr	12.00	1.78	0.027	-	-	0.025	-	0.0053	-	Balance
Mg-12Li-1.5Al+0.2TiBor+ 0.2Sr	12.00	1.77	0.028	0.0028	0.013	0.020	<0.001	0.0067	0.0017	Balance

The as-cast grains of the etched samples were examined using polarised light in optical microscope Leica equipped Q-WinTM image analyser. The grain size was measured by the linear intercept method at the centre of transverse sections.

3. Results

Figure 2 presents the microstructure of Mg-12Li-1.5Al in as-cast alloys, and after treatment by TiB and Sr. Addition of grain modifiers as TiBor and AlSr to the alloy, the β-lithium grains in the alloy were refined, and the grain morphology becomes with a granular shape.

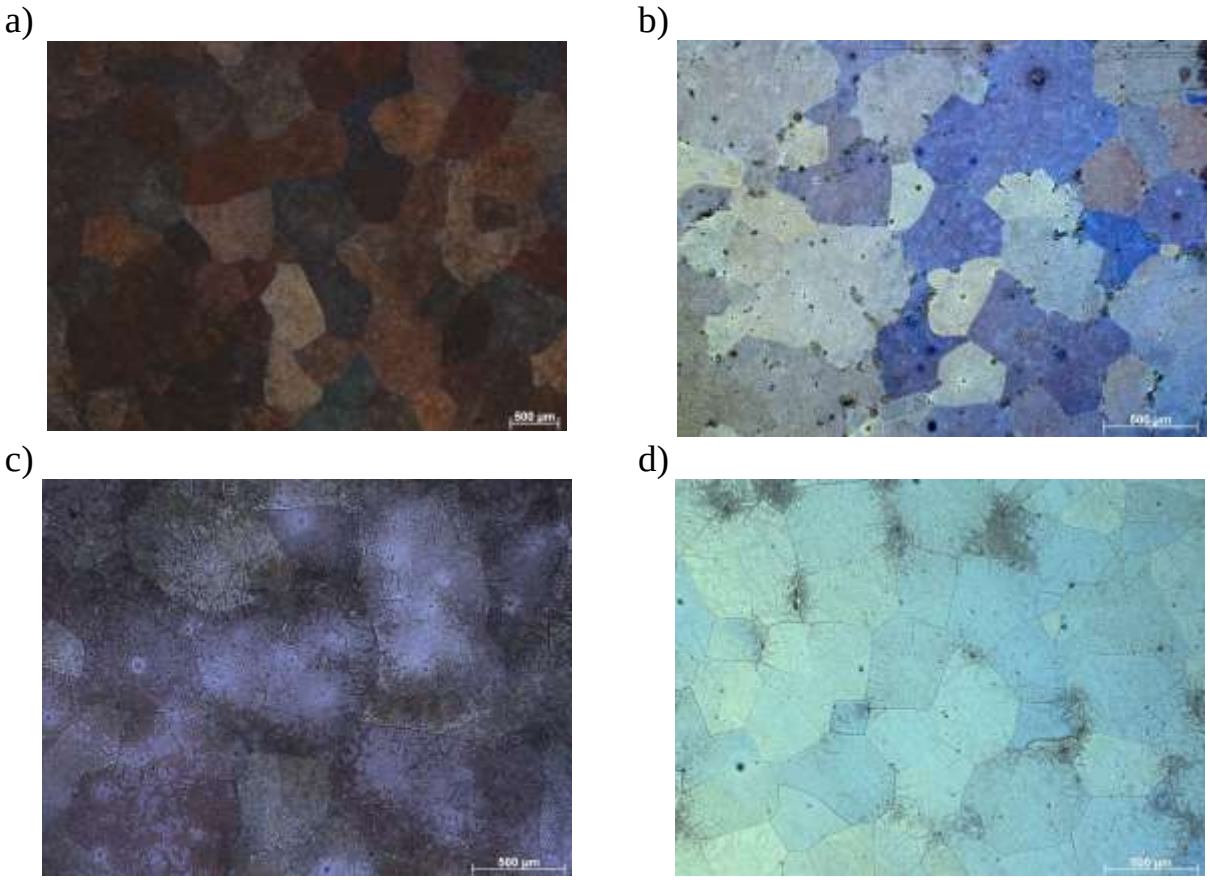


Figure 2. Microstructures of Mg-12Li-1.5Al in as-cast state (a), and treated by TiB (b) and Sr (c) and TiB+Sr (d)

Computer image analysis of the average grain size of ultralight Mg-Li alloys determined by line intersect method exhibit that the modification level is different for every analysed alloys. When the TiBor is applied, a notable decrease in average grain size is observed.

Average grain size of Mg-12Li-1.5Al alloy presents that appliance of TiBor as a grain refinement causes the reduction in average grain size from 628 to 385 μm. The measurements exhibit that the application of AlSr influence on a decrease of average grain size to 483 μm, while the addition of TiB and Sr simultaneously decreased the average grain size to 394 μm.

Measurements of hardness according to the Rockwell method in F scale of alloys displays that the grain refinements affect the average hardness of analysed alloys (Fig. 3). When the 0.2 wt.% of TiBor is added to the ultralight Mg-12Li-1.5Al alloy, significant increment of average hardness from 70 to 79 HRF can be observed. The results indicate that the application of Sr slightly increase the average hardness of Mg-12Li-1.5Al cast alloy to 75 HRF similarly, when the application of TiB and Sr simultaneously cause a increment in average hardness to 73 HRF.

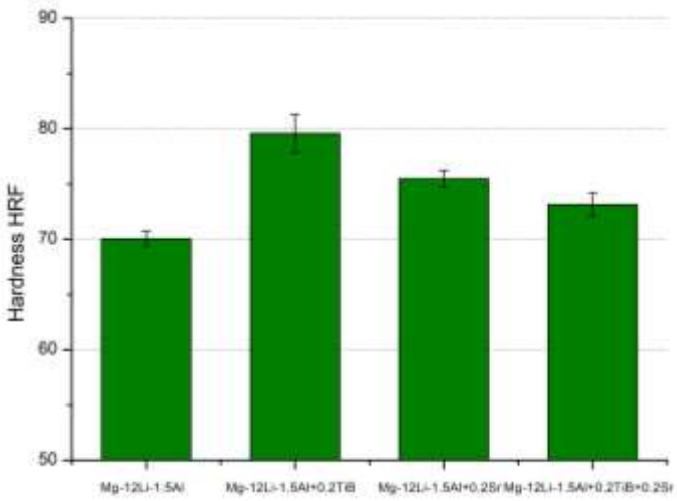


Fig. 3. Variation of hardness of Mg-Li as-cast alloy

All analysed ultralight Mg-Li specimens for compression tests showed similar plastic material behaviour in the uniaxial compression test.

Under compressive loading, Mg-12Li-1.5Al, compression σ=525±11 MPa was determined. The Mg-12Li-1.5Al alloy modified by TiBor as a grain refinement is characterised in the improvement in compressive stress 533±8.5 MPa. The

compression test of Mg-12Li-1.5Al+0.2AlSr shows that the compressive stress increase to 540±3.5 MPa μm, while the addition of TiB and Sr simultaneously improve the compression strength to 595±3.25 MPa. The compression modulus was not determined due to the fact that the compression tests were not carried out with an additional external extensometer.

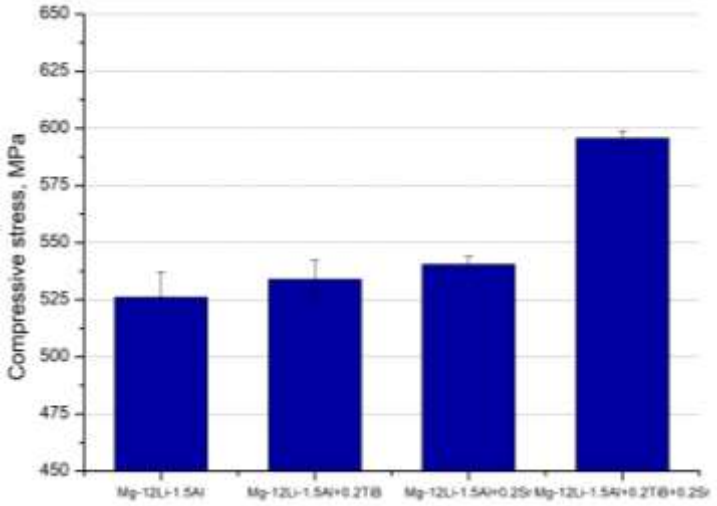


Fig. 4. Variation of compressive strength of Mg-Li as-cast alloy

4. Conclusion

The influence of grain refinements on Mg-Li-Al alloys has been investigated in detail microstructural observations and mechanical test. The results are summarised as follows:

1. The of TiB and Sr can refine the microstructure of the resultant alloy. The application of TiB and Sr refines the grain of *β*-Li, the grain size becomes smaller.
2. The most potent effect on hardness was observed when TiB as a grain refinement was added. The hardness of Mg-12Li-1.5Al risen from 70 to 79 HRF.
3. Based on compressive test it was found that the application of grain refiners increases in compressive stress. Application of TiBor and AlSr to ultralight β-Li single phase Mg-12Li-1.5Al alloys can be improved about 15 %.

Acknowledgement

Mariusz Król is a holder of Scholarship of International Visegrad Fund, granted for the period between September 2021 and June 2022.

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THE USAGE OF SOLIDWORKS CAD/CAM/CAE TECHNOLOGIES IN KHMELNYTSKYI NATIONAL UNIVERSITY

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DOI: 10.31891/monograph/2021-10-44

Khmelnytskyi National University was one of the first higher education establishments in Ukraine who started to use Computer-Aided Design (CAD) technologies in the academic process when teaching the students in the field of mechanical engineering. We started to use CAD systems in the academic process in the early 90s and since that time we used a number of different CAD/CAM/CAE systems. Firstly, we used simple 2D drawing editors (Autodesk AutoCAD, KOMPAS, etc.), then – 3D mechanical CAD systems (Autodesk Inventor, T-Flex etc.). Besides, since 1998 to 2012 our university also carried out Ukrainian Student Contest on CAD and computer modelling in machine building. It also became an international status because participants from other countries also take part in the Contest every year.

It is no doubt that nowadays computer technologies are widely used in the designing and engineering. One of the world leader of Computer-Aided Design software is SOLIDWORKS which has more than 3,5 millions of licensed users worldwide. It can be used for designing and manufacturing the wide range of products of different purposes and complexity. Khmelnytskyi National University is a licensed user of SOLIDWORKS software since 2006 when we received the first grant from the SOLIDWORKS Corp. Since that time, we have been using SOLIDWORKS extensively for training students at the Faculty of Engineering, Transport and Architecture and at the Faculty of Information Technologies.

During 2006-2008 we were using 30-users license of SOLIDWORKS 2005-2008 in 2 computer labs. During that period, we noticed that SOLIDWORKS software can be used not only in particular educational courses but in a number of educational courses which are used to prepare a mechanical engineer. We found it so convenient because there is no need to use different software in the academic process – SOLIDWORKS can be used during the whole period of education. In this case, there is no need for the students to study fundamentals of many CAD-systems – it is better for them to study mechanical engineering instead of learning

new software every semester. For example, during the 3rd academic year students are to learn “Machine Elements” course and instead of teaching students how ***to use*** CAD-system to design machines, we could teach them how ***to design*** machines using SOLIDWORKS, because the students had already studied SOLIDWORKS fundamentals earlier. In 2009 we were granted 60-users license and in 2010, due to the support of SOLIDWORKS Corp., we were granted a 500-users license of SOLIDWORKS and it significantly helps us to enlarge the usage of SOLIDWORKS in our University, in particular – it enabled us to develop a program of continuous training of the students of the mechanical engineering specialties using SOLIDWORKS: our students use SOLIDWORKS in a number of educational courses during the whole period of education.

In 2009 we also received the official status of **SOLIDWORKS Academic Certification Provider**, it allows us to organize SOLIDWORKS certification exams both basic and professional levels – Certified SOLIDWORKS Associate (CSWA) and Certified SOLIDWORKS Professional (CSWP). Since that time more than 500 specialists from our university and from other establishments have successfully passed official certification exams in our SOLIDWORKS Center. Since 2010, we maintain our subscription service program (500 workseats), which enables us to upgrade the SOLIDWORKS software every year.





Fig. 1 The SolidWorks Center at our university (3-103) and the students who successfully passed CSWA certification exams

So, for the present time we have equipped more than 140 workseats of SOLIDWORKS software at 9 University computer labs and created a special computer lab – *SOLIDWORKS Center of Khmelnytskyi National University* (head of the Center – prof. Viacheslav Kharzhevskyi) where we carry out SOLIDWORKS certification exams.

Thus, we have at least 360 free licenses of SOLIDWORKS which are not used in the academic process at the same time – these licenses can be used by students in the hostels (in particular – in computer laboratories in the hostels for the self-practice), because those computers are within the same network. Besides, all the students can use SOLIDWORKS software at home for free, because SOLIDWORKS campus licenses are additionally equipped with the same number (500) of home-use licenses.

For the present time, students of the following specialties of the Faculty of Engineering, Transport and Architecture study SOLIDWORKS:

- Applied Mechanics (education program "Manufacturing Engineering");
- Materials Science (education program "Restoration and technical service of Automobiles");
- Industrial Engineering (education programs "Robotics and mechatronic systems" and "Machines and Devices for Food Production");
- Electric-power industry, electrical engineering, electromechanics;
- Automobile Transport.;
- Agricultural Engineering.

The peculiarities of the academic process

When the students entered the University, they started to learn SOLIDWORKS fundamentals from the **1st academic year** within the course "Engineering and Computer Graphics". That course is divided into 2 parts: the first part is dedicated to the study of SOLIDWORKS fundamentals in creation of 3D-models of parts and assemblies. While learning the second part of the course the students study how to create drawings using national Ukrainian standards.



Fig.2. Samples of projects which were created within the course "Engineering and Computer Graphics" (the 1st academic year)

During the **2nd academic year,** the students study the course of "Theory of Mechanisms and Machines". While learning that course, students study how to

create and analyze different mechanisms and mechanical systems – linkage mechanisms, cam mechanisms, gear mechanisms etc. Within that course the students have to complete a course paper. The course paper is divided into several parts and each part is dedicated to the study of different types of machines. The students are to learn theories of designing of mechanisms, analytical formulae and dependences and then they are to make computer 3D-models of mechanisms and perform all necessary engineering calculations using SOLIDWORKS Motion.

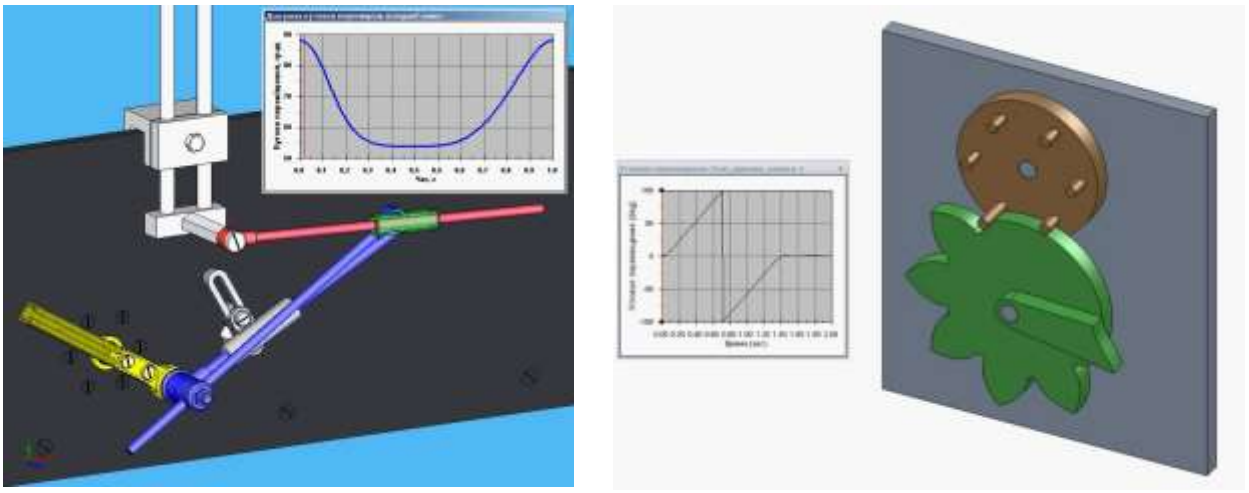


Fig. 3. Samples of the course paper on "Theory of Mechanisms and Machines" (the 2nd academic year)

During the **3rd academic year,** the students learn the fundamental course of "Machine Elements". Within that course the students study how to design machines and devices. Within that course the students also have to complete a course paper. Every student has his own task and a whole course paper is divided into several parts:

- making all the necessary calculations using traditional analytical methods;
- designing of a machine and making a 3D models and assembly;
- performing strength calculations of machine elements using Finite Elements Analysis (SOLIDWORKS Simulation);
- making up drawings and necessary design documentation using national standards.

Additionally, the students can study another course: "Computer-Aided Engineering". Within that course the students study the fundamentals of the Finite Element Analysis and fundamentals of the SOLIDWORKS Simulation. These

skills are useful for the students to study other courses and while completing course papers on different courses and diploma paper.

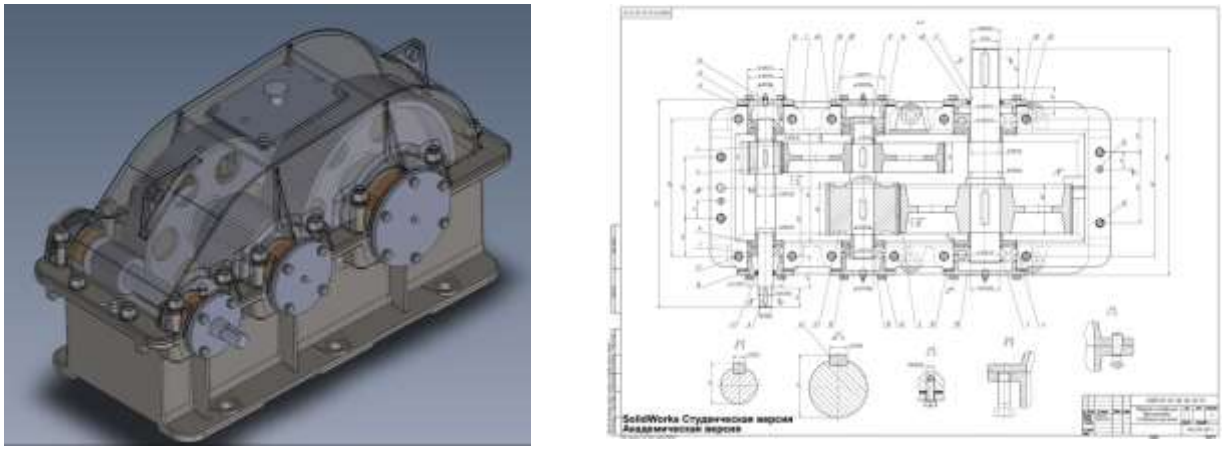


Fig.4. Sample of the course paper on "Machine elements" (the 3rd academic year) – designed model of a reducer and one of the drawings

After finishing the **3rd academic year,** the students use SOLIDWORKS in the educational courses which are linked with their specialty. For example, the students who study the education program "Machines and Devices for Food Production" use SOLIDWORKS during completing the course paper on the course "Technological Equipment of Food Industry" – students use SOLIDWORKS Flow Simulation to complete their course papers.

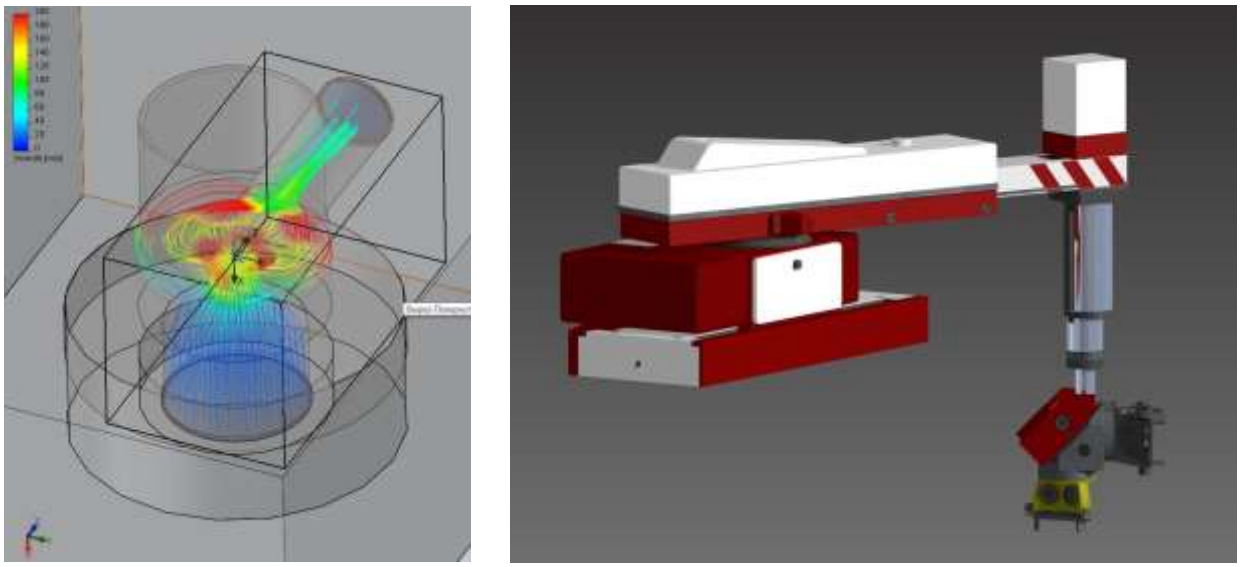


Fig. 5. Sample of the course paper on "Technological Equipment of Food Industry" (designing of the milk homogenizer, calculations were made using SOLIDWORKS Flow Simulation) and course paper on "Modeling of Electromechanical Systems" (designing of a robot)

Students of another education program – “Robotics and mechatronic systems” use SOLIDWORKS in the course “Modeling of electromechanical systems”. While learning this course students also have to complete a course paper.

At the department of Manufacturing Engineering SOLIDWORKS is used in the courses “Computer-Aided Design systems in the technological processes” and ”Manufacturing Engineering”. Since 2011, this department also uses CAMWorks software (20 workseats) in the academic process – students study how to write CNC programs. Students of the specialties “Automobile transport” and “Materials Science” study such courses as “Modelling of the technological processes”, “Restoration processes” – students use SOLIDWORKS and especially SOLIDWORKS Simulation during learning these courses.



Fig. 6. Sample of the laboratory work: students study CNC-programming using CAMWorks

As a result of the continuous training of the students using SOLIDWORKS software during the whole period of education, the students use SOLIDWORKS while completing their diploma papers. All the calculations are made by the SOLIDWORKS Simulation, Motion and Flow Simulation.

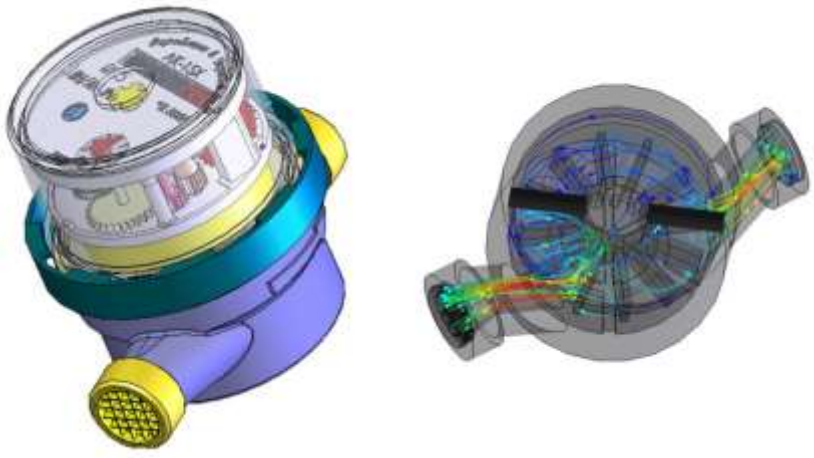


Fig. 7. Sample of the diploma paper: designing of the water counter

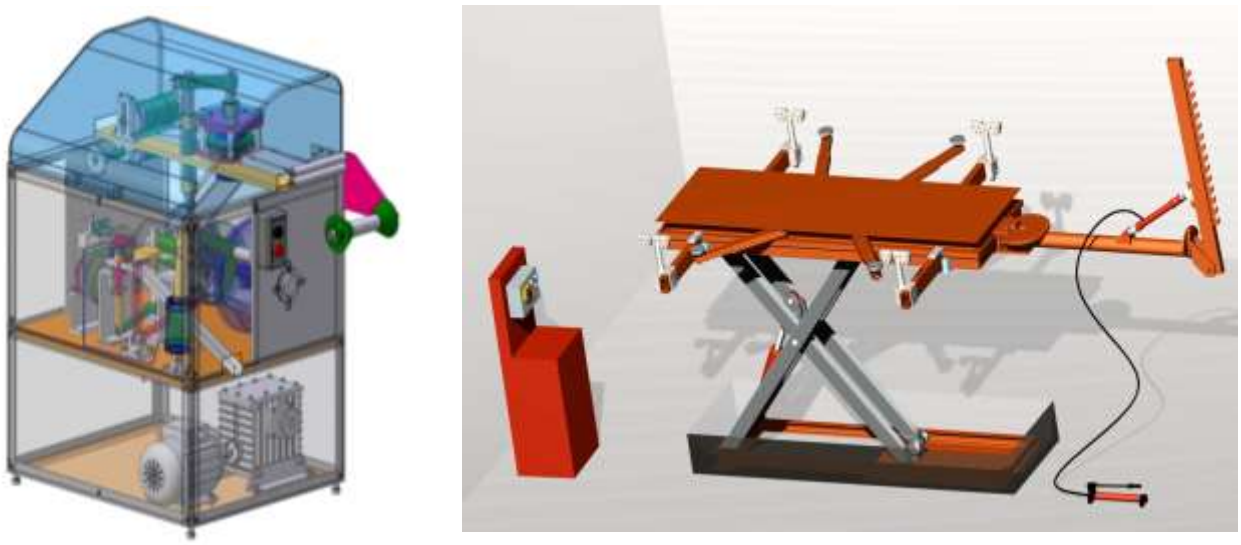


Fig. 8. Samples of the diploma papers: "Development of the construction of the automatic machine for the candy wrappers production" and "Universal stand for the restoration of the geometry of frames and bodies of the cars"

The conception of continuous training of the students using SOLIDWORKS is implemented at the Faculty of Engineering, Transport and Architecture for a number of specialties. The graduates of these specialties can work as mechanical engineers in such fields as: engineer in the design department, manufacturing engineer, chief of the CAD department, production manager, electrical engineer in the field of design and maintenance of electromechanical equipment and systems, mechanical engineer in the field of implementation of new technologies and others.

Students of the specialty "Computer Science" (the Faculty of Information Technologies) also study SOLIDWORKS and graduates of this specialty work as software developers. They study SOLIDWORKS and especially SOLIDWORKS API during education, so they can also work as the developers of Add-Ins for SOLIDWORKS.

Thus, using SOLIDWORKS, our University was able to re-arrange the academic process and make it more effective, interesting and up-to-date.

SOLIDWORKS Certification

Since 2009 we have an ability to organize official SOLIDWORKS certification exams for the students and educators. It is so important, because our students have an opportunity to pass official SOLIDWORKS exams at our university and receive ***Certified SOLIDWORKS Associate (CSWA)*** and ***Certified SOLIDWORKS Professional (CSWP)*** certificates. It motivates them to study

better and they understand that these knowledges are useful for the present time and for the future.

From 2010 to 2021, we carried out additional courses for our best students on advanced SOLIDWORKS learning with a goal of preparation for the passing CSWA certification exams. This course was developed by prof. Kharzhevskyi and it includes the advanced topics on: part modelling, assembly modelling and design validation using SOLIDWORKS Simulation.

During 3 months students study the additional course which includes:

- advanced functionality of SOLIDWORKS for complex geometry creation;
- study literature which is recommended by SOLIDWORKS Corp. for passing certification exams;
- advanced functionality of SOLIDWORKS for creation of drawings according to the national standards;
- problems with complex assemblies creation;
- strength calculation using SOLIDWORKS Simulation. Optimization of constructions;
- preparation for theoretical questions for passing CSWA exam.

As a result, from 2010 to 2021 we organized 539 certification exams, 466 certificates were issued.

Cooperation with enterprises

An important component in the training of specialists in university is the cooperation with enterprises. Knowledge of modern engineering technologies of design and engineering analysis allows our graduates to be competitive in the job market: modern computer technologies are widely used in industry.

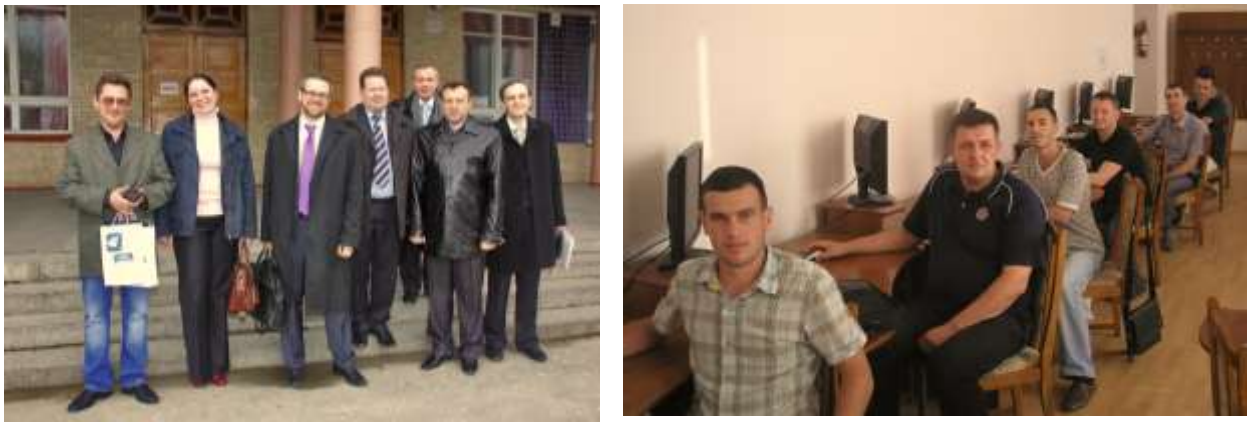


Fig. 9. Visit of SOLIDWORKS Corp. representatives (USA) in Khmelnytskyi National University (left), cooperation with enterprises: carrying out of the scientific consultations for the designers (right)

As a result, there is a need for both new specialists and retraining of existing designers and technologists. The SOLIDWORKS Center of the Khmelnytskyi National University cooperates with a number of Ukrainian machine-building enterprises to conduct advanced training and provide scientific consultation on the use of modern engineering design technologies. For now, more than 40 specialists were retrained in our SOLIDWORKS Center.

The SOLIDWORKS courses for the specialists from the enterprises includes an overview of the advanced functionality of SOLIDWORKS for solving production problems, in particular – the creation of complex geometry, parameterization of parts and assemblies, work with sheet metal and weldments, strength calculations, working with PDM-systems, automation in design documentation creation. All the specialists from the enterprises have also successfully passed the SOLIDWORKS international certification exams.

Conclusion

Traditionally, specialties in the field of mechanical engineering are much harder to study for the students in comparison with the other specialties. Students are to create many drawings during education, perform large variety of complex engineering calculations and so on. SOLIDWORKS simplifies the educational process and makes it much more interesting for the students. They can design, validate their designs, make up all the necessary design documentation and create CNC programs using SOLIDWORKS.

DIFFERENTIAL ACTIVE EMG ELECTRODE IN PROSTHETICS – PERFORMANCE ANALYSIS

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DOI: 10.31891/monograph/2021-10-45

Abstract

This paper presents the analysis of low component count, accurate and robust differential electrode to measure skin surface electromiographic (sEMG) signals which was designed by Design Pro Technology Sp. z o.o. in Poland for applications in prosthetic equipment. Surface electromiography as a non-invasive way to detect muscle activity is widely used in the fields of healthcare (diagnostics and rehabilitation), mechatronics and prosthetics. Demanding process of EMG signal acquisition and processing is still challenging. Small amplitude of electrical muscle activity signal requires high level of amplification and sophisticated filtering on the exposure of the ambient noise (including power line interferences and EMI), electrode shifts, motion interferences, humidity and sweat. Therefore the EMG signal acquired by the sEMG sensors should be carefully conditioned and processed to produce quantifable output capable to reliable control the prosthetic equipment. With presented differential active approach, high signal-to-noise ratio (SNR) as well as common-mode rejection ratio (CMRR) was obtained to clearly extract useful EMG signal components. Signal processing such as complex filtering and signal magnitude estimation were performed in digital domain allowing small component count and robust design of the electrode. This paper presens the analysis of the electrode's preformance outlaning outstanding features of the proposed differential active approach to apply in hand prosthetics.
Keywords:EMG signal, signal processing, hand prosthesis

I. Introduction

Human hand is a vital part of human body allowing its effective operation. Amputation of a hand evidently decreases the quality of life affecting common daily tasks. Fortunately there is a number of currently available active hand prostheses with the prominent share of myoelectric devices. The battery-powered myoelectrical device interpretes intentional muscle contractions present in residual

limb to control the robotnic hand gestures. The main effort is to obtain higher precision of gestures with robust control simultaneously with intuitive control by the user [1]. Reliable operation of such devices require dependable EMG electrodes which secure reliable detection of the muscle contraction sEMG signal in the presence of external interferences.

II. Emg signal and the noises

EMG signal is the elactrical process initiated in neuromuscular actuation at muscular contraction. The electric potential is generated at passage of Na^+ and K^+ ions through nerve cell membranes. The difference of potential, spike-shaped electrical voltage transient within single muscle fiber, ranges about 100 mV, lasts about 1 millisecond and propagates across a muscle fiber. The EMG signal is composed of number of such single impulses. Fig. 1 shows the EMG signal from the extensor carpi ulnaris muscle which was acquired with an invasive method. The energy of EMG signal depends on a degree of contraction (i.e. number of single nerve fiber impulses). The EMG signal propagating towards the skin surface is further attenuated by the impedance of the tissues to the amplitudes less than 5 mVpp [2]. Therefore only a fraction of signal EMG energy reaches the surface of the skin where it can be detected by the sEMG sensors [3].

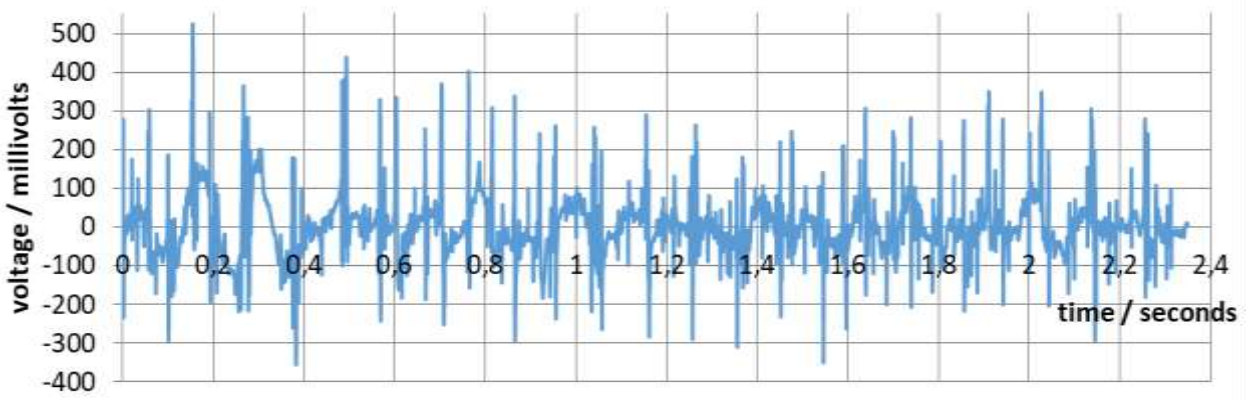


Fig. 1 Example of muscle EMG signal during muscle contraction (physionet.org)

The bandwidth of EMG signal ranges from 20 Hz up to 500 Hz with the dominant components within the range of 50-150 Hz (Fig. 2). Millivolt-level, weak sEMG signal is exposed on different kinds of noises and interferences among which the most severe is the ambient noise caused by electric line interference and electric devices (including RF devices) with dominant frequency component of 50 Hz or 60 Hz (depending on electric grid standards). Other sources of noise

are ECG and EEG signals that residue in the frequencies not higher than 10 Hz (Fig. 2). The RF noise in a ranges of MHz and GHz, which is generated by wireless and radio devices, can affect high impedance inputs of sEMG sensors. EMG signal processed by the electrode can contain other artefacts caused by electrode shifts, motion interferences, humidity and sweat, muscle deseases or fatigue. On a daily basis the amplitude of the EMG signal decreases with tiredness.

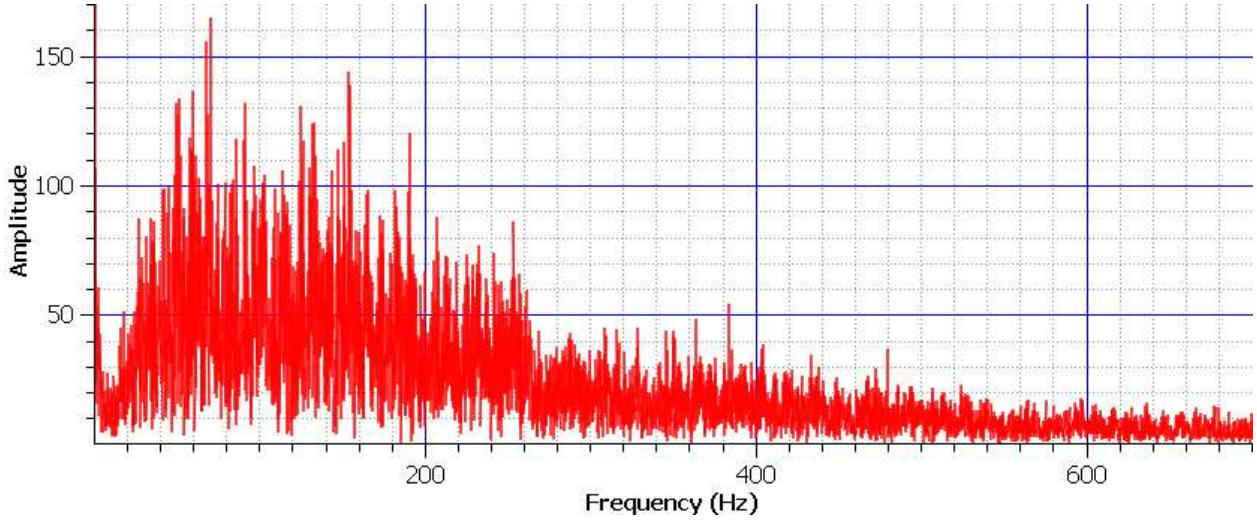


Fig. 2 Representation of EMG signal in the frequency domain

These factors require careful signal conditioning as well as further processing to provide informative and reliable information about muscle activity.

III. Emg signal conditioning, topology of the electrode

The electrode designed by Design Pro Technology is composed of three non-invasive stainles steal sEMG sensors. One sensor provides reference potenial to the skin, two others act as differential sensors. The active electrode in its electronic part is composed of analog part containing minimal number of indispensible analog circuits for EMG signal acquisition, and digital part where EMG signal is processed. Fig. 3 presents the topology of the electode. The use of a microcontroller helped reducing the overall component count of the electrode moving the tasks traditionally performed by analog circuits (filtering and RMS calculation) into the digital domain. Moreover it allows achieving outstanding filter parameters, provides flexible and seamless changes in the filter parameters and makes it possibile to apply more advanced signal detection methods [4]

(e.g. frequency domain analyses, wavelet analyses), not affecting the electrode PCB design.

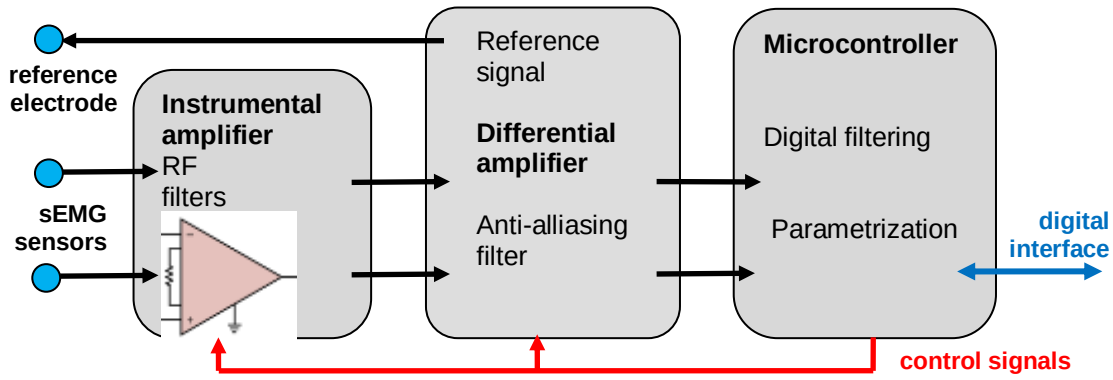


Fig. 3 Topology of the differential active EMG electrode.

A. Differential Signal Processing

The EMG electrode based on the approach of differential signal conditioning has following advantages in contrary to traditional single-ended electrodes:

- immunity to common-mode interferences including electrical grid and electrical devices electromagnetic interferences (EMI);
- lack of ground noise in the signal path which is commonly present in single-ended electrodes powered from unipolar voltage rail;
- two times higher signal range with respect to reference voltage of an analog-to-digital converter (ADC).

The above mentioned features allow topologically to design low noise electrode which is less exposed to ambient electromagnetic noise.

B. Amplification

Signal from differential sEMG sensors touching the surface of the skin is initially amplified by the instrumental amplifier forming the active electrode (Fig. 3). Instrumental amplifier with high common mode rejection ratio (CMRR) assures sufficient attennuation of common-mode noise signals from sEMG sensors. Its high impedance inputs are equipped with low-pass RF filters that prevent instability of the amplifier. Second stage of signal amplification is performed in the differential amplifier with adjustable gain. Overall gain ranges from hundreds up to single thousands.

C. Analog Filtering

Only necessary circuitry was accommodated to perform analog pass-band filtering. High-pass filter suppressing DC and low frequency signal components

precedes the differential amplifier. Anti-alliasing filter applied at differential output of the differntial amplifier prevents the spectral artifacts generated in non-linear analog-to-digital conversion (ADC) process to be present within the bandwidth of the EMG signal. Fig. 4 shows the waveform of amplified and filtered analog differential EMG signal recorded while three consecutive extensor carpi ulnaris muscle contractions.



Fig. 4 The waveforms of bipolar EMG signals (channels 1 and 2, gain 500 mV) and differential EMG signal (channel MATH, gain 1 V)

D. ADC Conversion

To adapt analog EMG signal to further signal processing in the digital domain, ADC conversion is required. For the given bandwidth of the EMG signal of 500 Hz, conversion rate above 1 kHz is demanded. It determines the data throughput in the digital system considering all processing requirements.

Nowadays the microcontrollers are distinguished with a rich set of peripheral modules such as ADC converters, hardware-based data processing units (floating-point co-processors, multiple and accumulation units, etc.). Together with a range of digital interfaces they can serve as stand-alone data processing units allowing digital (wireless) data transmission to the other devices. The EMG electrode is equipped in the microcontroller (Fig. 3) which carries out

differential ADC conversion, digital filtering and calculates the EMG signal amplitude in a form of RMS value of the signal.

E. Digital Filtering

Two stages of digital filtering were implemented: band-pass filter 20-500 Hz which secures the bandwidth of the EMG signal and the band-stop „notch" filter at 50 Hz to precisely attenuate unwanted 50 Hz ambient electrical noise. The digital filters offer the signal filtering quality not available in conventional analog approach. Fig. 5 shows the comparision of analog and digital high-pass filtering approach.

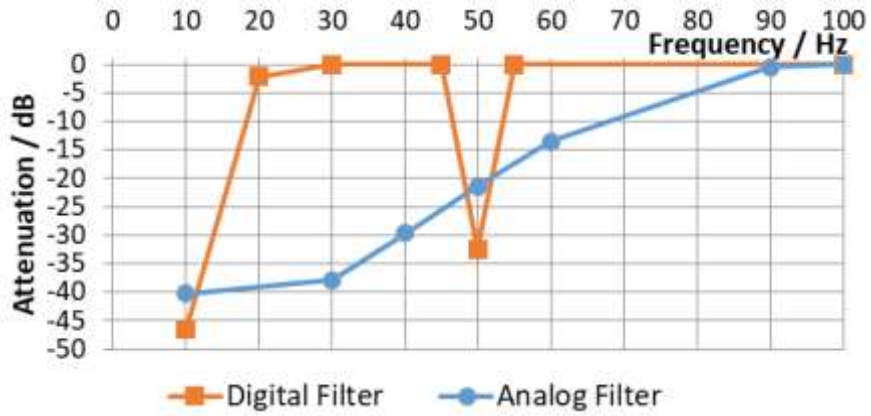


Fig. 5 Comparision between digital and analog filter frequency characteristics in 0-100 Hz range

To achieve the attenuation for the noise signals within the frequencies lower than 10 Hz with the attenuation lower than -40 dB, 4-tap highpass Chebyshew analog filter (utilizing 4 operational amplifiers) with cut-off frequency at 90 Hz (Fig. 5) was designed and tested. With described digital filtering approach it was possible to obtain much steeper slope of the filter at 20 Hz and additionally achieve selective filtering of 50 Hz signal components (Fig. 5). With digital approach it was possible to preserve the spectral components of the EMG signal in the range of 20-90 Hz allowing more precise estimation of the EMG signal level. The reduction in component count was achieved by eliminating analog filter circuits.

F. Amplitude of EMG signal

Filtered digital EMG signal is the subject of its features extraction. One of the most intuitive parameter is the RMS value of the signal which informs about effective amplitude of the signal. The process of RMS esitmation is often called

envelope computation [5]. Fig. 6 shows the RMS signal waveform from the electrode.

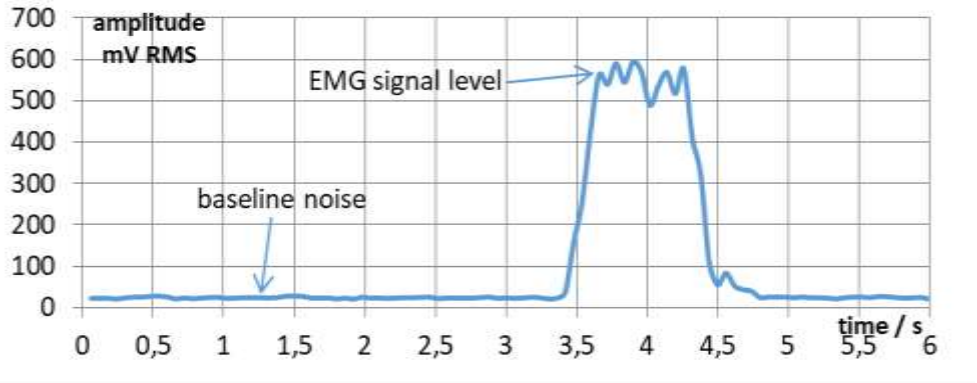


Fig. 6 The example of RMS waveform of the EMG signal produced by Design Pro Technology electrode at extensor carpi ulnaris muscle contraction

For given number *k* of *N* filtered samples, EMG time series is represented as

$$X_i^k = \left\{x(i), x(i+k), x(i+2k), .., x(i+\frac{N-i}{k}k)\right\}, \qquad (1)$$

and RMS value of k consecutive samples is

$$RMS(X_i^k) = \sqrt{\frac{1}{N-k}\sum_{i=k}^{N} x(i)^2}\ . \qquad (2)$$

G. EMG signal parametrisation

RMS value is the very first intuitive parameter of the EMG signal needed to determine the muscle activity. There are a number of time domain, frequency domain, time-frequency domain or AI methods [4] that improve EMG signal detection which can be futrher implemented in the microcontroller.

IV. Performance test results

Design Pro Technology differential sEMG electrode prototype was tested in laboratory bench to prove its performance and readiness to apply in prosthetics. Solid-state sEMG electrodes were made of stainless steel 316L, placed on extensor carpi ulnaris muscle. Digital RMS values of the EMG signal levels were transmitted via USB interface and further analysed on the computer. Signal-to-

noise ratio (SNR), CMRR and filter bandwidth were determined. In case of CMRR and filter bandwidth tests, the electrode was excited by the test signals from the laboratory equipment.

A. SNR

Signal-to-noise ratio determines the ability of the electrode to extract informative data about the muscle contraction from the EMG signal. For the filtered dataset, basing on (1) and (2) SNR is defined as

$$SNR(X_i^k) = 20log_{10}\frac{RMS(X_{i\ EMG_signal}^k)}{RMS(X_{i\ Baseline_noise}^k)}, \quad (3)$$

In [5] collated are the results from the tests of textile EMG sensor and Ottobock 13E68 EMG sensor, all applied on applied on extensor carpi ulnaris muscle. The best SNR values reported are 12,5 dB for textile sensor and 17,0 dB for Ottobock sensor. In the example of EMG signal in Fig. 6, SNR is equal to 23,7 dB indicating inherent low noise of the proposed electrode.

B. CMRR

CMRR is the measure of electrode's ability to attenuate unwanted ambient common-mode noise. It mainly depends on component inbalances in differential circuits of the electrode. Considering (1) and (2) CMRR is defined as

$$CMRR(X_i^k) = 20log_{10}\frac{V_{iCM_RMS}}{RMS(X_i^k)}, \quad (4)$$

where V_{iCM_RMS} is RMS value of the sinusoidal common mode voltage applied to the inputs of the electrode.

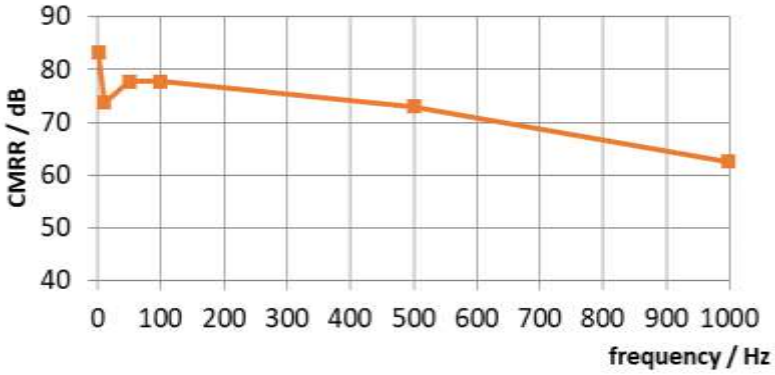


Fig. 7 CMRR test results

Since each active electrode incorporates an instrumental amplifier at measurement front end (Fig. 3), CMRR, reported by the myoelectic electrode vendors, only refers to the differential measurement front end. Fig. 7 presents the CMRR of the whole differential electrode circuit vs. frequency. It reveals CMRR of the whole electrode higher than 74 dB across the bandwidth of EMG signal whereas, according to [6], the range of 70-90 dB is sufficient for measurement front end solely.

C. Differential electrode signal bandwidth

Indispensible analog circuitry in RF filter and anti-aliasing filter together with digital filter implemented in microcontroller determine the overall bandwidth of the electrode (Fig. 8).

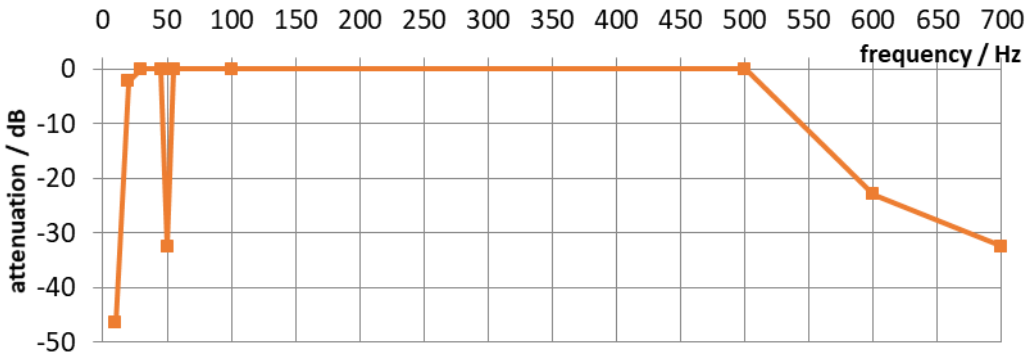


Fig. 8 The bandwidth of the differential active EMG electrode

With digital filtering it was possible to preserve full bandwidth of the EMG signal, i.e. 20-500 Hz additionally applying narrow bandstop „notch" filter for unwanted electrical grid noise at 50 Hz cutting out selectively only narrow fraction of full EMG signal band.

V. Conclussion

With proposed fully differential circuit it was possible to achieve outstanding performance of the porposed active electrode. Differential approach allowed to obtain high CMRR of whole electrode proving its immunity to ambient common-mode noises. Ground noise was effectively separated from differential signal path providing high SNR in processed RMS signal. Thanks to precise filtering it is possible obtain high quality signal and reliable extract the EMG signal features from the frequency band of interest. Separation of analog data acquisition from digital data processing allowed decreasing component count

in the electrode design and made room to implement more advanced EMG signal detection techniques in the microcontroller. The differential active EMG electrode described in this paper has a potential to apply in prosthetic and control equipment.

Acknowledgements

DESIGN PRO TECHNOLOGY Sp. z o.o. carries out the research project WND-RPPD.01.02.01-20-0181/19 „Prosthetics 2.0 - research and development works on intelligent exoprostheses”

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THE IMPORTANCE OF POST WELDING CLEANING AND ITS INFLUENCE ON THE CORROSION RESISTANCE OF WELDED DSS

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DOI: 10.31891/monograph/2021-10-46

Abstract

This paper presents the review of main methods of surface finish treatments used in fabrication of welded stainless steels components, with special emphasis on the welded duplex stainless steels (DSS). The DSS as all corrosion resistant alloys require careful surface treatment after the completion of the welding process. Improper methods applied in this stage of material processing may drastically reduce corrosion resistance and lead to numerous local corrosion phenomena, despite of used welding parameters itself. Therefore, knowledge of proper post-welding surface cleaning is essential to achieve the expected performance of welded DSS elements. The paper describes main processes and methods (mechanical and chemical) applied during post-welding cleaning of DSS surface. The importance of finishing operations and its influence on corrosion resistance of stainless steels is discussed.

Keyworks: duplex stainless steel, post welding surface treatment, heat tint, pickling, passivation

1. Welding process factors influencing corrosion performance od duplex stainless steels

Welding procedures of duplex stainless steels should consider following aspects in order to achieve acceptable corrosion resistance and mechanical properties - toughness in the weld zone of duplex stainless steels (DSS) [1÷7]:

- Precisely control the thermal cycle to maintain proper phase balance – minimum heat input to allow sufficient transformation of ferrite to austenite and minimize intermetallic phases precipitations – maximum heat input to avoid precipitation;
- Maintain nitrogen levels in the weld deposit of gas shielded welds to assure maximum pitting resistance;

- Minimize hydrogen content to avoid hydrogen embrittlement of the ferrite phase.
- Minimize oxygen content to maintain weld deposit toughness (most important for flux shielded weld deposits).

Steel composition affects greatly on austenite formation. High nickel and nitrogen levels allow austenite to form at higher temperatures. This is due to the fact that high nickel and nitrogen levels reduce Creq/Nieq ratio at which time ferrite solvus temperature rises and austenite can form at higher temperatures. Other elements that assist austenite formation are manganese, carbon, vanadium and copper. Respectively elements that stabilize ferrite phase are chrome, molybdenum and silicon.

In most of the industrial applications, it is recommended that less than 25% austenite content in DSSs weld is unacceptable [5], while Norsok standard [6] recommended 30% austenite content in the welded joints for piping inspection. The recommendation [7] to achieve better mechanical properties and corrosion resistance of the weld when using duplex filler metal (or fully austenitic) can be illustrated as follow (fig. 1).

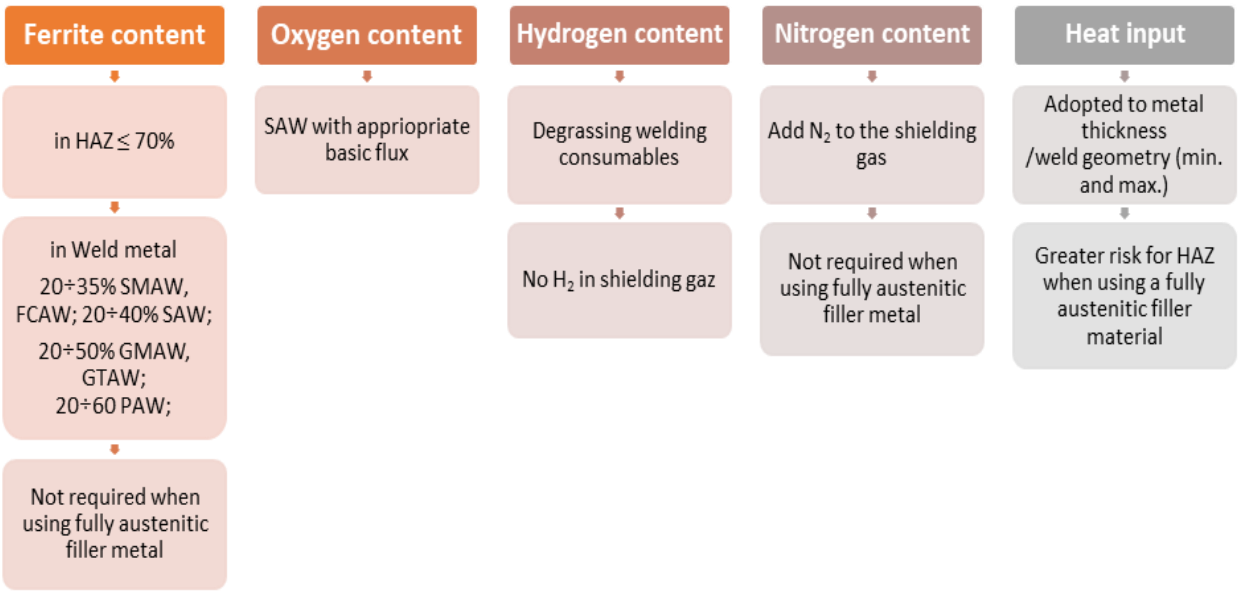


Fig. 1. The principal factors controlling mechanical properties and corrosion resistance of welded DSS

To ensure the correct ferrite-austenite phase balance (i.e., avoid excessive ferritization), duplex stainless steel filler metals are over-alloyed with nickel.

Duplex steel steels (DSS) should not be welded without the use of filler metal due to the risk of high ferrite content of the weld resulting from melting the parent material. The filler metal recommended for duplex stainless steel have a content of austenite-forming nickel higher by 2 ÷ 4% compared to the parent material in order to increase the kinetics of austenite formation ($\delta \rightarrow \delta + \gamma$) and to compensate the lack of possibility of subsequent balancing of the microstructure of welded elements by post welding heat treatment. All duplex stainless steels shall be welded using matching, over-alloyed filler materials.

It is recommended to weld the lower alloyed grades of DSS with the alloy of the composition corresponding to the higher grade category (e.g., DSS are welded with alloys of the chemical composition of super duplex stainless steel ((SDSS), especially in case of root passes exposed to direct contact with the corrosive medium. Using 2507 filler metal type to weld 2205 DSS maximizes the corrosion performance of the weld metal, but slightly reduces high temperature HAZ fracture toughness [1,13].

Nitrogen present in the chemical composition of most duplex steel grades is an element that strongly increases the kinetics of austenite formation. The relationship between the content of nitrogen and δ-ferrite, and thus austenite in the weld, is linear. Accordingly, microstructural evaluation of duplex welds with determination of δ-ferrite content are generally performed in the root and last bead of the weld face in order to obtain information about the extent of ferrite content and thus the expected pitting resistance on both significant surfaces of the welded joint. Unfortunately, the high vapor pressure of nitrogen at the welding temperature causes it to migrate from the weld to the surrounding environment and, consequently, reduce the proportion of austenite in the structure of the weld increasing the risk of losing the pitting corrosion resistance and reduced toughness of the weld. A weld poor in nitrogen contains up to 80% of δ-ferrite, while a weld very rich in nitrogen only approximately 20% of δ-ferrite [18].

Since the electric arc does not transfer electrically neutral nitrogen atoms, it is not present in arc welding consumables, and the only option to supplement the nitrogen content of the weld metal during welding is the addition of N_2 to the shielding and forming gas. The nitrogen content in shielding gases for GTAW welding (TIG, 141) should be in the range of 1 ÷ 1.2% for standard 22% duplex stainless steel grade and 2 ÷ 2.5% for 25% DSS, SDSS and HDSS steels.

The root pass of welds shows the weakest nitrogen absorption. Nitrogen deficiency in the DSS root material is the main cause of the negative pitting resistance test results. Unfortunately, the root weld is usually the place with the greatest risk of corrosion, therefore it is extremely important to use nitrogen-rich mixtures as forming gas. The highest nitrogen content – even up to 60% higher than in the root weld, is observed in the face weld seams. Thus, such differentiation of nitrogen content in the weld contributes to its various corrosion resistance depending on the face and root of the weld. This can be taken into account in the sequence of welds and their exposure to corrosive agents.

The application of shielding gases with too high a nitrogen content may result in exceeding the nitrogen solubility limit in solid solution and may result in the appearance of weld porosity, especially in thick-walled joints of DSS. Since the corrosion resistance of stainless steels is primarily determined by the properties of the top layer, the filler layers of multi-run welds can be welded in a pure argon shield without nitrogen, to avoid porosity. The addition of 20 ÷ 40% He to the shielding gas increases the thermal energy supplied to the weld, which enables the GTAW welding efficiency to be increased.

Full control of the oxygen content in welding gases prevents its absorption in the weld pool and a harmful increase in the content in the solid solution, and allows to reduce the thickness of the oxide layer above the welded joint, and thus the depth of the depletion of the steel surface layer in Cr and Mo. The oxygen content in atmosphere during welding effect on the oxide layer formation on the surface of welded zone. The oxide layer formation and their influence on the corrosion resistance of welded DSS was described in the next section.

The importance of post-weld cleaning of duplex stainless steel

Stainless steel is protected from external environment by a thin passive layer, that consists mainly of chromium oxide and hydroxide. The oxygen content present in the atmosphere or aqueous solutions is normally sufficient to create and maintain this protective layer. Unfortunately, surface defects and imperfections introduced during welding may drastically reduce resistance to local corrosion phenomena. This means that a final cleaning process is required to restore an acceptable surface quality regarding hygiene and corrosion requirements.

The typical weld surface defects, that should be restored during post-welding treatment, include heat tint and oxide scale on the surface, weld defects, iron contaminations, organic contaminations, and a rough surface in welded zone. These defects can initiate corrosion on the duplex plate surface and must be removed. That is why post-fabrication clean-up is very important and shall be the same as for other families of stainless steels [1].

Mechanical surface treatment methods such as fine abrasive grinding are commonly used to preliminary remove any contamination of the welded areas caused by the welding operation. Ferrous contamination can be removed by chemical cleaning with nitric acid. That is why the carbon steel tooling must be avoided as much as possible when working with stainless steel to decrease the risk of iron contamination. Organic contamination (oil, grass, paint, etc.) can be removed with a chlorine-free solvent [1,13].

With exposure to oxygen at high temperature, a thin "straw tinted" chromium oxide layer form. One of the most crucial surface effects, regarding corrosion performance of welded DSS, is related to weld high temperature oxidation and formation of an oxide layer with inferior protective properties, compared with those of the original passive layer (fig. 2). As a result, a chromium-depleted layer forms beneath the heat tint and may have a reduced corrosion resistance. The metal surface directly under the oxide layer (thickness 0.02 ÷ 0.2 μm) shows a depletion of chromium and is known as chromium-depleted zone. When cleaning the surface after welding, both heat tint discoloration and the chrome-depleted zone underneath should be removed. It is necessary to remove this layer to completely restore the DSS corrosion resistance in the weld heat affected zone. Heat tint oxides can be removed by pickling using commercial picking pastes or by means of immersion in pickling HNO_3/HF solution bath [3,13].

The weld defects (i.e., pores, slag inclusions, weld spatter, etc.) have negative effects on resistance to local corrosion and mechanical properties. Therefore, they must be removed, normally by mechanical surface treatment, typically grinding. Similarly, iron contamination must be removed from stainless steel surface. Iron particle in contact with noble stainless steel surface corrode in the presence of electrolyte (humid air) and damage the passive layer, what result in reduced corrosion resistance. This type of corrosion at the beginning produces only

surface discoloration, but with the passage of time and lack of cleaning, a favorable area is created for initiation of crevice and pitting corrosion on the surface. In turn, organic contamination of the surface in the form of greases, paints, dirt, etc. can cause crevice corrosion in aggressive media. For this reason, they should be removed from the surface, especially for effective chemical treatment (surface pickling), as they can render pickling process ineffective.

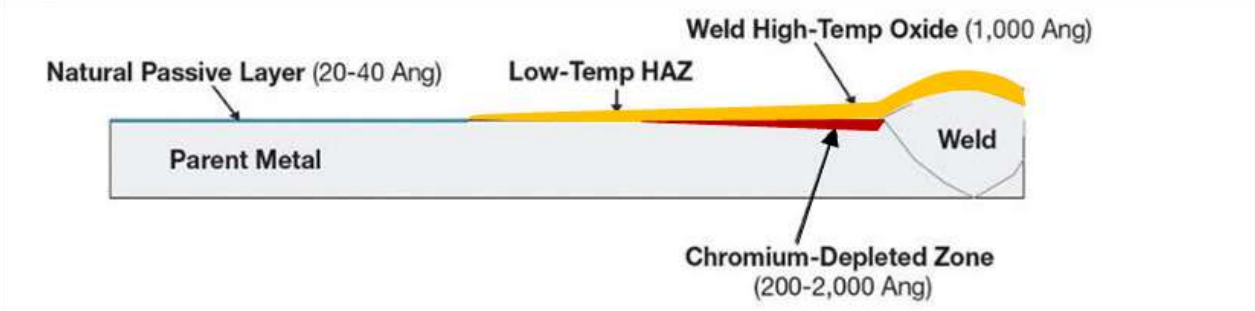


Fig. 2. Oxide layer formation on the welded surface [22]

Cleaning of stainless steel weldments is important to achieve adequate corrosion resistance after welding with particular emphasis being given to the heat affected zones. Methods such as mechanical and chemical cleaning are typically used. Electrochemical methods are also used where low surface roughness of cleaned area is highly required. After welding the surface condition of the metal should be restored by methods that include brushing, grinding, pickling, blasting. Combinations of these processes can be used to produce surfaces with the required corrosion resistance. The chemical surface treatment of welded duplex stainless steel requires various methods depending on surface contamination level.

The uneven weld beads and further mechanical surface finishing of the welded zone can result in rough surfaces. Rougher surface, more deposits is collected at that thereby increase the risk of corrosion initiation (fig. 3). When mechanical finishing also introduces high tensile stresses in metal surface, the risk of stress corrosion cracking and pitting corrosion is further increased. Manufacturing methods that result in rough surfaces should generally be avoided. For the above reasons there is a maximum allowed surface roughness (Ra value) for many applications, which will ensure consistently high surface corrosion resistance. The corrosion resistance of the stainless steel is affected by the surface roughness after grinding/polishing, with a marked decrease in the corrosion

resistance as the surface roughness increases above the Ra value of about 0.5 micrometers. This roughly corresponds to the surface produced by grinding with 320 grit abrasives. The acceleration of the corrosion of the surface at Ra above 0.5 micrometers is apparent.

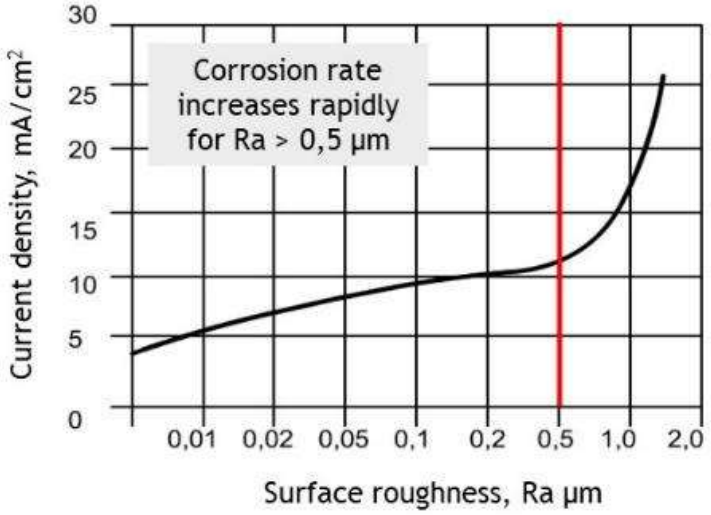


Fig. 3. Influence of surface roughness on the corrosion resistance of stainless steels [24]

To remove heat tint and restore the corrosion resistance of duplex stainless steel surfaces, they are pickled after welding. The pickling process involves the following steps: cleaning and degreasing, pickling, passivating, rinsing. Pickling and passivation can be done using several methods, including immersion pickling, paste pickling, spray pickling. Mixtures of nitric and hydrofluoric acid are used for pickling. After pickling and passivation components must be thoroughly rinsed by water. This will ensure that all the pickling and passivation solution used has been fully removed.

When brushing DSS surface a suitable stainless steel brushes must be used to heat tint removing. Once used for stainless steel surface treatment, the stainless steel brushes should be reserved for further stainless steel work only. Mild steel or brass brushes must not be used for brushing DSS surfaces. Surface rust staining can occur in storage or service if these guidelines are not followed.

Grinding of weld seams to remove heat tinting should be done with wheels that are not too coarse, used at a low surface pressure. Residual stresses can be left in the metal if wheels that are too coarse or too high a surface pressure are used for grinding. In service these residual stresses can result in stress corrosion cracking

failures. The grinding wheels used should be of the types specifically intended for grinding stainless steels. They should not contain any iron constituents.

Shotblasting of DSS surfaces is normally done using glass beads with a diameter of approximately 0.3 mm. The blasting medium must only be used once. After shotblasting pickling is normally done to produce a clean, smooth, matt finished surface.

Pickling of welds and embedded surface contamination is an important consideration to maintain optimum corrosion resistance performance for any fabricated duplex stainless steel material. It becomes even more important if the application is an aggressive pitting or crevice environment. Pickling with a HNO_3/HF solution can remove heat tint and embedded carbon steel particles, both of which can affect the corrosion performance of the material. Duplex stainless steels seem to exhibit more sensitivity to heat tint than austenitic stainless steels, so pickling of the welds should be considered if the tint is straw brown or darker (fig. 4). It should also be noted that duplex materials are generally more resistant to pickling solution and, therefore, may require more pickling time to achieve the expected results. It is recommended to use welding gases with O_2 content below 200 ppm for duplex stainless steels and to flush the pipes from the root side with forming gas in order to reduce the O_2 content as much as possible. In practice recommendations suggest a reduction of O_2 concentration below 50 ppm and even below 25 ppm to limit heat tint formation.

Another technique used to remove the oxide layers formed on the surface by welding is electropolishing process. Electropolishing is an effective method of surface cleaning, which also results in removing oxides and iron from the metal surface. Beside that it also preferentially dissolves iron and hence improves the Cr-Fe ratio of the surface layers. It alters the surface appearance by smoothing. The electrochemical polishing of the surface significantly improves the corrosion resistance of welded stainless steels. Electropolishing results in a clean, fully passivated surface which is generally superior to that produced using conventional pickling or passivation solutions and especially by mechanical methods (brushing, grinding) (fig. 5).

The importance of the surface roughness and chemical surface treatment on the corrosion resistance of stainless steel can be analyzed based on the G. Coates [15] results, shown in figure 5. G. Coates [15] reported that surface finish is an

important additional factor that influences the resistance to initiation of pitting and possible crevice corrosion of stainless steels. It has also been demonstrated that oxide removal by adequate mechanical and/or chemical cleaning can restore the corrosion properties close to those of the bulk material. Among the analyzed methods the pickling process has proven to be the most effective one. As shows in the figure 6, the pickled or passivated rough, matt 36 grit finish shows better corrosion resistance than an untreated 220 grit finish. The overall conclusion is that weld discoloration must be removed to maintain the corrosion resistance and that mechanical cleaning followed by pickling gives the best result.

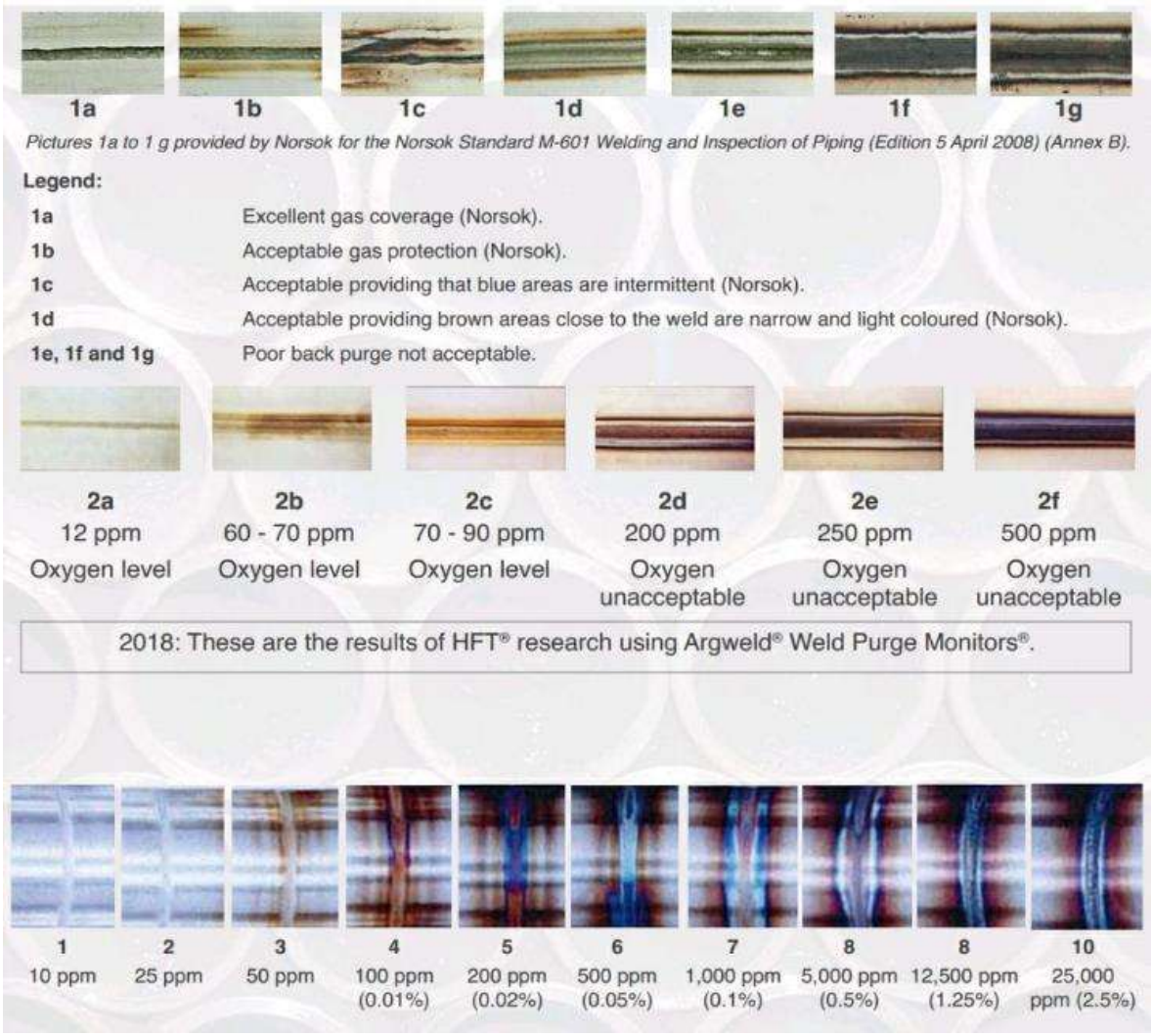


Fig. 4. The heat tint recognition chart for stainless steel welding. Recommended surface weld decolorization level according to AWS D18.2 Guidelines [23]

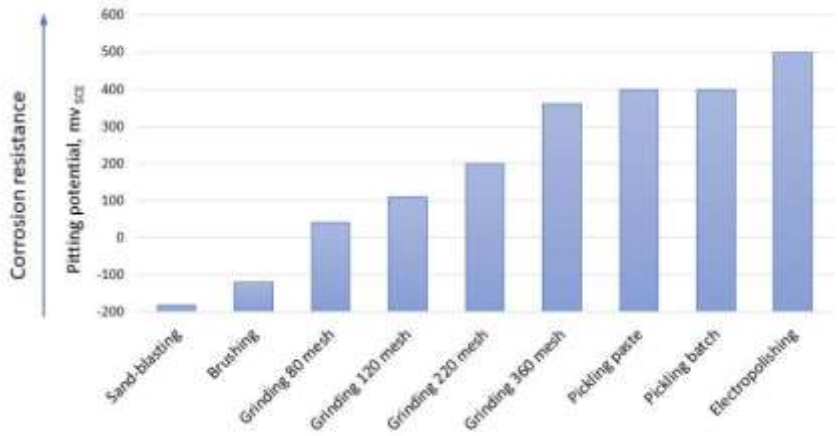


Fig. 5. The influence of surface finishing method on the stainless steel surface corrosion resistance

The final process and the most important for the corrosion resistance of the stainless steel surface is passivation. Passivation can occur naturally or accelerated with the use of oxidizing chemicals, as is the case in industrial practice. Passivation is the process of forming a natural, protective, corrosion resistant layer on stainless steel surfaces. This is promoted by cleaning the surface of dirt, grease, oil, salts, and iron contaminants. Water, detergents, and mechanical cleaning techniques can readily remove dirt, oils, and salts on the metal surface. Iron and iron oxides are not so readily removed with standard cleaning methods, hence pickling and passivating solutions containing phosphoric, citric, nitric, and hydrofluoric acid are often used for this purpose.

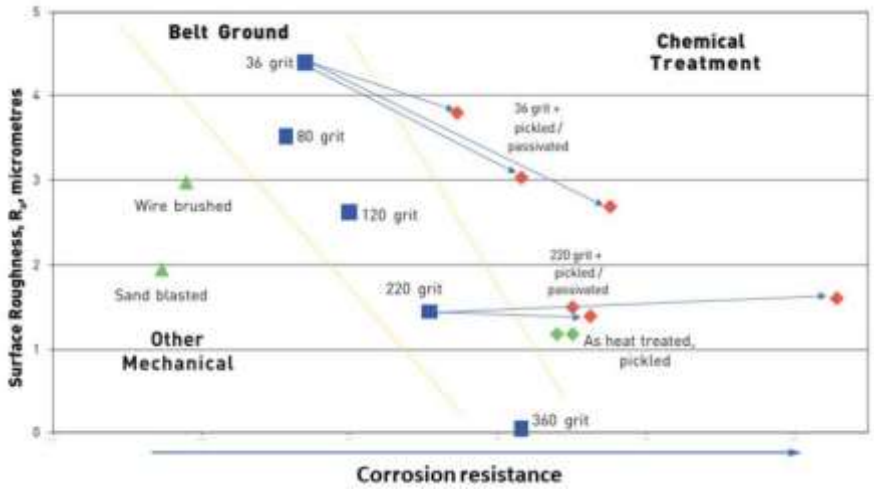


Fig. 6. The effect of chemical and mechanical surface treatments on corrosion resistance of stainless steel (316L austenitic stainless steel) [15,22]

It should be noted that the weld is always more susceptible to corrosion than the parent material. That is due to many factors, including those related to the welding technology and the weld material's resulting structure, the fraction of austenite and ferrite, and the applied post welding surface treatment/cleaning treatment welded zone. The critical pitting temperature (CPT) of the weld surface for stainless steels is lower than that of the parent material (fig. 7). As the welding can decrease the corrosion resistance of welded DSS, special attention should be paid when performing the post welding surface finish treatment.

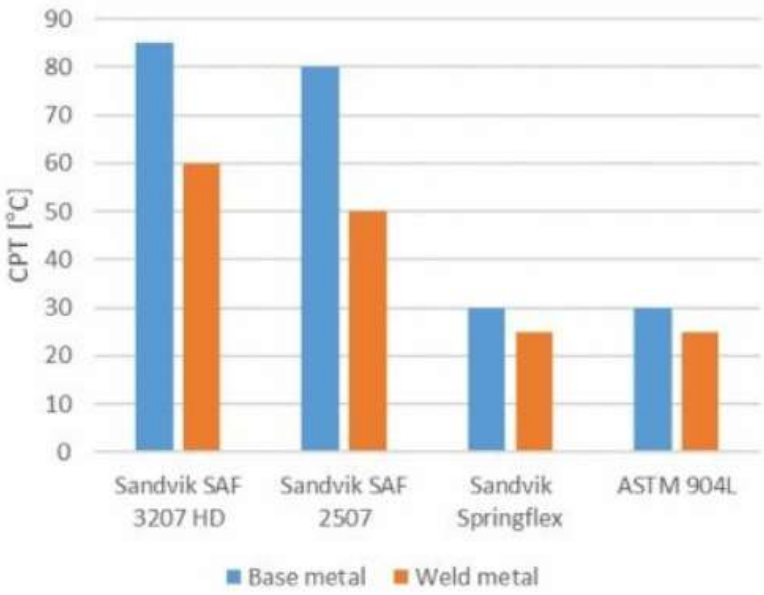


Fig. 6. Critical pitting temperature (CPT) determined in the ASTM G48A test for the mase metal and weld material of austenitic and duplex stainless steels [21]

Passivation is the treatment of the surface of stainless steels, often with acid solutions (or gels/pastes), to remove contaminants and promote the formation of the passive film on a freshly created surface, e.g., through grinding, machining, or mechanical damage. The passivation process works by dissolving any carbon steel contaminations (iron particles) from the stainless steel surface and dissolving out sulfide inclusions present on the surface. Nitric acid (HNO_3) may also enrich the chromium proportion at the surface (chromium to iron ration). Passivation treatments include HNO_3 solutions or pastes, which will clean the steel surface free of iron contaminants. The passivating compositions contain up to about 30% HNO_3 and may contain other oxidizers. The passivation process does not affect the appearance of the stainless steel surface. Nitric acid is generally used and involves

several ecological problems, citric acid could be a promising and environmentally friendly alternative to nitric acid.

The key parameters which can be used to identify the passivated stainless steel are the total Cr/Fe atomic ratio, the Cr oxide/Fe oxide ratio, and the total oxide thickness (fig. 8). The XPS studies [17] of passivated and un-passivated steel surface shows that passivation significantly changes the ratio of iron oxide and metallic states. The Cr/Fe ratio in oxide layer increase due to passivation. The un-passivated surface shows Cr/Fe ratio about 0.77, in contrast passivated surface Cr/Fe=1.56. Therefore, the Cr/Fe ratio and Cr/Fe oxide ratios are useful parameters used to assess the passivation process's quality. Concluding, the goal of the passivation process is then to maximize the chromium-containing layer on the surface.

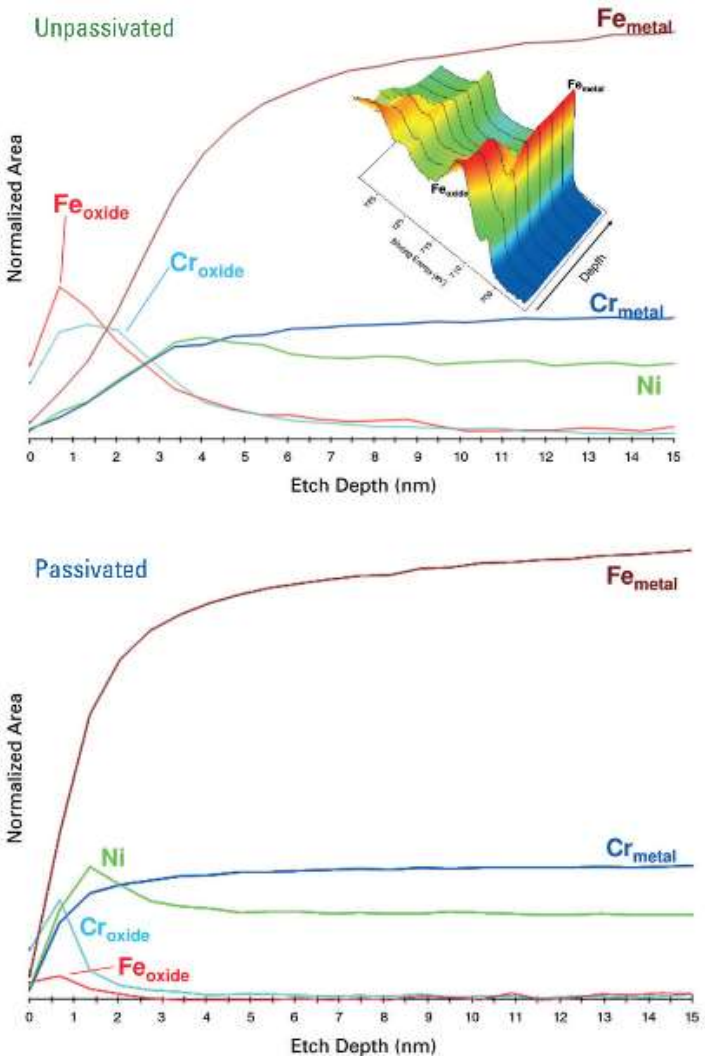


Fig. 8. The chemical composition depth profile of un-passivated and passivated steel surfaces [17]

Stainless steel surfaces have been successfully passivated in various citric acid solutions (commercial, waste extracted citric acid) and demonstrated the potentiality of citric acid-based passivation [11÷13]. The citric acid passivation treatment significantly increases the corrosion resistance due to a high Cr content in the passive film. Citric acid passivation is almost effective as well as nitric acid passivation. The citric acid passivation treatments, described in passivation standard ASTM A967, covers various batch composition (20 ÷ 25% 38 ÷ 42% vol. of citric acid and addition of sodium dichromate) and batch temperatures ranging from 20 to 70°C. Besides, a composition with the addition of chelates was developed that also need to be employed at elevated temperatures (60 ÷ 80°C) to be effective. Citric acid with chelates produces an even better passive film with more chromium in the surface than the other treatment methods.

Citric acid passivation produces passive film with a Cr/Fe ratio typically of 1.7 to 2.0 [19]. This ratio is the standard quality level of passive film that is specified in most industry standards, and it meets the requirements of ASTM A380 and A967. In contrast, nitric acid passivation produces a passive film of approximately 1.4 to 1.6 Cr/Fe. While using phosphoric acid in electropolishing process will generate a passive film of 1.1÷1.3 Cr/Fe [19].

Passivation processes with citric acid are also of great interest to producers of chemicals for the chemical treatment of stainless steels, which indicates the potential of such a solution as an alternative to the use of nitric acid. Although known for many years, passivation of the steel surface with citric acid has not been widely used in industrial conditions so far. Due to environmental aspects, a significant increase in interest in this passivation method can be noticed in recent years. Passivation with citric acid has many advantages, including a limited emission of nitrogen oxides NO_x, increasing personnel's safety, and meets the environmental protection requirements included in the latest environmental regulations. Another advantage is the more remarkable ability to effectively remove iron from the processed stainless steels' surfaces, which means that less concentrated acids are used.

Conclusions

Duplex stainless steels, especially in the welded conditions, resist corrosion best if they are clean and smooth. Clean stainless steel means free of contaminants or embedded particles that can either react with the steel surface (i.e., carbon steel

or salt) or create crevices and other initiation sites where corrosion can start. The smooth surface, having a low surface profile, is always beneficial to maintain the corrosion resistance of stainless steel. A wide variety of mechanical and chemical methods may use in the processing stage of welded duplex stainless steels. Mechanical grinding can roughen the steel's surface and embed unwanted particles, impairing corrosion resistance. For such reasons, after mechanical treatment, passivation is required for maximum corrosion resistance. The chemical surface treatments are aimed to clean the surface of the steel. They may also smooth like electropolishing or roughen like pickling the steel surface or leave it unaffected (passivation) depending on the process. But if carried out properly, they all increase the corrosion resistance of stainless steels.

Acknowledgements

The paper describes works related to project "Integration of advanced experiments, computation and data for Duplex Stainless Steel joining innovation — i-Weld". This project has received support from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement "i-Weld" No 823786".

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ANALYSIS OF ENERGY DISSIPATION USING A MATHEMATICAL MODEL UNDER CYCLIC LOADS OF AN ALUMINUM ALLOY

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DOI: 10.31891/monograph/2021-10-47

Summary. The paper presents the issues related to the determination of dissipated energy in fatigue life, taking into account the loading speed. A mathematical model of the behavior of materials and the determination of dissipated energy under cyclic loads has been presented. Verification tests were carried out for the AW-2017 aluminum alloy. Experimental verification of the selected energy fatigue life criterion was performed.

Keywords: cyclic torsion, energy dissipation, hysteresis loops, fatigue life, mathematical model.

Introduction

Determining the fatigue life is an essential issue for many structures and devices and therefore often described in many publications. Despite this, there is no universal fatigue life criterion taking into account various loading conditions. Accordingly, many criteria of fatigue life assessment have been developed based on multiple failure parameters [1, 2, 3]: stress, deformation, and energy criteria. The energy approach provides a more accurate and complete fatigue life estimation based on the magnitude of stress and strain. The measure of fatigue life in terms of energy is dissipated energy, the value of which is determined by the area of the hysteresis loop in the stress-strain system. The energy approach is particularly useful for determining the fatigue life in the low-cycle range, i.e., up to approximately 104 cycles to failure [4, 5, 6].

Analyzing the research results to date on fatigue life, especially in the low-cycle range, it appears that the leading cause of fatigue cracks is the occurrence of plastic deformations [3, 4, 7] responsible for energy dissipation in the material. The occurrence of this type of deformation causes deformation hysteresis. The size of the loop field determines the energy dissipated in the material during the loading cycle.

The basis of most of the energy criteria is the energy irreversibly dispersed in the material (dissipation energy) during an alternating load, up to the destruction of the element. The energetic approach takes into account both the influence of stress variability and deformation on fatigue strength.

1. Description of the mathematical model of plastic strains

The paper proposes using the mathematical model described in detail in the publication: [8] of the material behavior under cyclic loads for theoretical preparation of the hysteresis loop, Fig. 1, and determining its surface area while taking into account the influence of the loading speed.

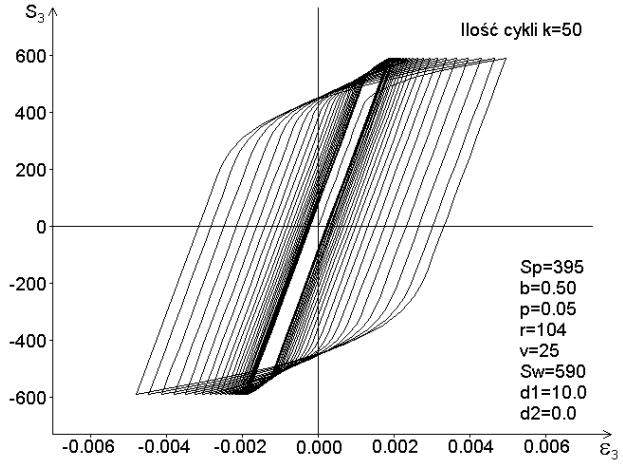


Fig. 1. Examples of fatigue loops based on the mathematical model.

Using this model allows one to obtain any nth loop and quickly calculate its surface area because the equation describing it is known. It will make it possible to replace some of the costly and labor-intensive experimental research with theoretical research. Moreover, empirical studies show that the behavior of materials subjected to cyclic loads (cyclic strengthening or weakening) depends, among others, on the speed of loading. The existing criteria of fatigue life, both in terms of energy, stress, and deformation, do not consider the influence of the loading speed on the behavior of the material.

The following is a brief description of the above-mentioned mathematical model to describe the material's behavior under cyclic loads. Plastic deformation in individual load cycles is determined by the relationship (1)

$$\varepsilon_{p\Sigma} = \sum_{i=0}^{k-1} \varepsilon_{ip}(-1)^i + \varepsilon_{kp}(-1)^k$$

where:

ε_{ip} - plastic deformation of the full i-th half-cycle;

ε_{kp} - plastic deformation of k - this half-cycle,

$$\varepsilon_{kp} = 2gF_2(a_k) \text{ for } k \geq 1, \quad g = \frac{\pi S_0^2}{6r};$$

$$F_2(a_k) = \frac{1}{a_k^2}\left(2\sqrt{1-a_k^2} - 5a_k^2\sqrt{1-a_k^2} + 3a_k^4 \ln\frac{1+\sqrt{1-a_k^2}}{a_k}\right);$$

$$a_k = \frac{\sqrt{2}S_0}{\sqrt{S_3^2 + S_A^2 - I^2_{(k-1)(-1)^{k-1}} - I^2_{k(-1)^k}}};$$

$$I_{k(-1)^k} = \frac{b\upsilon}{p}\left[1 + 2\sum_{i=1}^{k} e^{-p(t-t_{i-1})}(-1)^{i+k+1} + e^{-pt}(-1)^{k+1}\right];$$

$$t_{i-1} = (2i-1)t_0;$$

Where:

p, b - constant,

v - load speed,

S0 - yield point,

SA - stress amplitude,

The total deformation, which is the sum of elastic and plastic deformations, is presented using the equation (2):

$$\varepsilon_k = \frac{S_3}{2G} + \varepsilon_{p\Sigma}$$

where:

G - modulus of shear elasticity.

Knowing the deformation equations, which are also the equations describing the branches of the hysteresis loop, the area of the theoretical hysteresis loop can be calculated, Fig. 2:

$$W_{pl} = \Delta S_A \Delta\varepsilon_k - \int_0^{\Delta S_A} \varepsilon_{k-1} dS_3 - \int_0^{\Delta S_A} \varepsilon_k dS_3$$

where:

ΔS_A - stress range,

$\Delta\varepsilon_k$ - deformation range.

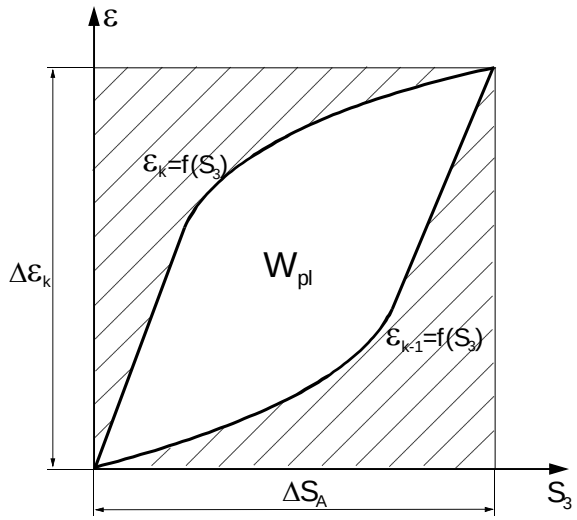


Fig. 2. Scheme of calculating the plastic deformation energy

Such a theoretical definition of dissipated energy enables the use of energy fatigue life criteria without the need to perform costly and long-term fatigue tests.

In the world literature, you can find many publications related to the use of the energy approach in various aspects [6].

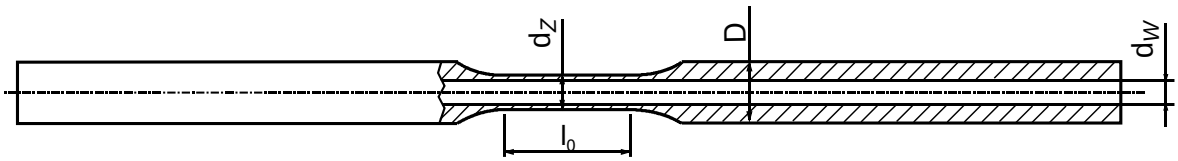
2. Research program

The fatigue tests were carried out in the low-cycle range with the stress exertion during cyclic torsion at the given three levels of load speed. The following stress rates S_3 were used:

v1 = 210 MPa / s, v2 = 340 MPa / s, v3 = 780 MPa / s for different stress amplitudes.

Samples

The tests were carried out on cylindrical, tubular samples made of aluminum alloy according to EN: AW-2017. Samples (Fig. 3)



l_0 = 20 mm, d_Z = 8 mm, d_W = 6 mm, D = 12 mm

Fig. 3. Sample for testing

Test stand

The test stand is shown in Fig. 4; it enables smooth control of the speed of loading or deformation and records deformations as a function of stresses, or vice versa. It can adjust the amplitude of stress or deformation. The station is coupled with a computer through which the control, recording, and display of the current values of the parameters are carried out. Depending on the given control parameters, fatigue tests can be carried out in two modes: stress excitation or deformation excitation.



Fig. 4. Test stand

3. Experimental research

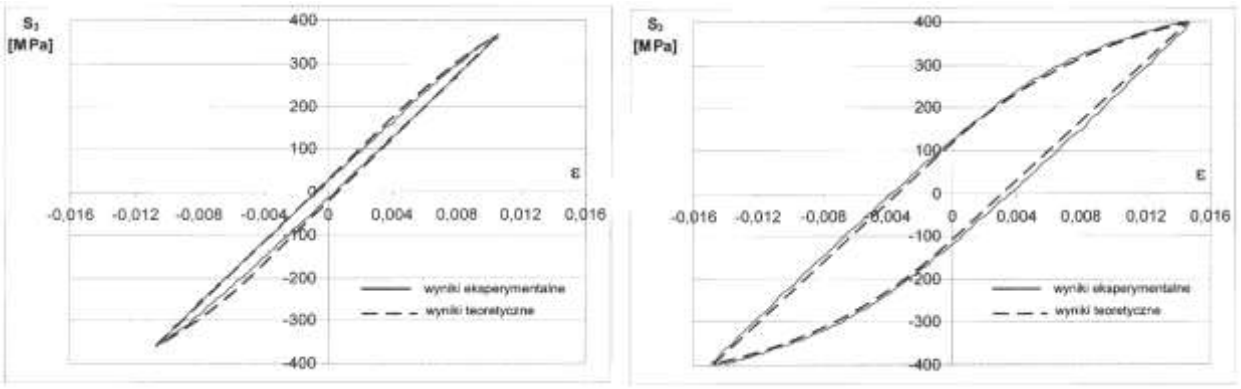
Verifying the presented model of deformations under cyclic torsion loads was made based on the experimental results obtained from the tests carried out with cyclic torsion.

As the load cyclically changes, the hysteresis loop is observed to change until the stabilization state is reached. These changes indicate the effect of cyclical strengthening or weakening depending on the type of material. Then we observe a

decreasing or increasing amplitude of the material's response in subsequent cycles to inputs of constant amplitude. After a certain number of cycles, no further changes in the amplitude of the material's response are observed; we achieve a saturation state and stabilize the material's behavior under cyclic loading.

The tested material is a cyclically strengthening material; stabilization of the cyclic properties took place after about 1/3 of the cycles to failure.

Fig. 5 shows the theoretical results based on the model and experimentally for two different stress amplitudes at a constant load speed. Two stabilized hysteresis loops were compared - theoretical and experimental.



a) b)

Fig. 5. Comparison of the theoretical and experimental results at the loading speed v = 330 MPa / s, and the amplitude: a) SA = 365MPa, b) SA = 395MPa

The presented results show that the model describes well the material's behavior under cyclic loads and considers the change in the stress amplitude. The results are very close to each other, and the error does not exceed 5%.

Based on the analysis of the theoretical results, Fig. 6, the influence of the loading speed on the value of the dissipated unit energy is observed, related to the change in the field size of the hysteresis loop is also confirmed by the results of experimental tests.

Figure 7 presents exemplary theoretical and experimental graphs of the energy dependence ΔW_{S3} of stabilized hysteresis loops as a function of the exciting stress for the applied loading speeds. The theoretical results obtained from the mathematical model are shown with a solid line in the graphs, and the experimental results are shown with points.

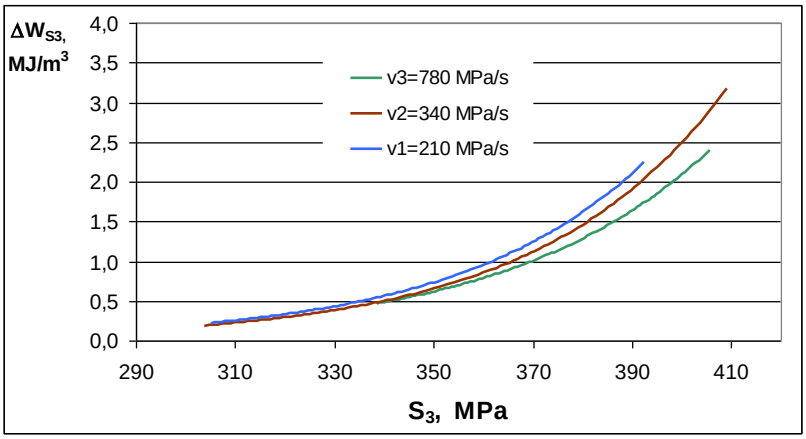
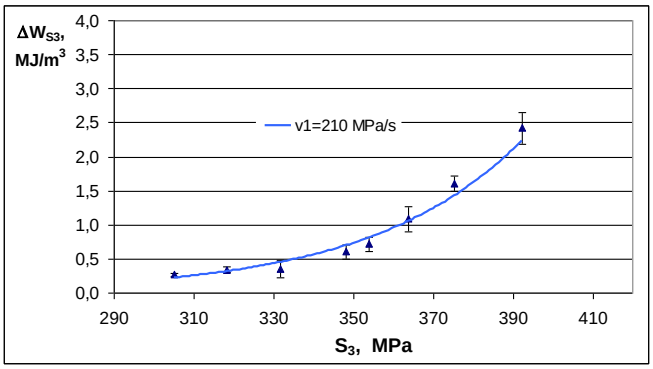
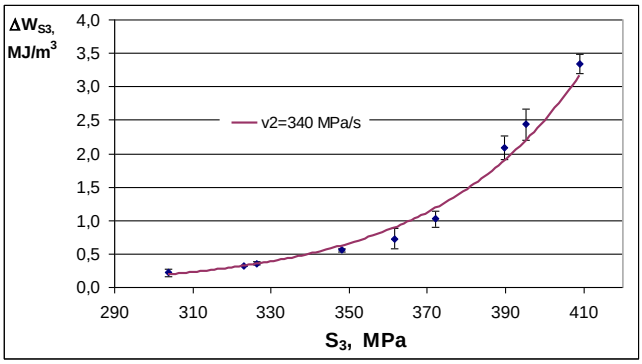


Fig. 6. The energy of theoretical stabilized hysteresis loops





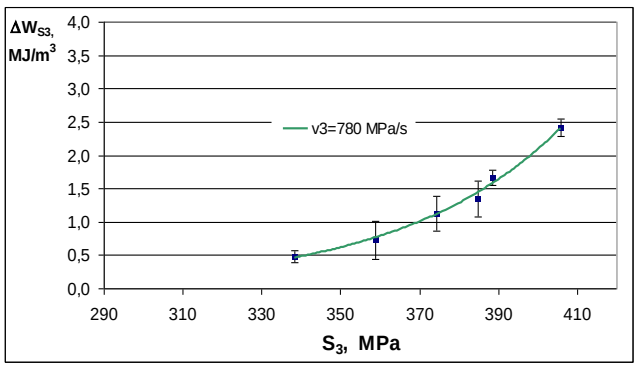


Fig. 7. Unit energy of stabilized loops

By analyzing the chart below, it can be concluded that to achieve the same fatigue life, and the tested material can be loaded with a greater stress amplitude (larger loop) for higher speeds. Knowing the exciting stress or the amount of dissipated energy, it is possible to estimate, based on the graphs in Fig. 8, the approximate fatigue life at a specific speed of load changes during cyclic torsion.

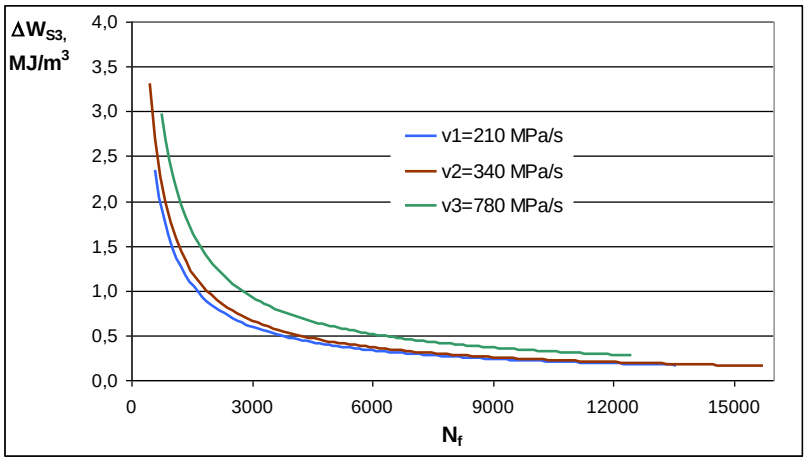


Fig. 8. Fatigue life charts described with unit energy stabilized hysteresis loops

Experimental verification of the selected energy fatigue life criterion showed the usefulness of the mathematical model for the modification of criteria based on dissipated energy, which is shown in Fig. 9.

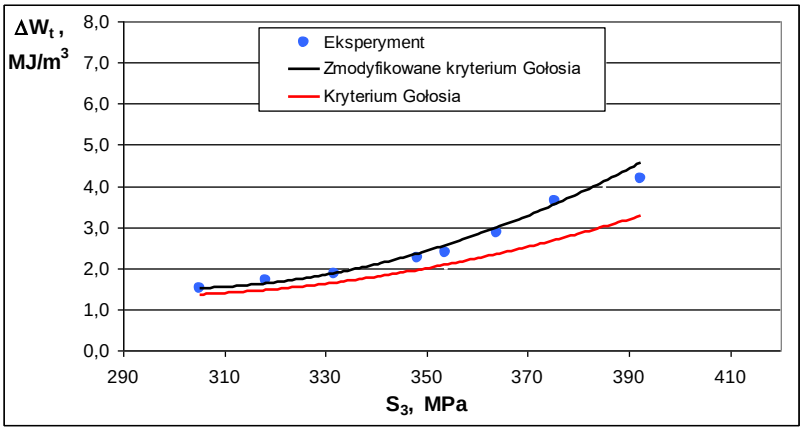


Fig. 9. Verification of the Golos criterion for the loading speed v = 210 MPa / s

Summary

Based on the conducted experimental and theoretical research, the following conclusions can be drawn:

1. A high compliance of the calculations of the dissipated energy was obtained using the mathematical model with the test results in the entire range of the given stress amplitudes and the loading speed.

2. After determining the material constants present in the model for determining the fatigue life, the method does not require experimental tests because hysteresis loops can be obtained based on a mathematical model.

3. It is possible to determine the dissipated energy during cyclic loading with the help of a developed computer program.

4. The applied mathematical model can be used to modify the energy fatigue life criteria.

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PROSPECTS OF USING COMPOSITE FILAMENTS WITH HIGH METAL CONTENT FOR MANUFACTURE OF INDUSTRIAL MACHINE BUILDING PRODUCTS METHOD OF 3D PRINTING

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DOI: 10.31891/monograph/2021-10-48

1. Introduction

One of the most promising areas of development of modern engineering is the development of new technologies for the rapid production of products (rapid fabrication). The essence of such technologies is the layered construction of products from powder material based on CAD-model - a model whose three-dimensional geometry is described digitally using solid modeling programs (AutoCAD, SolidWorks, Compass-3D, CATIA, ProE, etc.) [1].

Additive technology, which began its development in the 80s of the XX century, opens the possibility of manufacturing (growing) objects by gradually applying the building material to the generated object. The field of additive technologies is rapidly developing today, displacing older methods of processing and manufacturing parts.

The main advantages of using additive technologies are as follows:

- minimization of material losses and production waste;
- the possibility of making changes to the project at the stage of transfer of the product into production;
- the possibility of making parts of complex shape, which is impossible when using traditional production;
- no need to manufacture tooling, which is inherent in traditional methods of the processing;
- manufacture of products within the experimental production;
- the transition from mass production to individual orders and increase the range of products [1].

In the coming years, the cost of production using 3D printing will decrease, printing will become even more popular.

2. The main material

3D printing with metal powder has made a rapid leap in development over the past 10 years and is becoming increasingly popular. There are a large number of materials for 3D metal printing [2].

Known today filaments for printing based on various metals, combine practical and aesthetic properties. They can meet the requirements of various products, be it prototypes, miniatures, jewelry, functional parts, etc.

The reasons for printing with metals are so important that 3D printing with them is already being introduced into serial production. Some 3D-printed parts have already caught up with, and to some extent surpassed in their properties, those produced by traditional methods.

Traditional production of metals and plastics is too wasteful. The yield, in some industries, is not more than 30% of the material used. 3D metal printing consumes less energy and reduces waste to a minimum. In addition, the finished 3D-printed product can be up to 60% lighter, compared to the milled or cast part [3]. The strength and lightness of parts are required in the production of certain products in various industries. This, in turn, also leads to a reduction in the cost of products.

The process of 3D printing with metals, which is used by the largest companies today, is known as fusion or sintering of the powder layer. This means that the laser or other high-energy beam fuses into a single particle of evenly distributed metal powder, creating layers of product, one after another.

3D printers that print metal are conventionally divided into three groups:

1. Inkjet printers that work with plastic and low-melting metals, such as lead or tin.

2. 3D printers based on metal powder with an adhesive.

3. 3D printers that work based on laser melting technologies.

Metal powder is used in several 3D printing technologies:

- selective laser sintering, SLS (Selective Laser Sintering) - a 3D method that uses material that is sintered by laser;

- selective laser melting, SLM (Selective Laser Melting) - metal particles are melted, after which a rigid frame is formed;

- electron beam melting EBM (Electron Beam Melting). In the process of electron beam melting, the metal powder is melted by the action of electron rays.

The achievements of metallurgy are fully realized in additive production, allowing the use of unique materials and alloys for the manufacture of geometrically complex products of high accuracy, density and repeatability.

Metal is one of the materials that is successfully used for 3D printing. Recently, manufacturers are producing more and more powdered metals that are optimal for a 3D printer. Modern technologies make it possible to obtain powder for 3D printing of metal with certain properties to solve specific production problems. And since almost any metal can be sprayed, the range of metallic materials for 3D printers is extremely large [5].

The latest additive technologies involve the use of about twenty tested and ready-to-use materials, including titanium Ti, stainless steel SS, aluminum AL, copper Cu, iron Fe and others.

Ti – Titan. Pure titanium (Ti64) is one of the most commonly used metals for 3D printing, and certainly one of the most versatile, as it is both durable and lightweight. It is used in various industries, including medical, aerospace, automotive (for the manufacture of parts and prototypes) [3].

The only drawback is that it has high reactivity, it can easily explode when in powder form. When printing, it must be only in the environment of inert argon gas.

SS – stainless steel. Stainless steel is one of the most available metals for 3D printing. At the same time, it is very durable and can be used in a wide range of industrial and artistic industries. This type of steel alloy containing cobalt and nickel has high elasticity and tensile strength. 3D printing with such material is used mainly only in the heavy industry [3].

Al-aluminum. Due to the inherent lightness and versatility of aluminum, the material is a very popular metal for use in 3D printing. It is usually used in the form of various alloys, forming their basis. Aluminum powder is explosive and is used for printing in an inert gas of argon [3].

Cu – copper. With rare exceptions, copper and its alloys (bronze, brass) are used for casting using fired models, rather than for direct metal printing. Their properties are far from ideal for use in industrial 3D printing. They are more often used in arts and crafts. With great success, they are added to plastic filament for 3D printing on conventional 3D printers.

Fe – iron. Iron and magnetic iron ore are mainly used as additives to PLA

plastic. Pure iron is rarely used in industry.

Also used are instrumental, stainless, heat-resistant alloys, aluminum and titanium alloys, medical cobalt-chromium and more. Each metal and alloy has certain properties. The most common and in demand are the following materials: titanium alloy Ti6Al4V; nickel alloy IN718; aluminum alloy AlSi10Mg [5].

Ti6Al4V is the most common titanium alloy with excellent mechanical properties. It is considered the hardest and strongest titanium alloy. It has a particularly high complexity of processing. It has a density of 4500 kg / m2 and a tensile strength of more than 900 MPa [6].

Ti6Al4V alloy provides undeniable advantages in terms of weight reduction of products in such industries as aerospace, automotive and shipbuilding. These metals are used, in particular, in the manufacture of inserts in molds, turbine blades, combustion chambers, as well as products designed to operate at high temperatures (up to + 1100 ° C) [5].

IN718-heat-resistant high-quality alloy, which was developed and created for operation at temperatures up to 980 ° C (author and developer Eiselstein) [7].

Nickel can dissolve many other metals while maintaining plasticity. The presence of such a property leads to the existence of many nickel alloys. An alloy of nickel and chromium is widely used in aircraft engines. It is used to make working and nozzle blades, turbine rotor disks, combustion chamber parts, etc.

The most heat-resistant are nickel-based cast alloys, which can withstand temperatures up to + 1100 ° C for hundreds and thousands of hours at high static and dynamic loads [5].

Aluminum alloy AlSi10Mg is a perfect material for SLM technology and the production of thin-walled products with complex geometry [8]. This is the cheapest of the cast alloys. The material is widely used in industry due to its low density and good anti-corrosion properties. Its advantages include high fluidity, electrical and thermal conductivity. In industry, they are usually used for the manufacture of large thin-walled castings of complex shape [5].

Metal powders are the strongest materials for 3D printing. Products created on three-dimensional printers are in many respects superior to analogs produced using traditional technologies (casting, rolling, etc.).

One of the factors hindering the introduction of metal additive plants is the high cost of fine powders and the equipment itself.

Three-dimensional metal printers are markedly different from conventional printers, in particular in terms of dimensions. Devices for three-dimensional printing, even at relatively small sizes, have a significant weight.

The technology of manufacturing products using filament with a high content of metal powders based on stainless steel with the use of 3D printers with a closed construction chamber in a wide range of printing parameters, working on the technology of layer-by-layer surfacing of polymer thread (FDM).

The scheme of technological process of manufacturing products of branch mechanical engineering by the method of 3D-printing from composite filaments with high content of the metal is presented in fig.1.

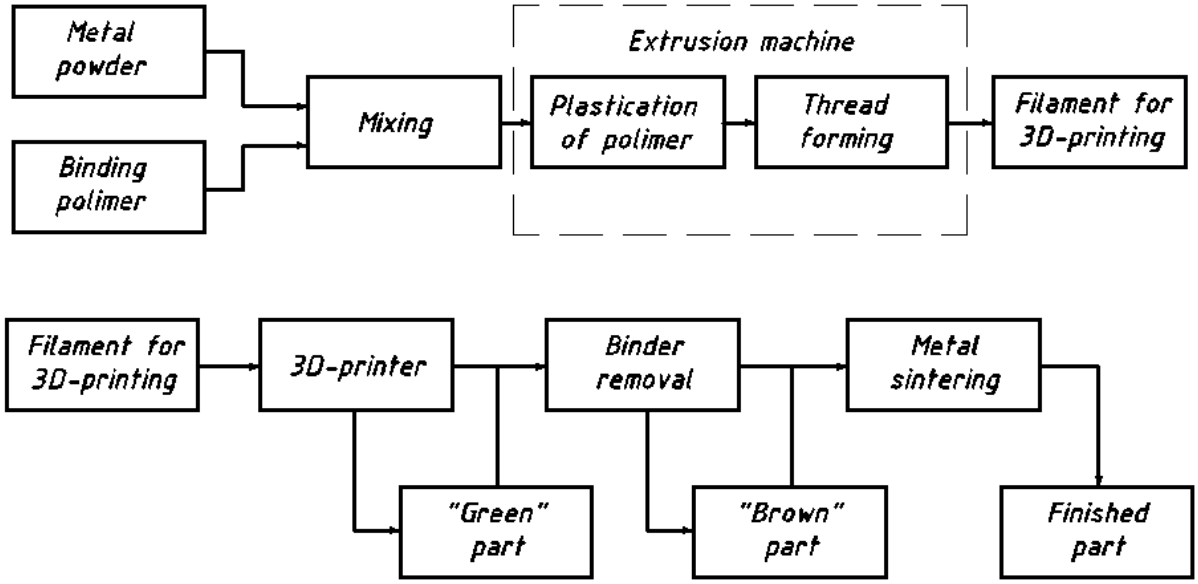


Fig.1. Scheme of technological process of manufacturing products of branch mechanical engineering by 3D-printing method from composite filaments with high metal content

This technology consists of five stages (Fig. 1): mixing of fine metal powder and binder polymer material; making filament for 3D printing from a mixture; printing on a 3D printer "green" part; removal of the polymeric binder to obtain a "brown" part; sintering in the oven and obtaining the finished product.

The raw material for this technology is a mixture of fine metal powder and a polymeric binder.

In the first stage, using a mixer, the two components are mixed to obtain the raw material.

In the second stage, an extrusion machine is used to obtain a filament for 3D printing. The raw material is filled into the hopper, captured by the auger and fed

into the working area of the extruder housing. The polymer is heated, melted to the required state of the process and binds metal particles together. The mixture is fed by an auger towards the die. The shape of the screw in the cylinder in the exit zone of the mixture creates a pressure that causes the polymer to "swell" after leaving the extruder. The outlet of the extrusion head regulates the diameter of the polymer thread. The extruded thread is fed through a forced cooling system.

The thread is a filament with a high proportion of powder metal filler, which can reach 90% and is suitable for use with conventional desktop FDM 3D printers, but with improvement.

In the third stage, a blank, called a "green part", is obtained from a polymer thread on a 3D printer. The use of materials filled with metal powder is a more complex task than printing using conventional filaments. Threads with metal filler (especially steel powder) are very abrasive and require a printer with an advanced filament loading mechanism, as well as a different printhead design.

In the fourth stage, the binder is removed using a solvent, catalysts, or thermally to obtain a porous "brown part".

The final stage of the process is the sintering in the furnace of metal particles of the "green" part. In the process of performing this operation, the pores are filled and the material is compacted by merging the particles (finished part) without a noticeable increase in the size of the crystals.

3. Conclusions

The main advantage of this method of manufacturing parts is that it does not require the use of expensive additive equipment of the industrial class, and consumables are cheaper than fine metal powders used in laser sintering by the method of additive technologies.

The considered technology requires selection of optimal modes of operation of technological equipment, in particular 3D-printer, thermal furnaces for the release of binder and sintering of metal particles of the "green" part.

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SYSTEM RESEARCH «SHAPING FABRIC – LOADING DEVICE»

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DOI: 10.31891/monograph/2021-10-49

Introduction

Currently, the main type of equipment on which the operations of forming garments and final wet heat treatment (WTO) are performed, are presses equipped with different types of pillows (bulk, corrugated and flat). However, this equipment does not radically solve the quality problem. The main reasons for the deterioration of the quality of molding on the press equipment are the lack of conformity of work surfaces, unforeseen changes in the deformation properties of cushion coverings, the use of the same type of cushions for forming products of different full-size groups and others. the figure of the consumer.

To ensure high quality in obtaining the three-dimensional shape of garments on the press equipment is very important to establish not only rational modes of formation and correctly select the properties of cushioning coatings, but also the mechanism of interaction of upper and lower cushions, which ultimately determines the mechanism of deformation and fabric deformation.

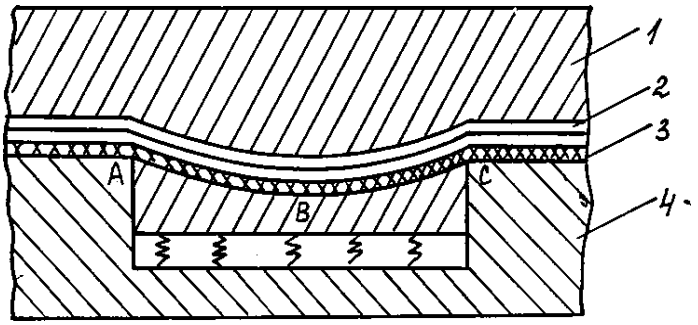
Flat areas of the pillows interact almost simultaneously and evenly over the entire area of the workpiece. On the curved sections of the forming surfaces, the upper and lower cushions are in contact over the entire area only at certain ratios of their shapes. At the same time, in the process of convergence of pillows pressure on all surface of a product is unequal. In [1], three fundamentally different in degree of correspondence of the upper and lower cushions on the radii of curvature of the surface RB> RN, RB <RN, RB = RN. It is established [2] that the best molding effect is achieved if RB> RH, when the peripheral contours of the parts are not clamped by pillows. In this case, favorable conditions are created for the deformation of the network angles of the fabric threads at the level of 10 ... 12 °, and at the same time the relative change in the length of the warp and weft threads does not exceed 0.8% and 1.5%. extremely difficult due to the lack of means to monitor the condition of surfaces.

During the operation of the upholstery, the conditions of conformity of the working surfaces are often violated [3], which is the reason for the formation of local polishes, the appearance of folds and creases.

Methods

The process of forming three-dimensional shells on the press equipment can be represented as follows. In the case of equidistant forming surfaces, lowering the upper cushion provides compression of the fabric at point A (Fig. 1). The presence of spring mats with subsequent lowering of the cushions allows you to clamp the material at points B and C.

In the process of obtaining a three-dimensional shape [4] on the edge of the fabric is formed wavy, the length of each wave varies from to l0 = 0 ln = lmax 2.b.). Accordingly, the minimum deformation takes place in the most convex area, and the maximum at the transition from the convex shape of the pillow to the flat (Fig. 2, a). When lowering the upper cushion to the lower initial large waves are broken into smaller, which are distributed under the action of heat, moisture and pressure of pillows at full closing of a press. If the waves of the fabric are very large, and the forming ability of the fabric is small, then when pressing the landing will not be compressed and the edges of the part being formed will form folds, replacements, creases.



1-top pillow; 2-section of the processed product; 3-depreciation coating; 4-bottom pillow

Fig.1. Formation of convexity by pressing

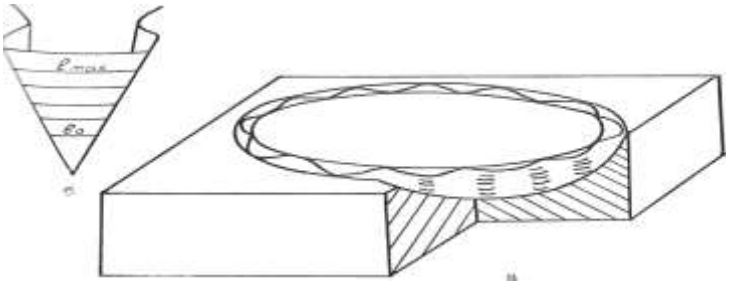


Fig. 2. Shaping the details by pressing

The geometric parameters of the pillows have a significant impact on the quality of molding. In [5], pillows used in the industry for the formation of files and backs of men's jackets were studied. The results indicate significant

differences in the radii of curvature of the eponymous areas of the cushions of presses of different firms. Thus, the radii of curvature of the longitudinal sections of the pillows on the convex section vary from 307 mm (pillow SPB-1 to 540 mm) (pillow PO-PMP-52). –PO-PMP-52), and on the thighs from 628 mm (pillow AAHST-42A) to 750 mm (pillow CS 12 -12/11), this is a serious problem in obtaining the required spatial shape of clothing.

Moreover, the use of the same type of pillows for the formation of parts of different size - complete groups leads to the degeneration of the form inherent in the design of products.

A certain influence on the quality of molding has the processing of parts of garments, regardless of the size - complete characteristics on the same presses, which affects the conditions of orientation of the parts relative to the pillow [6].

A characteristic disadvantage of the press equipment is the intensive formation of polishes on the front surface of the fabric, which are formed due to the contact effect on it of the working body at high pressing pressure [7]. This requires the performance of steaming operations, which contribute to the relaxation of the resulting form and additional energy costs.

It should be noted that on the existing equipment the formation of garments is carried out by static loads, which do not provide the necessary conditions for the active work of the "rough" and "thin" structure of the materials.

The need to improve the operations of forming garments has led to numerous studies aimed at creating new methods and equipment for molding, which will solve the above shortcomings.

Given the complex nature of the processes occurring in the system "forming organ-tissue-loading device" in vibration, it should be noted two approaches to the disclosure of the mechanism of interaction of system elements: analytical [8] and experimental [9]. predict the behavior of the system, although in general gives only a general idea of what happens in the process. The experimental method, although more time consuming, but allows you to get a more realistic picture of the processes occurring and together with the statistical method of processing the results reveals their basic patterns. In this paper, we have chosen the second way.

Experimental

As an object for research the original, from the point of view of novelty, technical system which fundamental difference from known [10] is chosen, that

textile material is formed on one convex surface, and as the second forming element the hollow element is used. small mass, the internal profile of which is congruent to the toroidal region of the main forming organ (Fig. 3), and the element itself moves freely relative to the object in the vertical plane.

It was assumed that in this method of forming the role of the upper loading device is reduced to the distribution of tissue waves formed during vibration in the toroidal region of the forming organ, and the structural changes in the tissue (network angles) occur during separation of the upper loading device from the tissue.

Checking the effectiveness of the proposed method of vibroforming was carried out on a specially designed experimental stand with the possibility of varying the main input factors (frequency and amplitude of vibration, the magnitude of the initial statistical load on the fabric by changing the mass of the upper loading device). Quantitative and qualitative assessment of ongoing processes was provided by continuous registration of amplitude-frequency characteristics of the working bodies and construction of mathematical models of the vibration load process.

The research was carried out on an experimental installation (Fig. 3), consisting of an electrodynamic stand VZDS-IO 1 connected to the rod 2 with the forming body 3, which is installed upper loading device 4, freely moving in the vertical guides 5 and in contact with sensor-converter 6.

The vibrating stand allows to change the amplitude (A = 0 ... 6 mm) and vibration frequency (V) = about ... 4000 s -1) of the forming organ in a wide range.

Forming body in the form of a spherical segment, made of duralumin. The geometric parameters of the forming body (radius of curvature of the spherical section R 1 = I, 46 mm and the curvature of the forming arc of the toroidal section R 2 = 0 5 mm) were chosen taking into account the data of a number of works performed earlier [11].

Studies [5] have shown that the most significant influence on the process of fabric formation is the nature of the interaction of the cushions of the presses in the transition zones of the bulky areas of the surface in the flat, which is due to the difficulty of matching the cushions in shape. In this regard, for the first time it is proposed to use the upper forming body - a loading device in the form of a hollow element, the contact surface of which corresponds to the transition region of the

spherical surface in a flat, toroidal part of the forming body. Thus, the upper loading device is used as a means of breaking the formed during the formation of tissue waves in the transition zone of the forming organ.

Based on previous experiments, the mass of the upper loading device was selected so as to provide a load on the material of about 730 PA, much lower compression pressures [12], adopted on modern equipment. In order to prevent the appearance on the part of the product of the formed traces of the upper loading device, its contact surface was made of elastic heat-resistant material - porous rubber.

To measure the magnitude of the loads occurring in the contact zone of the upper loading device 4 and the forming body C, a transducer 6 was used.

This provided the natural oscillation frequency of the sensor V = 250 s-1 at a frequency of forced oscillations V = 50 s-1 of the process under study and which allows to comply with the following condition:

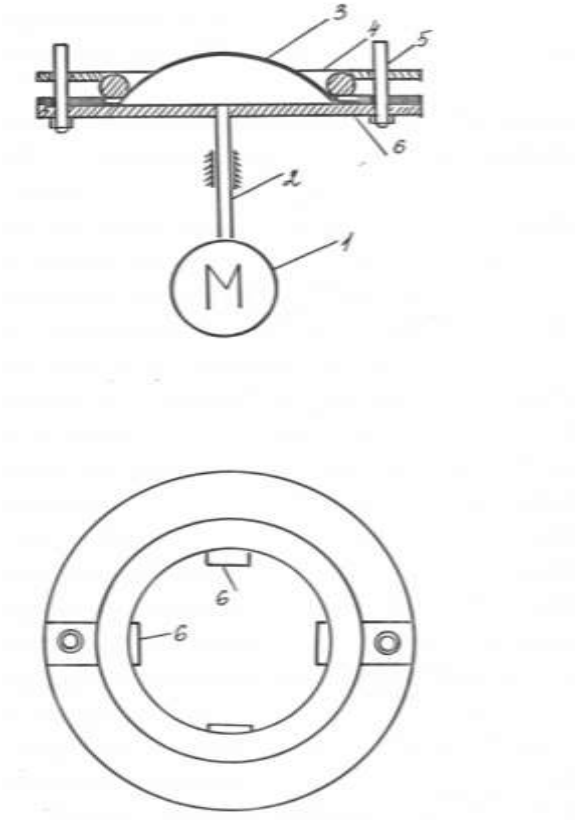


Fig. 3. experimental setup for the study of the mechanism of interaction in the system «shaping fabric – loading device»

$$V/Vg \geq 0{,}2 \qquad (1)$$

Strain gauges were glued to the plates on both sides. The circuit of strain gauges is a half-bridge with an output resistance R = 200 0m, which allowed to obtain a balanced bridge circuit, the second arm of which is a strain gauge with the same resistance at the output.

The number of plates and their placement are chosen so as to ensure that the average signal value is obtained, because the upper loading device is freely located on the forming body and on the sample and in the process of vibration moves at random.

The amplitude and frequency of vibration were selected on the basis of previous work [8,9], and were in the range A = 0 ... 5 mm V = 0 ... 50 s-1. The required vibration parameters were set using the VZDS-IO amplifier, which transmits sinusoidal signals to the moving coil of the vibrator, and hence to the forming organ.

It was assumed that in the process of sample formation there is a separation of the upper loading device from the tissue and the forming body, which leads to loads and bending of the steel plates of transducers and, accordingly, changes in the resistance of strain gauges. Strain gauges assembled according to the bridge scheme.

It was assumed that in the process of sample formation there is a separation of the upper loading device from the fabric and the forming body, which leads to loads and bending of the steel plates of transducers and, accordingly, changes in the resistance of strain gauges. Strain gauges assembled according to the bridge scheme.

Results

The decoding of the obtained oscillograms was performed using a previously obtained calibration graph.

Before conducting the experiments, the required number of measurements was substantiated by the methods of mathematical statistics, which provided the required measurement accuracy. The results of experimental studies of the nature of the vibration load of the upper loading device on the processed sample and the time of separation from it were determined based on the use of a known sampling method in statistics.

The essence of the method is that one or another statistical population corresponding to the whole mass phenomenon is studied not by measuring all its

members on some basis, but by measuring only some part, which is called a sample or sample [13].

Processing of the obtained experimental values of loads and separation time in the studied system "forming organ-tissue-loading device" was used the method of mathematical statistics on a small number of measurements (n <10)

Statistical processing of the results was performed on a computer. The results of studies of the nature of vibration load in the system "forming organ-tissue-loading device" and the time of separation of the upper loading device from the formed sample are given below (Fig. 4, 5).

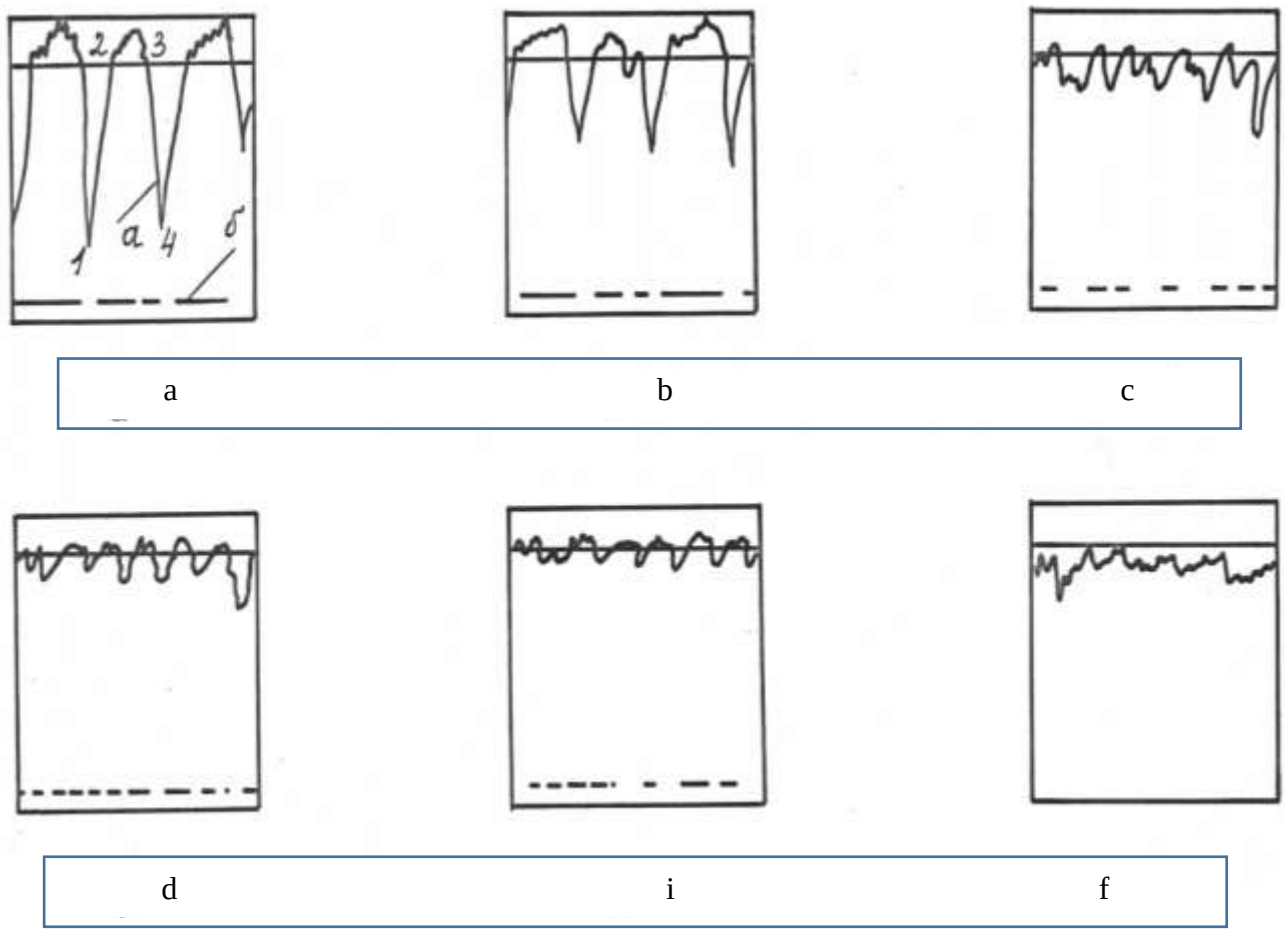


Fig.4. Copies of curves of change of dynamic loading (F, H) and time of separation (t, c) in the investigated system

Consider the features of the interaction in the system "forming organ-tissue-loading device". As can be seen from Fig.4, which shows the typical combined curves of the dynamic load (a) and the time of separation of the loading device from the forming organ and, accordingly, the tissue (b), section 1-2 of the curve characterizes the downward movement of the forming organ. In this case, the

loading device is delayed in time from the forming body and there is a slight separation, which causes a decrease in the dynamic load on the sensor - transducer.

At section 2-3 there is a separation of the loading device from the sensor, which creates favorable conditions for shaping. Section 3-4 indicates the contact of the sample with the loading device. During this period, the system moves to the uppermost position and the load on the object reaches a maximum and creates favorable conditions for the distribution of tissue waves formed in the process of forming a three-dimensional shape.

Analysis of the obtained oscillograms (Fig. 4) and the results of experimental studies allowed to determine the range of input parameters, within which the necessary, in terms of the possibility of obtaining a three-dimensional shape, the technological conditions of vibroforming. It should be noted that at the amplitude of vibration A = 0.65 ... 65 mm the best values of the initial factors F and t are provided. The maximum time of separation of the loading device from tests is provided in the frequency range V = 10 – 30 c^{-1}. It is in this frequency range that significant loads on the material are provided, which is clearly seen in Fig.4

In order to identify the degree of influence of each of the input factors of the process on the output function, a number of experiments were performed. The main controlled factors are the amplitude (A, mm) and vibration frequency (V, c - 1), as well as the mass of the upper loading device (m, kg). The remaining factors stabilized at the same level. Varying these parameters, a three-factor experiment was performed, where the initial parameters were the value of the dynamic load on the fabric (F, H) and the time of separation of the upper loading device from the formed sample (t, c).

Initially, a multifactorial experiment of the 1st order was performed. After processing the experimental data, it was found that the obtained polynomial inadequately describes the studied process. Then it was decided to supplement the experimental data on the plan CRCP-2. In compliance with all the conditions of the planning of the experiment, it was obtained: by the dynamic load-polynomial of the second order (2); by the time of separation-polynomial of the first order (3).

$$У = 1{,}07 + 0{,}122X_I - 0{,}411X_2 + 0{,}438X_3 - 0{,}316x_2x_3 + 0{,}076x_1^{\,2} + 0{,}009X_{\,2}^{\,2} - 0{,}0\,88\,X_{\,3}^{\,2} \qquad (2)$$

$$У=0.595+0,035X_1-0,120X_2+0,055X_3 \quad (3)$$

In Fig.5. Roman numerals indicate the ranks of the influence of input factors on the output parameters.

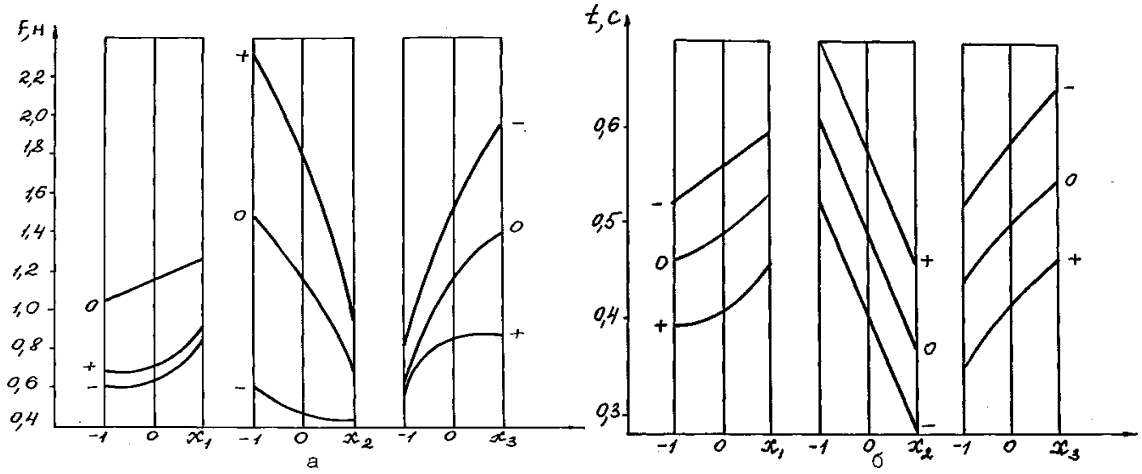


Fig.5. Influence of parameters x1 x2 x3 on dynamic loading F (a) and separation time of loading device in the process of vibroforming t (b)

For the analysis of the received mathematical models one-factor dependences of dynamic loading F and time of separation of the loading device t from samples from each of factors (A, V, M) at stabilization of other factors at levels +1, 0, -1 are constructed.

Ranking is performed on the maximum difference ρU.

As can be seen from the figure, the ranking of input factors at all levels of stabilization gives a number

$$\triangle У(X_2)>\triangle У\ (X_3)>\triangle У(X_1) \quad (4)$$

That is, the value of ΔF is most significantly affected by the vibration frequency V and the least amplitude A

With increasing frequency of vibration of the forming organ X_2, the dynamic load decreases significantly, which is due to the increase in vibration acceleration of the studied system. The increase in the vibration acceleration of the system eliminates the possibility of separation of the loading device from the forming

body due to which mainly there are loads that allow to break the folds that are formed in the transition of bulky areas of the surface to flat.

As the value of factor X_3 (mass of the loading device) increases, the dynamic load on the sample decreases, which is due to the inertial forces on the part of the loading device.

The obtained mathematical models (2 and 3) and their graphical interpretation (Fig. 5 a, b) show that the initial parameters F and t mostly depend on the mass of the loading device (m). It should be noted that when m> 0.174 kg, the value of F and t decreases, increasing the mass of the loading device above the specified value is impractical.

As can be seen from Fig.4, b the most noticeable effect on the value of the initial function ρ t has a vibration frequency V and least of all - the amplitude A

As the vibration frequency (X2) increases, the value of the initial function decreases significantly, which is mainly due to the peculiarities of the vibration acceleration of the forming organ. At certain values of the vibration frequency, the interaction in the system "forming organ - tissue-loading device" can occur without separation, which complicates the implementation of the basic idea laid down in the proposed method of vibroforming.

The increase in the mass of the loading device (X3) causes (causes) a significant increase in the separation time, due to the nature of the inertial forces of the loading device.

Conclusions

The obtained results are the basis for the development of the experimental setup and were used in conducting technological experiments.

The material presented in this publication was the beginning of scientific research in this field - the creation of complex three-dimensional shapes through the use of deformation properties of fabrics. As part of such research, 40 patents have been obtained to date on methods of forming three-dimensional parts and devices for their implementation.

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EFFECT OF LASER HPDL SURFACE MODIFICATION OF X40CRMOV5-1 HOT-WORK TOOL STEEL

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DOI: 10.31891/monograph/2021-10-50

1. Introduction

Forecasts pertaining to the global economic development factors regard laser manufacturing techniques as the most promising and efficient ones for ensuring the development in many industry branches in which materials processing dominates. It is considered that in future only these economies will be competitive in the global market in which laser technologies will be widely used [1, 3-6]. No other materials processing technology development is funded to such extent and worked out with such concentration of efforts of the research institutes as laser technologies [2]. Laser radiation features currently the state-of-the-art source of heat energy, used to form structure and properties of the surface layer. There is an opinion that laser manufacturing techniques belong to the most promising and efficient ones, for ensuring the development in many industry branches, and especially those in which materials processing dominates. Thanks to the very precise energy delivery laser radiation makes it possible to carry out the technological operations better or faster within the framework of the technologies known to date. It makes also possible introduction of the new technologies whose realisation is impossible when using the conventional power density [2].

The world industry already makes widely use of laser technologies and the most extensive industrial use in the laser materials processing have currently the solid state lasers with the Nd:YAG crystal active element and the CO_2 gas lasers. Diode lasers have appeared in materials engineering only in 1998 among many lasers used for materials processing. A growing interest is observed in using this energy source since that time. This growth is very dynamical and it is forecasted that within a few years applications of diode lasers will take more than a half of all applications of lasers in the area of surface layers' modification and welding technologies. The laser has several unique properties used in heat treatment of materials' surfaces. Figure 1 presents the experimental setup with high power diode laser. In laser remelting and alloying processes heat is transported away from

the surface by thermal conduction, inducing rapid cooling [1, 5-6]. Austenitised material, provided with sufficient quantities of carbon, forms martensite on quenching, producing a hard and wear resistant surface.

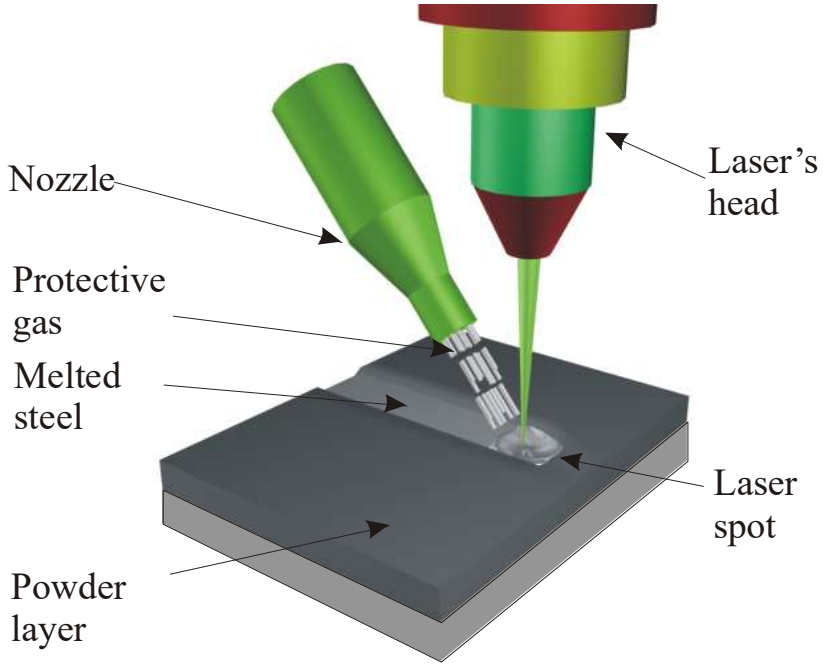


Figure 1. Experimental setup with high power diode laser HPDL ROFIN DL 020

The properties of the hardened layer are controlled by the energy input, which depends on the beam power density and interaction time. Long interaction times enable more heat to be conducted into the material before the melting temperature is attained at the surface, thus producing a deeper hardened layer. Higher traverse rate and power density result in a faster cooling rate, at the expense of the depth of the hardened layer. The geometry of the hardened layer depends on the processing parameters and beam-matter interaction, and their effect on the thermal cycle induced by laser radiation. Consequent phase transformations, which determine the hardness of the resulting microstructure, are affected by material composition, initial microstructure and processing parameters. The advantages of laser treatment in comparison to other surface layer modification methods are: fast treatment, possibility to carry out the treatment without shielding facilities, modification of small – freely selected surface fragments responsible for tool and machine elements life, as well as materials economy. However, its disadvantages are the relatively high purchase cost of the high power lasers and high surface roughness after laser treatment.

2. Material and experiment

The experiments were made on specimens made from the X40CrMoV5-1 hot work tool steel. The specimens were austenitized on the salt bath furnace and tempered in the chamber furnace in the protective atmosphere – argon. The specimens were tempered twice for 2 hours at the temperature of 510°C after quenching. Next, powder layers of the WC tungsten carbide of two different thicknesses of 0.06 mm and 0.11 mm bounded with the inorganic binding agent were put down onto the degreased specimens. Specimens of the X40CrMoV5-1 steel were remelted with the Rofin DL 020 high power laser beam (HPDL). The multimode energy distribution was used. It was found out in the preliminary investigations that the maximum feed rate at which the process is stable is 0.5 m.min. Further experiments were carried out at the constant remelting rate, changing the laser beam power in the 0.5-1.9 kW range during alloying the test pieces. It was established experimentally that the argon blow-in with the flow rate of 20 l/min through the ϕ 12mm circular nozzle oppositely directed in respect to the remelting direction provides full remelting zone protection. The test pieces were machined after remelting and alloying, to remove the non-remelted layer of the tungsten carbide.

Metallographic examinations of material structure after laser alloying of its surface layer were made on Leica MEF4A light microscope at magnifications from 100 to 1000x. The Leica – Qwin computer image analysis system was used for thickness examination of the particular zones of the surface layer and for measurement of grain areas and dendrite lengths. Grain size analysis was carried out on the steel microstructure images saved in the electronic form. The stored examination results of the average grain size and dendrite lengths in the particular zones were analysed statistically. The X-ray qualitative and quantitative micro-analysis and analysis of the surface distribution of the alloying elements in the test pieces of the investigated steel, subjected to the standard heat treatment and remelted and alloyed, were made on the Opton DSM-940 scanning electron microscope with the Oxford EDS LINK ISIS X-ray energy dispersive spectrometer at the accelerating voltage of 20 kV and on the JEOL JCXA 733 X-ray micro-analyser.

3. Analysis of experimental results

The dynamical temperature increase was revealed in the remelting location, reaching by the material the temperature higher than the solidus, and a quick temperature drop after laser beam transition, caused by transferring the heat from the remelting area to the quasi-infinite volume of the native material. Employment of the concurrent temperature registration in the remelting area proves that the laser surface layer modification process proceeds relatively smoothly. The initial experiments with alloying the X40CrMoV5-1 hot work alloy tool steel indicate the clear effect of the alloying process parameters, especially the laser beam power, on the run face shape. Increase of the laser power, thickness of the tungsten carbide layer put down onto the steel surface before remelting, and decrease of the laser beam feed rate result in the increase of surface roughness and shape irregularity of the run face. This effect is connected with the increase of laser radiation absorption by the specimen surface, due to the high tungsten carbide absorption coefficient. Absorption increase causes growth of the steel surface layer remelting process intensity. Columnar crystals developing in the remelted layer under such dynamical crystallization conditions are oriented in the direction of the maximum temperature gradient (Figs. 2,3). Growth of crystals in directions <110> and <111> is also possible, which leads often to sudden change of the crystals growth direction.



Fig. 2. Remelting edge of the steel surface after alloying with parameters: scanning rate – 0.5 m/min, beam power – 1.9 kW, WC coating thickness – 0.11 mm

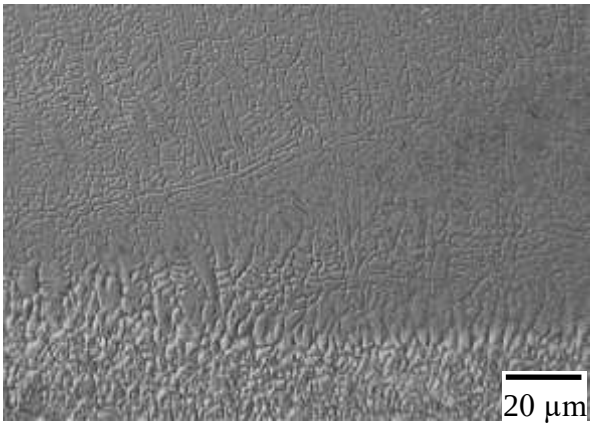


Fig. 3. Boundary of the remelted steel surface layer after alloying with parameters: scanning rate – 0.5 m/min, beam power – 1.9 kW, WC coating thickness – 0.11 mm

Possibility of re-nucleation on the partially melted dendrite arms, occurring due to concentration superfusion is an explanation of the sudden change of crystals growth direction from the <100> orientation. Carbide clusters appear in the central area of the remelted zone, arranged in the characteristic swirls, caused by the convection motion of the material in the liquid state. Size of the crystals depends on the remelting process parameters, and especially on the remelting rate and volume of the remelted material, and also on the non-remelted volume of the heat abstracting material.

Solidification rate grows along with shortening of the time period of the laser beam impact on the material and with the increase of the treated material volume, and the obtained crystalline structure is more refined.

The detailed results of the thickness measurements of zones obtained in the surface layer versus laser power and of the alloying material thickness changes are presented in Figure 4. It was found out, basing on the experiments carried out, that thickness of the analysed layers, evaluated basing on the computer image analysis made on pictures from the light microscope and confirmed by examinations on the scanning electron microscope, falls within the broad range and is a function of two variables: laser beam power, and the alloying material thickness in the form of tungsten carbide.

It was found out in the experiments that laser fusion results in refinement of structure in the entire laser power range, i.e., from 0.5 to 2.5 kW. Different grain

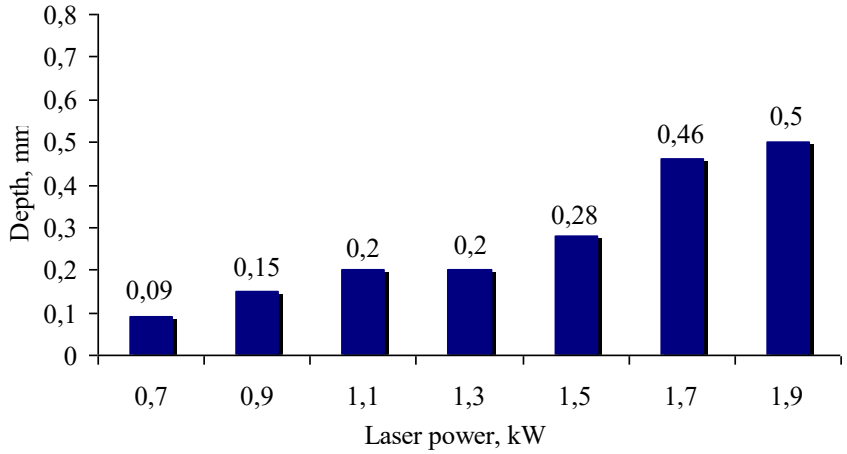


Fig. 4. Diagram with thickness changes of remelted zone of X40CrMoV5-1 steel alloyed with the tungsten carbide of the 0.11 mm layer thickness, laser power from 0.7 do 1.9 kW

size was revealed during examinations in the particular zones of the surface layer after laser fusion and alloying. It was found out after remelting with laser beam that the average grain size in the remelted zone varies from 11.74 to 20.88 μm^2. After alloying the steel with the tungsten carbide with the layer thickness of 0.06 mm, the average grain size in the remelted zone varies from 12.48 to 28.38 μm^2. The smallest average grain areas were revealed in the remelted zone after alloying with the tungsten carbide with the layer thickness of 0.11 mm. The range of grain area values in this case is as follows: in the remelted zone from 6.11 to 28 μm^2 and in the heat affected zone – from 7.93 to 30.36 μm^2, whereas, it ranges from 221.45 to 284.07 μm^2 in the native material. Matrix grains shape and size do not change during fusion. Only at the crystallization front, between the fused and heat affected zones, the elongated and smaller grains were found, which are subjected to partial melting and re-crystallization during laser modification.

The chemical composition of the steel and conditions of its crystallisation affect phase transformations occurring during the solidification and cooling processes. Due to the quick crystallisation of the hot-work tool steels after their laser remelting precipitation of the high-temperature ferrite from the liquid solution is observed most often. Next, the peritectic reaction occurs, which leads to origination of austenite. Concentrations of carbide and alloying elements, that – depending on their portion - may precipitate directly from liquid, demonstrating clear segregation at the dendrite boundaries, have a significant effect on austenite origination.

4. Conclusion

Experiments of remelting and alloying with tungsten carbide the X40CrMoV5-1 hot-work tool steel indicate to the clear influence of the remelting and alloying processes' parameters, especially of the laser beam power, on the bead face shape. Treatment in the analysed laser power range ensures the regular and flat face shape, with no partial melting and with the relatively high surface quality. A small number of depressions and surface irregularities, resulting from its intensive heating occur on paths developed during laser alloying of the surface layer. Material transport in the molten metal, caused by surface tension forces features the main factor deciding development of the alloy layers. Increase of the laser power during remelting and of the thickness of the tungsten carbide coating put down onto the steel surface at the constant laser beam feed rate cause increase

of roughness and irregularity of the beam face shape. This effect is connected with the increase of the laser radiation absorption by the test piece surface, thanks to the higher value of the tungsten carbide absorption coefficient compared to the steel surface absorption coefficient.

Acknowledgments

The publication is result of cooperation within the Visegrad Scholarship Program 2021/2022.

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THE INFLUENCE OF THE MILL-TURNING TECHNOLOGICAL CONDITIONS ON THE SURFACE QUALITY

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DOI: 10.31891/monograph/2021-10-51

Abstract

This paper investigates the possibilities of using mill-turning axisymmetric elements for finishing. The essence and used types of machining were characterized. The technological conditions of machining in terms of the obtained surface accuracy were analyzed. The advantages and disadvantages of mill-turning were discussed.

Introduction

Machining of axisymmetric parts usually takes place by turning, and then, in case of increased requirements related to the dimension and form accuracy, grinding. Such conventional approach of the technological process is problematic to implement, when elements are made of materials that form the turnings and are unbalanced, asymmetrical, with geometric discontinuities. These factors generally reduce the quality of work surface and have a negative effect on tool life. An alternative to the conventional shaping method axisymmetric elements is mill-turning in other words rotary milling. During this treatment both the workpiece and the cutting tool perform a rotary motion. Rotary milling has found wide application. It may be used for the external and internal surfaces as well as for pretreatment finishing [1, 2, 6, 10].

In general, the advantages of this treatment include high quality of the machined surface, forming short turnings that facilitate process automation, workpiece low heating, high machining efficiency, longer tool life and lower energy consumption in comparison to turning and cost-effective machining of large and heavy workpieces. However, obtaining the desired results in mill-turning operations it’s conditioned by knowing the influence of many different factors on this process. In general, they may be divided into several groups: related to the machine tool, process conditions and cutting tool factors. These factors directly affect the efficiency of the process, the quality of machined surface, dimension and form accuracy and form of turnings [3, 4, 8].

Characteristics of mill-turning

Rotary milling is a machining process in which the workpiece and cutting tool perform a rotary motion. In this process the cutting speed is made up of three components: the relative velocity of workpiece and the cutting tool as well as the tool feed rate or workpiece. The tool relative velocity is usually higher than the workpiece relative velocity.

In mill-turning process the main movement is cutting tool rotation motion and the speed of which the basic quantity magnitude is subject to cutting conditions optimization. Depending on the machining task, cutter is moving along a path parallel to the axis of the workpiece relatively performs in-feed motion. There are two types of rotary milling due to the rotation directions of the workpiece and the tool. The out-cut milling takes place when the directions of the workpiece and tool rotary motion are opposite and the in-cut milling when these directions are compatible. However, the basic division criterion of rotary milling types is the mutual alignment of workpiece and tool axes. Due to this arrangement, a distinction is made between orthogonal rotary milling, in which the axes are perpendicular to each other.

A significant advantage of rotary milling is fact that the cutting speed depends on speed tool rotation because of which the workpieces may be unbalanced or made of difficult-to-cut materials with optimal cutting speed for a given type of object material and the tool point material [5].

The cutting discontinuity of each tool point is characteristic milling process, and it causes that the thermal load of the cutting points in rotary milling is going to be much lower than in turning with the same cutting productivity. Unlike to a turning tool, which is in constant contact with the workpiece material, the cutter blades are in periodic contact, which shortens the friction path and improves cooling conditions. The tool rotation generates its blade cut successively into the rotating workpiece and at the same time a large amount of short, comma turnings are produced.

The usage of appropriate tools, machine tools and optimal machining parameters may affect the surface quality, which in many cases eliminates the need for further machining.

The basic technological parameters that determine the movement of the tool and the workpiece are [2, 10]:

- cutting speed, v_c [m/min],
- rate of feed per tooth, f_z [mm/1],
- longitudinal feed rate, f_w [mm/feed],
- cross-feed, f_r [mm/feed],
- width milling – B, [mm].

Cutting speed is the principal motion temporary speed of considered cutting edge point in relation to the workpiece. This speed is the geometric sum of all cutting component movements speed, i.e., tangential velocity of tool, tangential velocity of workpiece, longitudinal feed, or cross-feed. Rate of feed per tooth corresponds to the length of feed motion path section per rotation in the principal motion by the inter-blade angle scale.

The longitudinal feed is the feed in the longitudinal direction to the workpiece axis, which falls on one turn of the workpiece.

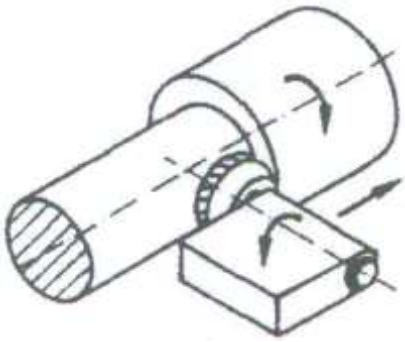
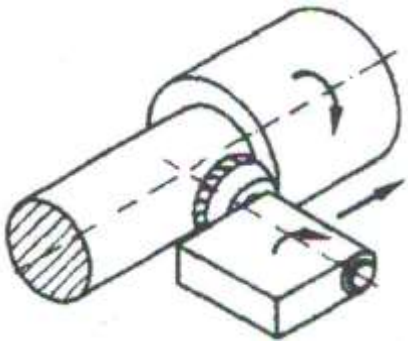
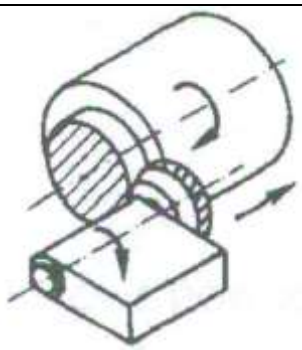
Cross-feed corresponds to the displacement of the milling cutter into the workpiece per one turn of the workpiece. Depth setting motion of cutting edge is equal to the tool traverse.

Face milling is the distance between the work surface and the work machined surface measured in a direction perpendicular to the axis of the workpiece. In parallelism rotary milling depth setting of the cutting edge is the distance between two successive positions of the cutting edge, measured in the direction perpendicular to the width of the cut layer per one turn of the workpiece. The milling width is defined as the segment respondent to the contact projection of the cutter with the workpiece.

The basic criterion for the division of rotary milling is the mutual positioning of the tool and workpiece axes. There is then orthogonal rotary milling, in which the axes of the tool and the workpiece are mutually arranged perpendicularly, and parallel rotary milling (also described as the concentric or cylindrical mill-turning) in which the axes of the tool and the workpiece are parallel.

As an additional criterion of rotary milling division mutual directions of workpiece and tool rotary motion are assumed. Then, when the directions of the workpiece and tool rotation are opposite, out-cut milling is distinguished and in-cut milling, when these directions are compatible (tab. 1) [4, 9].

Table 1. The division of mill-turning depending on the tool and workpiece axes position and the direction of their mutual movement [9]

Mill-turning	Out-cut milling	In-cut milling
Orthogonal		
Parallelism		

In parallelism rotary milling, the workpiece, which is clamped in the spindle chuck, rotates around its axis as in turning. The tool, on the other hand, is mounted in the tool spindle and the axis of which is parallel to the workpiece axis. In addition to the rotary motion, which mainly determines the cutting speed, the milling cutter can perform a longitudinal feed motion in the direction parallel to the workpiece axis or a radial motion perpendicular to the workpiece axis. Parallelogram milling of the external surfaces it may extend with an external contact of the cutting tool and the workpiece or with an internal contact using toolheads with cutting edges directed inward. Machining of internal surfaces by parallelism rotary milling method is possible only with the internal tool contact with the workpiece.

Parallel rotary milling can occur in two cases [4, 6]:

- rotary milling, where at the first phase of machining there is only radial feed, and at the second only peripheral feed, rotary motion of the workpiece (this is the so-called variant of rotary milling to the full depth of the machining allowance),

- rotary milling, in which simultaneously at first and second phase there is radial and peripheral feed, while at the third only peripheral feed.

At the first case (first phase) the cutting of the blades to the desired depth of cut follows. The machining at this stage is similar to cylindrical peripheral milling, and the selection of cutting parameters may base on the existing recommendations for this method. The following factors are characteristic for the first phase: variable contact of cutting-edge point length with the workpiece and the character of the cross-sectional area of the cutting layer (increase from zero to maximum and again decrease to zero) changes, irrespective of the tool and workpiece rotation direction. At the second phase, occurs peripheral feed, the machining allowance takes place during one turn of the workpiece. There are constant geometrical parameters of the cutting layer, and the cross-section of the cutting layer course changes are similar at the first phase. Rotary milling of external surfaces with external contact is often replaced by rotary milling with internal contact.

Rotary milling of internal surfaces is divided into planetary rotary milling and circular rotary milling. During planetary rotary milling, the workpiece performs an axial feed motion or is motionless, while the cylindrical cutter performs a rotary motion around its axis and a planetary motion inside machined cylindrical surface.

For rotary orbital milling the cutter performs only rotary motion around its axis, and the workpiece performs rotary and axial feed motion. With this machining method, kinematically more useful cutting conditions are obtained (more teeth are simultaneously in contact with the workpiece) than with rotary cylindrical milling [4, 6].

Influence of technological conditions on the surface quality

The surface quality is defined by the micro-irregularities of the machined surfaces, and it’s related to the shape and size of the cut layer cross section and depends on the stock properties, cutting blade geometry, cutting parameters, cooling conditions, blade wear and the stiffness of the machine tool-holder-object-tool system. The rotary milling process is a machining method which, despite many advantages, has the disadvantage of the process-related machined surfaces shape defects in circumferential and longitudinal directions. As the result of the interrupted cutting process during rotary milling deviations of the workpiece surface actual contour from the theoretical one to be produced because of

machining. Facet arises on the machined surface circumference, depending on various sizes of cut-in process parameters values. Formed facets, shape an equilateral polygon with the workpiece circumference. The deviation from the given circle contour (when machining cylindrical surfaces) at the boundary edge between two faults determines kinematically determined roundness errors or kinematic roughness [1, 5, 7].

The obtained surface quality is influenced by the location of the tool and workpiece axes. In order to obtain a high-quality surface, it is necessary to ensure that the axis of the milling cutter and the workpiece are aligned. In parallel rotary milling, the tool and workpiece axes are always parallel. On the other hand, the mutual position of the tool and the workpiece during orthogonal rotary milling plays a significant role in the process of surface constitution. One of the decisive parameters are workpiece axis distance and tool rotation, which is referred to as eccentric or eccentricity. When the cutter is centered in relation to the workpiece, the value of the axial feed is limited by the length of the auxiliary cutting edge. Characteristic of this arrangement is that all points of the leading cutting edge come into contact on the circumference of the workpiece surface at the same time. When the axial (longitudinal) feed is increased to exceeding length value the of the leading cutting edge, at the workpiece surface microscopic shape deviations (in longitudinal direction) appears. An additional limitation of the axial feed may be the cutting-edge loads appearing with machining difficult-cut materials. In this process variant, a high quality of the machined surface is achieved at high relation of the tool and workpiece rotational speed. Changing the wheelbase brings about fundamental changes to the machining process. In rotary milling with displaced milling cutter and workpiece axes the leading cutting-edge points reach the machining diameter sequentially. As a result, the cutting edge-contact angle with the workpiece is increased (the cutting-edge contact angle) and the value of the longitudinal feed shall be increased. The longitudinal feed may be increased to the length value equal to the projection of the auxiliary (leading) cutting-edge in the longitudinal workpiece direction, where it does not lose its cylindrical form.

A significant difference between machining with a centrically and eccentric set tool is related to the influence of changes in cutting forces on the workpiece surface. Larger leading cutting-edge contact angle values with the workpiece negatively affect the quality of the machined surface, especially when there is a

small number of cutting teeth in contact. The accuracy of the cutting blades positioning has a significant influence on machined surface quality. One of the assumptions of the optimal design of the tool for rotary milling precision machining of use the mechanism that allows to change the setting of multi-edge cutting inserts in order to eliminate errors in their positioning at the tool body.

The surface quality deterioration obtained as a result of a surface roughness or waviness increase is caused by the axial runout in face milling and the radial run-out of the cutting blades in rotary parallelism milling. The accuracy of the rotational movement of the peripheral cutting edges plays an important role in rotary milling with a parallel positioned tool and workpiece. Even a small value of the radial runout of one main cutting edges contributes to an increase in surface roughness. A milling cutter intended for high surface quality should be made as a single-edge tool, or in case of a multi-edge tool, feed per tooth values such as those for single-edge tools must be used. In order to obtain the lowest possible surface roughness, measured in the workpiece longitudinal direction, it is important when machining rotary peripheral milling with longitudinal feed that the main cutting edge has an entering angle of 90°. Then, the influence of the edge contour of the blade on the generated surface is reduced [1, 5, 7].

With the orthogonal version of rotary milling, the accuracy of movement in the plane of all leading cutting edges of the milling cutter should be ensured. The cutting volume by the main cutting edge of the milling cutter accounts for a large proportion of the total cut layer volume. The quality of the machined surface, however, depends on the auxiliary (leading) cutting edge, which, while cutting the rest of the material, smoothes the surface of the machined part. As a result, particularly high demands are placed on the rigidity of the milling unit and the design of the tool, which must have adjustable face blades or ground blades on the front side.

The quality of the produced surface and the course of the cutting process depends on the blades number simultaneously cutting the material of the object. Rotary milling machining with the number of active teeth less than one takes place in very difficult conditions due to the high dynamics of the process. It is harmful to the machine tool and tool, as well as deteriorating the quality of the machined surface. In this case, chipping of the cutting edges often occurs. Much better working conditions occurs when the number of cutting teeth simultaneously in

contact with the workpiece is greater than one. The greater number of active teeth makes the cutting process smooth, because the changes in cutting forces are smaller during the contact of the blade with the workpiece. The deviation of the workpiece surface shape processed by rotary milling is macrogeometrically determined by the kinematics of the tool and workpiece movement. The accuracy of the shape is also influenced by the workpiece radius and the tool radius. Since the diameter of the machined surface results from the assumed machining task, it cannot be used to optimize the surface quality. On the other hand, the surface quality of the workpiece is influenced by the radius of the cutter, the number of cutter teeth and the ratio of the rotational speeds of the tool and workpiece. Control of the surface quality parameters in rotary parallelogram milling may be done by using the so-called trajectory coefficient μ, which results from the quotient of the milling cutter rotational speeds ratio and workpiece to the ratio of the workpiece and tool radius. It is a measure of the quality of the machined surface [1, 5, 7].

The obtained surface quality is also influenced by the rotational speed of the cutting tool and the rotational speed of the workpiece, which are most often considered together. The ratio of the tool and the workpiece rotational speeds λ is one of the most important process parameters. It determines the quality of the produced surface and affects the efficiency of the process and tool life. Increasing the rotational speed ratio leads to a reduction in surface errors. The use of additional rotations of the workpiece leads to a reduction in surface shape errors but increases the machining time. Therefore, this method of improving the surface quality is used when the optimization of the rotary milling process other parameters does not bring the desired results [1, 5, 7].

Summary

Summarizing the characteristics of rotary milling, the following main advantages of this process should be mentioned:

- short chips formation conditioned by the kinematics of the machining process favors the automation of machining,
- a slight increase of the workpiece material temperature during milling enables the processes to be carried out without use of cooling and lubricating liquids,
- critical limits of high-speed turning (maximum rotational speeds of the main spindle, the influence of centrifugal forces on the change chuck and drops of

jigging) are eliminated by the effect of adding three components of the cutting speed, which allows the use of very high cutting speeds,

- the possibility of obtaining a high-quality machined surface, small dimensional tolerances, and high accuracy of shape, make high-speed rotary milling as a substitute technology for so far widespread methods of precision machining,
- useful for the economic processing of difficult to machine materials,
- the possibility of large objects efficiently processing with unevenly distributed mass,
- may be used for overall machining, which allows you to avoid errors in reattaching on subsequent processing stations,
- much higher machine cutting compared to high-speed turning, which results in a significant reduction in manufacturing time.

However, the basic disadvantages are mainly:

- shape errors caused by the kinematics of the machining process on the machined surface in the longitudinal and circumferential direction of the workpiece,
- complex description of the geometric surface structure geometry and the forces occurring in machining.

Obtained the desired surface quality with milling is conditioned by knowing the influence of many different factors on this process. Among these factors, technological factors determining the conditions of the process and factors related to the cutting tool are very important.

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EVALUATION OF ACCURACY OF THE METHOD OF CALCULATION OF THE EFFECTIVE LEVEL OF DEFORMATION OF CONTACTING SURFACES OF CYLINDER-PISTON SEALS

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DOI: 10.31891/monograph/2021-10-52

1. Research results

The paper considers the elastic contact of a strongly anisotropic rough surface (polymer surface) with a smooth (metal surface) piston metal-polymer seals Due to the reshaping of the rough surface material during contact loading, two average planes of the rough surface should be distinguished (Fig.1) - the average plane of the rough surface before deformation (the distance from the smooth surface to this middle plane is called the deformation level $\boldsymbol{h}$) and the average surface of the rough surface after deformation. (the corresponding distance is called the effective level of deformation $\boldsymbol{u}$). The value $\boldsymbol{h}$ characterizes the contact displacement of the surfaces and the normal contact stiffness of the joint.

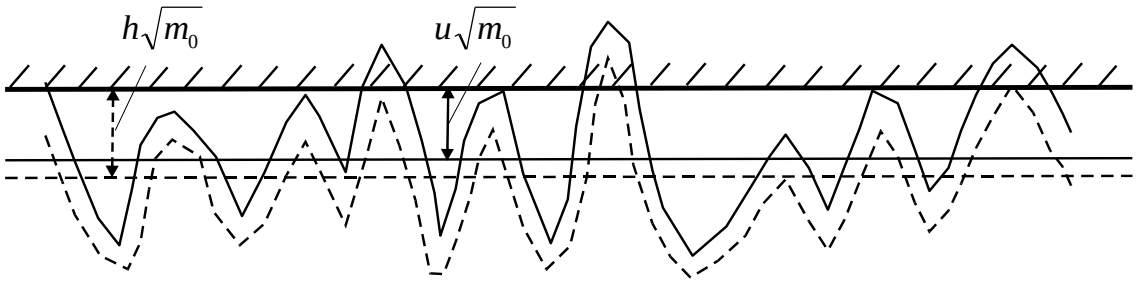


Fig. 1. The scheme of contact of conjugate surfaces

The value $\boldsymbol{u}$ is important when calculating the flow of liquid or gas through the joint. The relationship between the strain rate $\boldsymbol{h}$ and the effective strain rate $\boldsymbol{u}$ is described by the equation [1]:

$$\left(\frac{2}{\pi}\right)^{1/2}\exp\left(-\frac{h^2}{2}\right)+h\left[3+\operatorname{erf}\left(\frac{h}{\sqrt{2}}\right)\right]+$$
$$+(2a-1)\left[\exp(h_g-h)\operatorname{erfc}\left(\frac{h}{\sqrt{2}}\right)-\exp\left(h_g+\frac{1}{2}\right)\operatorname{erfc}\left(\frac{h+1}{\sqrt{2}}\right)\right] \quad (1)$$
$$=2\left[\left(\frac{2}{\pi}\right)^{1/2}\exp\left(-\frac{u^2}{2}\right)+u\operatorname{erfc}\left(-\frac{u}{\sqrt{2}}\right)\right],$$

$$a = 2/erfc\left(h_g/\sqrt{2}\right);$$

$h_g = -0{,}845$ – limit level of deformation (level of deformation at which the contact area is equal to the cross-sectional area).

The amount of space bounded by a rough surface and a plane intersecting the surface at level $\boldsymbol{u}$ [2]:

$$V_S(u) = \frac{m_0^{1/2}}{2}\left[\left(\frac{2}{\pi}\right)^{1/2}\exp\left(-\frac{u^2}{2}\right) + u\ \mathrm{erfc}\left(-\frac{u}{\sqrt{2}}\right)\right]. \qquad (2)$$

The formula for the contact volume was obtained [1]:

$$V = \frac{m_0^{1/2}}{4}\left\{\left(\frac{2}{\pi}\right)^{1/2} exp\left(-\frac{h^2}{2}\right) + h\left[3 + erf\left(\frac{h}{\sqrt{2}}\right)\right] + \right.$$
$$\left. + (2a-1)\left[exp(h_g - h)\, erfc\left(\frac{h}{\sqrt{2}}\right) - exp\left(h_g + \frac{1}{2}\right) erfc\left(\frac{h+1}{\sqrt{2}}\right)\right]\right\}. \qquad (3)$$

At infinitely large loads, when $h \to h_g = -0{,}845$, the contact volume V goes to zero. At low loads, when $h \to \infty$, we have:

$$V \to h m_0^{1/2}\ , \qquad (4)$$

$$m_0 = \frac{\pi}{2} R a^2\ ,$$

m_0 – zero-order spectral moment.

At low loads, the values of the deformation level $\boldsymbol{h}$ and the effective deformation level $\boldsymbol{u}$ are equal.

The connection between the level of deformation $\boldsymbol{h}$ and an effective level of deformation $\boldsymbol{u}$, calculated on the basis of the equation (1), is presented in Fig. 2. Calculations are made using the Niveau program [1] written using the software product Mathcad Professional.

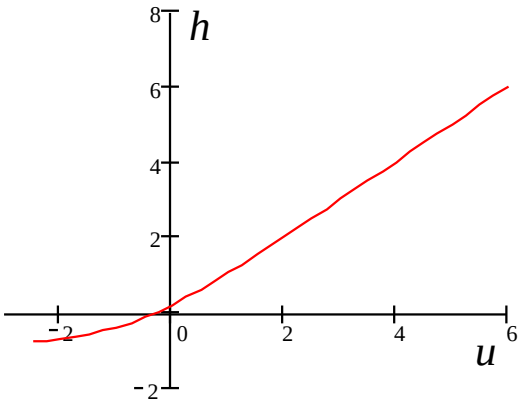


Fig. 2. The relationship between the level of deformation h and the effective level of deformation u

The support surface of the surface corresponding to the level u can be calculated by the formula [3]:

$$\eta_c(u) = \frac{1}{2} erfc\left(\frac{u}{\sqrt{2}}\right). \quad (5)$$

The connection of an effective level of deformation with a complex of contact conditions can be obtained as follows. The actual contact area η can be defined as a muscular area of a rough deformed surface that corresponds to the level u. Then, according to (5), we have:

$$\eta = \frac{1}{2} erfc\left(\frac{u}{\sqrt{2}}\right). \quad (6)$$

At the same time, in [4] the following communication of the actual contact area with the complex of contact conditions is obtained:

$$\eta = 1 - exp(-K). \quad (7)$$

Thus, the following equation is obtained to determine the effective level of deformation according to a given value of the complex of contact conditions:

$$1 - exp(-K) - \frac{1}{2} erfc\left(\frac{u}{\sqrt{2}}\right) = 0\ , \qquad (8)$$

$$K = \frac{1{,}83\sigma_n}{E\ q}\ .$$

Based on formula (8) using the Effectiv program [1], written using the MathCad Professional software product, calculated the effective level of deformation with the complex of contact conditions. The results are presented in Fig. 3.

The dependence presented in fig. 3, was approximated by formula (9), which was obtained by calculations on the programs Appr_E_1, Appr_E_2, Appr_E_3 [1], written using the software product Mathcad Professional:

$$u = \begin{cases} -7{,}890 + 4{,}453\ ln(5{,}562 - C), & (K \le 0{,}7); \\ -2{,}089\ exp[-(0{,}620 + C)^{-1{,}302}], & (0{,}7 < K \le 2); \\ -4{,}522\ exp[-(-0{,}062 + C)^{-0{,}967}], & (2 < K \le 5) \end{cases} . \qquad (9)$$

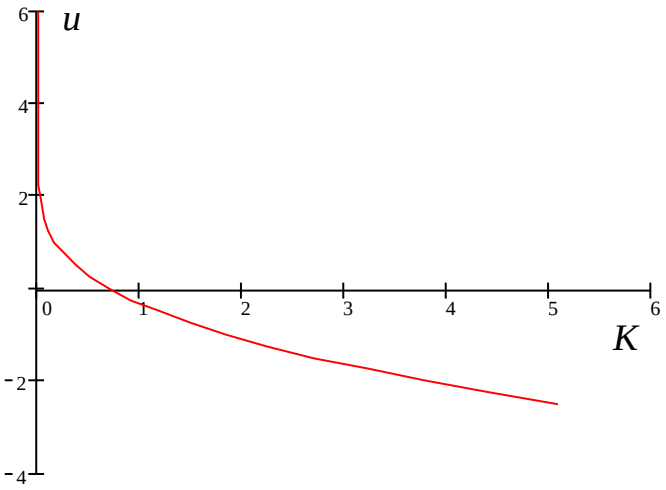
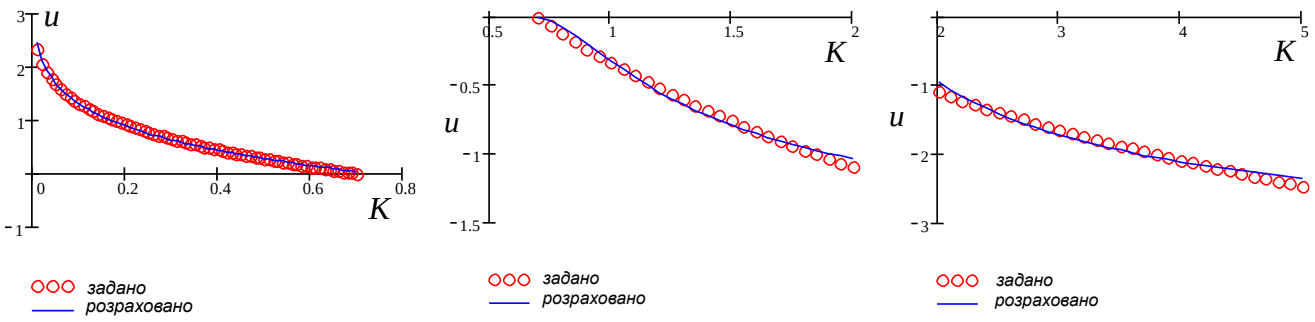


Fig. 3. Dependence of the effective level of deformation on the set of contact conditions

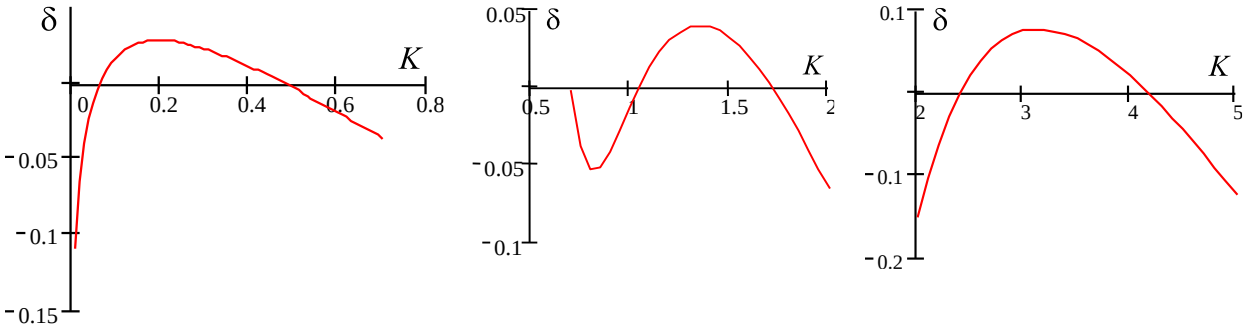
In fig. 4 the set and calculated values of the effective level of deformation are compared. Under the given should be understood the values determined from equation (8). Under the calculated - defined by formula (9). Since the set and calculated values are almost the same, in order to estimate the error that occurs when replacing the calculation equation with the approximate formula (9), in Fig. 5 shows the dependence of the difference between the set and calculated values of

the effective level of deformation (it is denoted as δ) from the set of contact conditions.



a) $K \leq 0{,}7$ b) $0{,}7 < K \leq 2$ c) $K > 2$

Fig. 4. Comparison of set and calculated values of the effective level of deformation



a) $K \leq 0{,}7$ b) $0{,}7 < K \leq 2$ c) $K > 2$

Fig. 5. Estimation of the error which arises at replacement of the exact equation of calculation of the effective level of deformation by the approximate formula (9)

2. Conclusion

Using the modeling of rough conjugate surfaces of the seal by a stochastic field, a method for calculating the effective level of deformation of the contact surfaces of the cylinder-piston seals was developed.

To calculate the effective level of deformation, the equation is obtained

$$1 - exp(-K) - \frac{1}{2} erfc\left(\frac{u}{\sqrt{2}}\right) = 0 \ , \qquad (10)$$

on the basis of which the calculation formula is derived:

$$u = \begin{cases} -7{,}890 + 4{,}453\, ln(5{,}562 - C), & (K \le 0{,}7); \\ -2{,}089\, exp[-(0{,}620 + C)^{-1{,}302}], & (0{,}7 < K \le 2); \\ -4{,}522\, exp[-(-0{,}062 + C)^{-0{,}967}], & (2 < K \le 5) \end{cases} . \quad (11)$$

The values calculated by the exact and calculated formula of the effective level of deformation differ by no more than 0.11 at $K \le 0{,}7$, 0,065 – at $0{,}7 < K \le 2$ and no more than on 0,145 at $2 < K \le 5$.

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PROBLEMS OF DESIGNING ROBOTS INTENDED TO WORK IN EXTREME ENVIRONMENT AND TEMPERATURES

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DOI: 10.31891/monograph/2021-10-53

1. Introduction

In this paper some aspects of designing of a mobile robot moving on ferromagnetic surfaces at high temperatures was taken into account. The main goal is to design and a device that can move on vertical walls of a fluidized bed boiler in a coal-fired power plant. The first stage of the project implementation, which resulted in the commencement of work on the device in question, was to conduct an environmental interview, enabling unambiguous definition of design and functional requirements that the robot must meet. The introductory part presents the result of the analysis of the working environment and existing solutions with similar properties that can be a potential help in dealing with potential problems. The main part of this work is divided into three elements: mechanical construction, electronic equipment and software. The first of them, in addition to the chassis and robot body, presents the most characteristic components of the device - magnetic wheels and a cooling system. It contains a thorough analysis of the applicable drive systems that comply with the structural requirements of the robot and discusses how to implement the chosen one. Electronic equipment includes all components with which a fully functional robot must be equipped to perform the intended operation. It includes a way to integrate the measuring sensors with the robot's central unit, calculations related to the energy balance, and developing the space needed to place the electronic components. In the further part of the work a description and implementation of the robot's movement method is presented along with the control program and user interface. The principle of effective cooperation between the robot and the operator is also presented here. The summary contains an analysis of the current implementation of the project and presents a concise description of further actions, as well as potential directions of system development.

2. Purpose and motivation

This work is a response to a specific problem - an inspection of an actual fluidized bed boiler in a coal-fired power plant. It is a complex technological

facility, the operating conditions of which are influenced by the physical and chemical parameters of the fuel and sorbent fed, the mass and size of coal grains, the streams of primary and secondary air fed, and the cooperation of the main chamber with the cyclone. Due to the multitude and complexity of phenomena occurring inside the boiler, it is very important to choose the appropriate method of carrying out the diagnostic analysis of the unit and the technical inspection of the boiler. Currently, the inspection of the technical condition of the boiler is carried out by specialized inspectors whose work mainly consists in measuring the thickness of the screen pipes at given points. Manual measurement is supported by the use of a drone. This process requires several days of downtime associated with turning off and cooling the boiler. The use of a robotic diagnostic system allows for a significant reduction in the time necessary to carry out the inspection, with a significant benefit being the use of a robot even before the unit is completely cooled down. The process of inspecting the internal walls of the boiler requires the use of a portion of the time that could be allocated to the basic operation of the unit, which reduces the profitability of the facility. The necessity to completely cool down the boiler, set up scaffolding and carry out measurements over a large area make the entire manual inspection process monotonous and takes up to a dozen working days. Thus, the use of a robot capable of carrying out high-temperature inspections without complete cooling of the boiler may significantly improve the economic results of its operation.

3. The essence of the problem

The robot should be designed to work in an environment with variable temperature reaching up to 200 ° C. Most electronic and mechanical systems are designed to operate at a much lower temperature, mainly due to the materials used in their construction. The basic operating temperature range of electronic devices is between 0… 45 ° C and 0… 70 ° C for industrial electronics. The above assumptions cause a fundamental technical and technological problem which must be solved in order for the system to function.

Ideally, instruments and components capable of operating at environmental temperature would be used. However, there are only a few devices that meet this condition, and most have to be custom-made. In the case of most devices, it is almost impossible to make them in high-temperature technology. This makes it necessary to isolate them from the environment and provide active cooling in order

to maintain an acceptable temperature. For this purpose, devices with limited temperature resistance were placed in an insulated compartment in which a temperature of 40 ° C is maintained. Temperature control methods can be divided into passive and active. Passive methods are intended to limit the transmission of thermal energy, while active methods are intended to regulate the internal temperature.

4. Solving thermal problems

The basic shield against heat is thermal insulation. Its purpose is to reduce the heat flux from the surroundings to the inside of the robot. Different materials protect against different methods of heat transfer. For this reason, multi-layer insulation was used, consisting of an outer metal shell, an insulator layer and an inner metal shell.

The main insulation layer is made of a thermal insulator, i.e. a material with low thermal conductivity λ. Insulators are materials with conductivity lower than 0.065 W / mK (1). Isolators primarily use the phenomenon of conduction. The heat flux can be reduced by using a material with a lower λ coefficient or by increasing the thickness of the insulation. For design reasons, it is better to use a better material than to increase the thickness.

The best insulators are made of airgel, i.e. silica foam with a high air content, even up to 99%. The vacuum panels use the same silica structure as airgel, but with air pumped out. However, due to the permissible operating temperatures, airgel mats will be used.

Materials with low thermal conductivity usually provide poor protection against other heat transfer methods. For example, an airgel has a large surface area due to its porosity. The amount of heat transferred by the transfer of heat largely depends on the area (2). Also, the emissivity of the airgel is high, at the level of ε = 0.93 (3), the large surface area increases the heat absorbed as a result of radiation. On the other hand, metals showing good parameters in the indicated applications have high thermal conductivity λ. Therefore, the outer shell is made of 1 mm thick polished aluminum sheet. The emissivity factor ε of aluminum is 0.05.

In order to determine the heat flux penetrating inside the robot, a simulation was carried out in the COMSOL program. For the outer surface, the heat transfer coefficient α = 3.75 W / m2K (9) was used due to the low speed of the robot's

movement. For the inner surface α = 20 (4) due to the forced air movement inside the robot. The results are presented in Fig. 1.

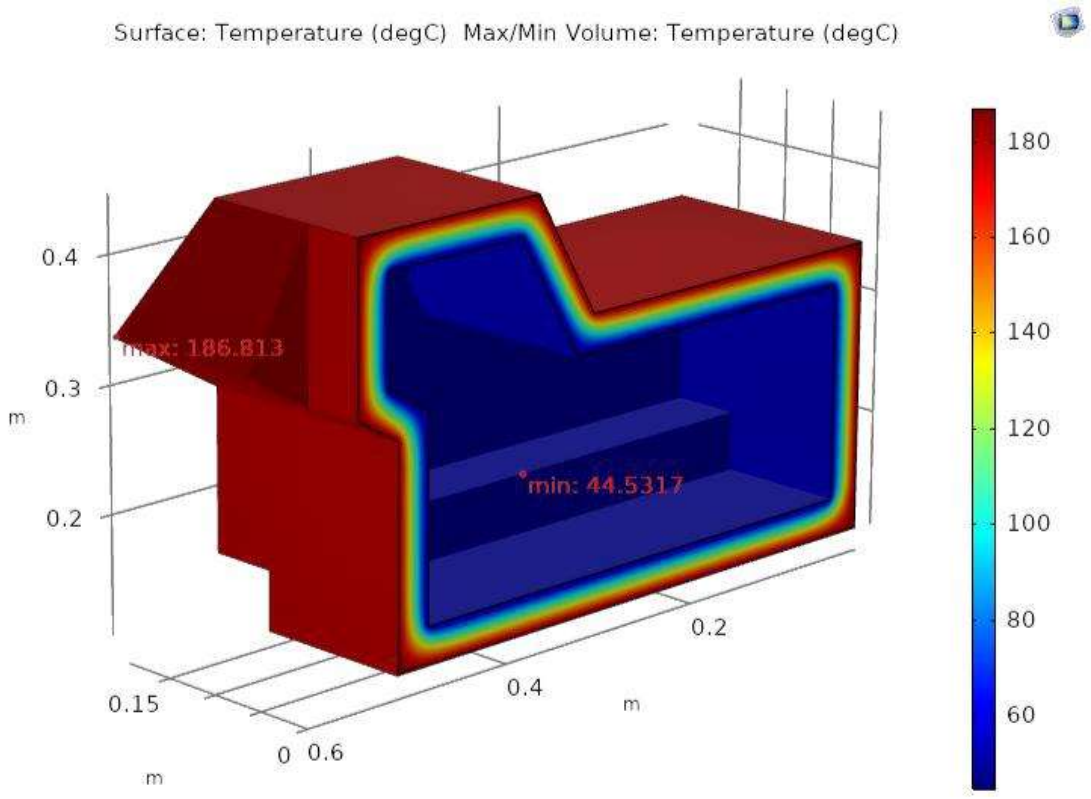


Fig. 1. Temperature distribution for the insulation cross-section

The determined heat flux penetrating inside the robot is Qz = 66W. Due to the use of multi-layer insulation, the temperature of the robot's surface is lower than the ambient temperature, while the temperature of the internal surface is lower than the temperature of the air inside.

Due to the high thermal conductivity of aluminum, the temperature distribution on the surfaces is equal. It is particularly important inside the robot, where the surface is in close contact with electrical systems.

Long-term operation of the robot in a high temperature environment requires a cooling system. The general principle of cooling is to collect excess heat energy from the cooled object and discharge it outside the system, most often to the environment. Most cooling systems are based on this principle. By using physical phenomena such as the Peltier effect, pressure fluctuation and condensation, the adsorption process and others, it is possible to obtain a temperature lower than the environment to which the thermal energy is dissipated. However, there are no

compact solutions that can take advantage of these phenomena with a temperature difference of 160 ° C between the inside of the robot and its surroundings.

Another solution is to store excess heat energy in a removable heat store. After reaching the storage capacity limit, it is replaced and the robot continues to work. The temperature in the interior is equalized by the forced air circulation provided by the fans. The electronics are moved away from the inner surface by plastic spacers to ensure good air circulation.

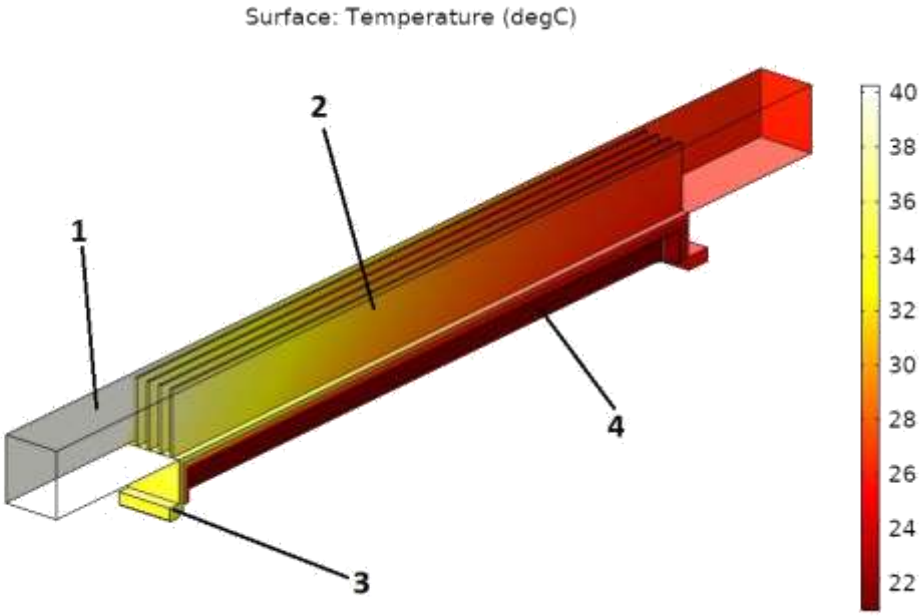


Fig. 2. Simulation of energy absorption by heat storage. 1 - air tunnel, 2 aluminum heat sink fins, 3 - aluminum container, 4 - PCM material

A simulation was carried out to check the operation of the cooling system. The purpose of the simulation was to determine the actual speed for which the required heat exchange takes place. For the gap between the fins of the heat sink of 3 mm, and the minimum speed determined, the Reynolds number was obtained = 223, which means laminar flow. Due to the repeating arrangement of the heat sinks and PCM chambers, a single sector consisting of one chamber and 4 heat sink fins was simulated as shown on Fig. 2.

5. Summary

This paper presents the important problems of designing a four-wheeled mobile robot intended for inspection in high temperature environments.

Preparation and development of a fully functional system design requires an interdisciplinary approach and the use of knowledge from various fields of science, such as: strength of materials, thermodynamics, electronics and programming. In the design process, certain technological assumptions should be taken into account, while taking into account the limitations resulting from the characteristics of the target workplace. The device designed as a result can be considered a relatively innovative solution, characterized by a highly personalized specification due to the strict dependence of the technical parameters of the device on the requirements imposed by its operating environment. One of such conditions is undoubtedly high temperature, the requirement of which resulted not only in the implementation of one of the title features of the designed device, but also limited the selection of other elements, such as the construction material of the robot body or the method of transmission. By adapting the mechanical structure to new tasks or a slightly different working environment, it is possible to expand the functionality of the robot. The system can be perfect for measuring structures that are unilaterally accessible with similar characteristics, such as:

- ship hulls
- pipes
- pipelines
- tank walls
- cisterns
- industrial structures

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$BaTiO_3$-DOPED PVP NANOFIBERS FABRICATED BY ELECTROSPINNING METHOD

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DOI: 10.31891/monograph/2021-10-54

Abstract

The article describes the method of electrospinning from solutions to obtain composite PVP/$BaTiO_3$ nanofibers, using two different parameters of the solution flow velocity through the nozzle of the device. Then, the obtained one-dimensional nanostructures were subjected to morphology and chemical composition analysis using a scanning electron microscope (SEM) and X-ray dispersion spectroscopy. Moreover, in order to investigate the optical properties of the obtained fibrous mats, UV/Vis spectrophotoscopic tests were performed and the influence of the reinforcing phase of $BaTiO_3$ nanoparticles on the optical properties of the polymer matrix was determined.

1. Introduction

Constantly developing and growing industry results in new problems and challenges that require appropriate and immediate solutions. Huge heat losses and CO_2 emissions prompts us to look for methods of better management of the energy used, e.g. heat losses, but also the use of geothermal, volcanic and solar energy sources that exist in nature. The already existing thermoelectric generators, however, require a constant spatial temperature gradient for proper operation, which is rare in the present environment [7]. In order to save energy, it also goes in a different direction, e.g. alternative energy generation methods for electrical devices and sensors that could be embedded in clothing [8]. Another problem encountered in the literature is the production of intelligent materials, i.e. materials whose properties can be regulated by external stimuli such as: pressure, temperature, pH, humidity, electric or magnetic field, chemical compounds or electromagnetic radiation [2].

Appropriate nanomaterials could be a solution to the above problems. They are characterized by exceptional physical and chemical properties, a smaller size and a larger surface-to-volume ratio (especially important in sensors industry) [1,2]. For heat processing, you can use, among others pyroelectric generators, requiring only temperature oscillation to convert heat into electricity [7]. Piezoelectric nanogenerators (PENG) and triboelectric nanogenerators (TENG) are a potential source of power supply for electrical devices [8].

One particular type of nanomaterials that deserve consideration are one-dimensional materials, which include, inter alia, nanofibers, nanorods, nanotubes and nanowires [1]. They are light materials with a continuous structure (which is important for the operation of sensors) and a large specific surface [2]. They can also be a building material for the production of complex structures in nanotechnology [9]. An additional advantage of these materials is that they can be functionalized [2]. One potential additive is metal oxides with a perovskite structure. They are often used in electronics due to their ferroelectricity, pyroelectricity and piezoelectricity. They include, among others $BaTiO_3$ or Pb(Zr, Ti)O_3. Ferroelectrics are materials that exhibit spontaneous polarization without an externally applied electric field and whose polarization can be reversed and oriented towards the applied field. Stable polarization of ferroelectrics can be used to generate 0-1 digital signals, which are the basis of logic circuits and memory [9].

Barium titanate ($BaTiO_3$) is a material that exhibits very good ferroelectric, piezoelectric and pyroelectric properties, and is also characterized by high electrical permeability and low dielectric losses. Due to its properties, it is used for the production of memories (e.g. non-volatile random access memories), capacitors (e.g. multi-layer ceramic capacitors), thermistors (e.g. PTCR), sensors, actuators and various optoelectronic devices. $BaTiO_3$ in the form of spheres or fibers is also used as a filler for polymer composites in order to increase their dielectric properties [1,7].

One-dimensional materials can be produced by many methods [2,7]. They include, among others template synthesis or molecular self-organization methods. However, these methods are associated with a complicated processes and high costs [2]. The currently preferred technique is electrospinning, which is simple, convenient and low-cost [1,2]. With its help, it is possible to produce fibers with a

polymer, ceramic or composite structure, showing a relatively uniform diameters [1,2,7].

Electrospinning uses an electric charge to pull threads from drops of polymer solutions or their alloys. The material is fed through a special needle, which is part of the spinning nozzle. Due to the electrostatic force, the drop is deformed and turns into a stream contained in a space with a conical structure, called the Taylor cone. It happens when the appropriate voltage value is exceeded. During the extraction process, the fibers are lengthened and thinned, as well as torn, and finally collected on a special collector, most often in the form of non-woven mats. The average diameter of the fibers is less than 1 μm, however, by appropriate selection of parameters, it is possible to obtain a diameter of the fibers in the order of tens of nanometers. The most important parameters are the voltage between the nozzle and the collector and the solution flow rate. An important factor is also the viscosity of the administered solution and the binding degree of the polymer contained in it [1.9].

The production of fibers is often associated with the sol-gel method [1]. It is a method of polymerizing mixed inorganic precursors. It allows the production of multi-component materials at lower temperatures than would be possible using traditional synthesis methods. The sol-gel method allows the production of glasses, ceramics, coatings or fibers straight from the solution without the need to use powdered substrates [3]. This method can also be used to produce compounds such as $BaTiO_3$ [1].

2. Materials and Methods

The following were used for the production of composite nanofibers: ethanol (C_2H_5OH, purity of: 99,8%), nanoparticles of barium titanate ($BaTiO_3$) and polyvinylpyrrolidone (PVP, Mw=1 500 000 g/mole). PVP (1.78 g) was added to ethyl alcohol (25 ml). The ingredients were mixed at room temperature for 24 h using a magnetic stirrer. Barium titanate (1.78 g) was then added to the solution and stirred for another day. The obtained solution was used to produce nanocomposite fibers using the FLOW - Nanotechnology Solutions Electrospinner 2.2.0-500 device. The distance of the nozzle from the substrate was set at 15 cm, and the potential difference between the nozzle and the collector at 18 kV. The

samples were prepared for two different solution flow rates: 1 and 3 ml/h. Upon completion, the samples were left in the air to evaporate the solvent for 24 h.

In order to examine the topography and chemical composition of the produced samples, a scanning electron microscope [Zeiss Supra 35] was used with an EDX spectrometer [Trident XM4 Series], while spectrophotometric tests were carried out on a Thermo-Scientific UV/VIS Evolution 220 spectrometer. $BaTiO_3$ and fibers using respectively 60 and 100 measurements per image. Based on the results, the mean value of the dimensions were calculated, and the chemical composition was determined by means of EDX. The UV-Vis analysis was also carried out by examining the absorbance of the produced materials as a function of wavelength. Based on the results, the absorption edge was determined.

3. Results and Discussion

Scanning electron microscope tests carried out showed that the produced $BaTiO_3$ particles were evenly distributed, but they tended to agglomerate. The particles were spherical in shape and their diameter did not exceed 16 μm (Fig. 1 a, b, c). The calculated mean particle diameter value was 2.034 μm.

Fibers produced at the solution flow rate of 1 ml/h and 3 ml/h were also analyzed with the use of SEM (Fig. 2 a, b). The fibers along their length maintained a uniform value of diameters and showed equal structure. The mean diameter value for both flow rates was determined. These values were respectively: 222.6 and 135.4 nm.

An analysis of the optical properties of the produced composite nanofibers was carried out, the results of which were presented in the form of a graph of absorbance as a function of electromagnetic radiation wavelengths in the range of 200-1100 nm (Fig. 3 a). Absorption maxima were determined using quadratic regression [Fig. 3 b, c], calculating the maximum at 265 and 255 nm for the samples produced with the solution flow rates respecctively 1 and 3 ml/h, which is similar to the results presented in [5,6]. Comparing the spectra of the above samples, it can be stated that they are very similar to each other. There was also a 0.5 greater absorbance in visible and infrared for the sample produced at 3 ml/h versus 1 ml/h, probably due to the greater thickness of the sample.

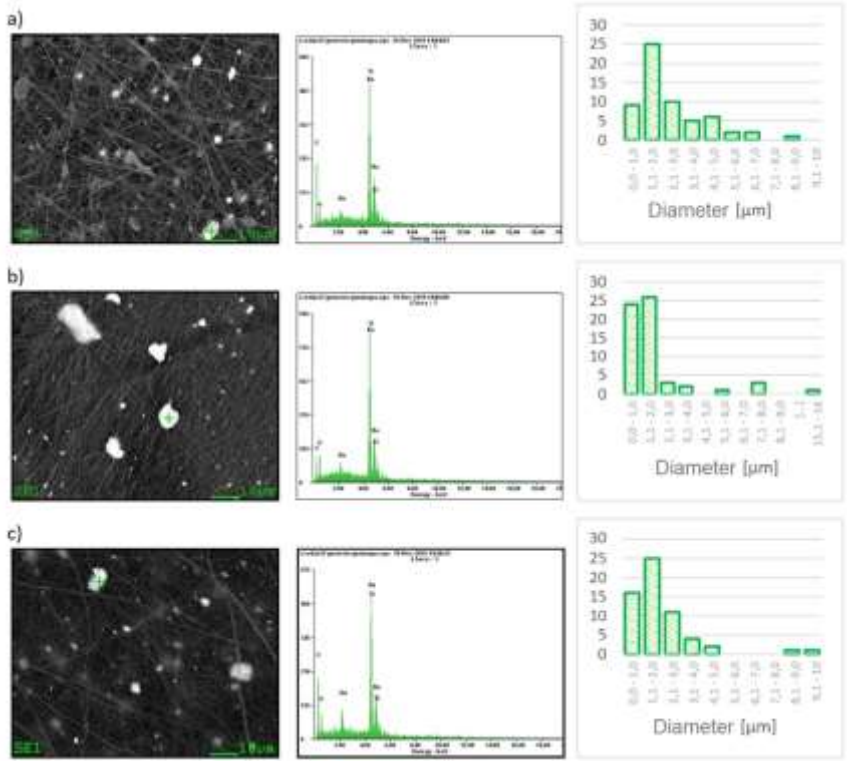


Fig. 1. SEM images of the obtained PVP/$BaTiO_3$ nanofibers, EDS analysis of chemical composition and histograms showing distribution of nanoparticles diameters.

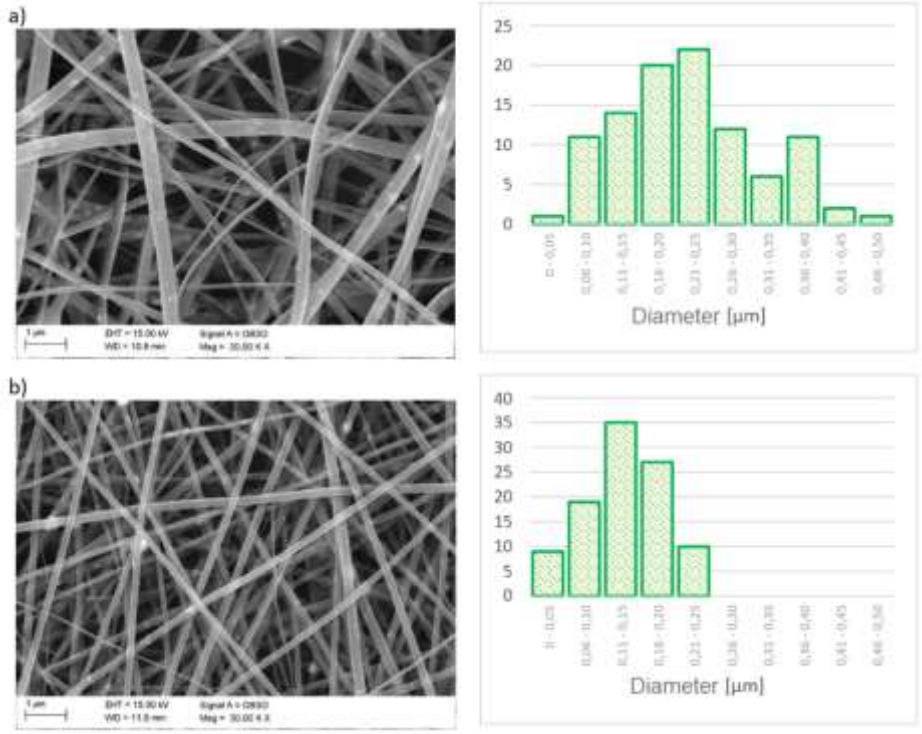


Fig. 2. SEM images of the obtained composite nanofibers and histograms showing the distribution of average diameters of one-dimensional nanomaterials: a) with flow rate of 1 ml/h and b) 3 ml/h

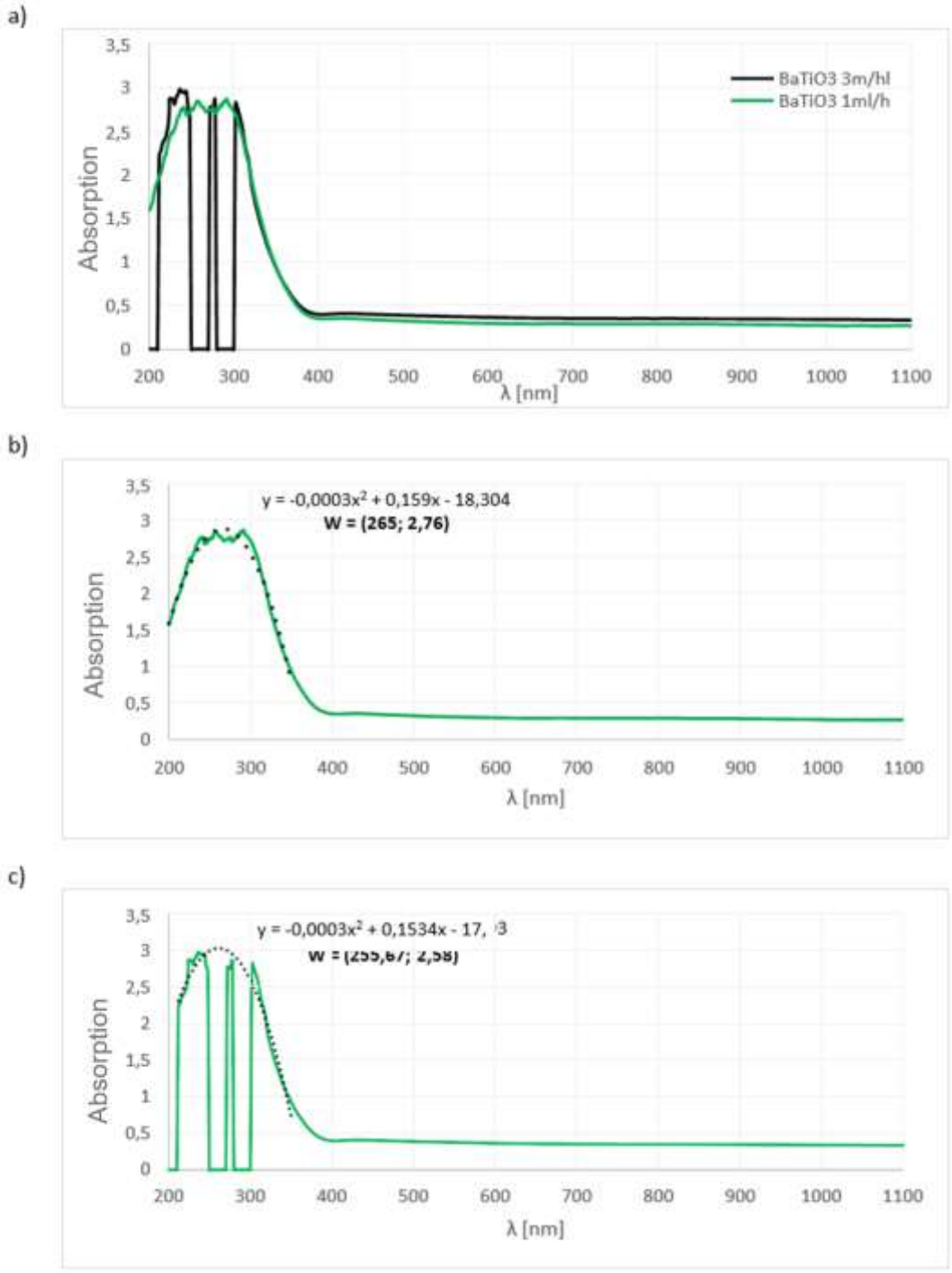


Fig. 3. Absorption spectras of the PVP/$BaTiO_3$ nanofibers using two different solution flow rates of 1 ml/h and 3 ml/h.

4. Conclusions

This paper presents the process of producing PVP matrix composite nanofibers containing $BaTiO_3$ particles using the electrospinning method. The fibers produced in this way were examined with a UV-Vis spectrophotometer and a scanning electron microscope. The study of optical properties was carried out in

the form of absorbance analysis as a function of wavelength in the range of 200-1100 nm, showing the edge of absorption in the near ultraviolet. Examination of the chemical composition confirmed the presence of $BaTiO_3$ particles in the composite. The analysis of the morphology of the samples showed a homogeneous structure of the fibers with a uniform distribution of particles, however, it also showed the presence of agglomerates of this nanoadditives. Agglomeration probably resulted from the simultaneous addition of polymer and nanoparticles to the solvent in the process of preparing the mixture. The particle size was less than 16 μm and the calculated mean value for the size was 2.034 μm. The average value of the fiber diameters differed depending on the spinning solution flow rate and was 222.6 nm for the flow rate of 1 ml/h and 135.4 nm for the speed of 3 ml/h. Summarizing the above properties, the produced nanofibers could be used, inter alia, in in electronic devices, capacitors or UV radiation sensors.

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AUTOMATIC CONTROL SYSTEM FOR THIN POLYMER APPLICATION DEVICES WITH EVALUATION OF QUALITY AND ECONOMIC EFFICIENCY OF COATING

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DOI: 10.31891/monograph/2021-10-55

1. Introduction

When analyzing the operation of such systems [1, 2, 3], face the problem of assessing qualitative and specific factors that occur in transient processes and depend on a number of variable characteristics and properties that depend not only on equipment but also on product characteristics. Existing deterministic approaches using accurate characteristics of objects, processes, accurate methods of modeling and decision-making and optimization procedures do not take into account these factors, so they can not be successfully used in assessing real processes [4, 5].

Problem measurement of geometrical parameters such as the profile of products often occurs in instrumentation industries. However, the standard equipment that can be used to solve this problem is in most cases a contact-mechanical and in the testing of small thickness can lead to damage. In this regard, considerable interest is the non-contact measurement methods complex shapes without damaging the surface.

Equipment performs manufacturing operations with certain accuracy. Therefore, determining the quality of the final result is always important. Especially then we consider the process of polymer coatings on parts of light industry.

The complexity of the process is in need of constant thickness control layer polymer is applied. Surface roughness of parts of light industry also strongly influences the technology application and requires equipment such work that provides uniform coverage at irregular profile. [6, 7].

In the apparel industry, handle, flexibility and drape are of major importance, but durability to flexing and to washing are also important. The problem arises, therefore, of finding the best method and adhesive materials for a durable bond and applying them in a controlled manner to maintain the fabric flexibility and aesthetics during the lamination process. For a bond of high strength, it is

generally necessary for the adhesive to penetrate the material and to cover the widest possible surface area. The challenge is to select the best adhesive and application process which has the least effect on the substrate aesthetics. Ideally, the least amount of a highly effective adhesive should be applied. Too much adhesive is a waste of resources and likely to lead to fabric stiffening and it could also result in thermal discomfort in the garment, because the adhesive itself could form an impermeable barrier to perspiration. This factor is especially important when waterproof breathable fabrics are being prepared by lamination of a membrane to a fabric. It is usual to apply the adhesive – hot melt powder or moisture curing polyurethanes – in dot or discontinuous form, as will be described below. The use of hot melt adhesives in film form would considerably reduce the breathability of the membrane and cause stiffening. Even with discontinuous methods of adhesive application, it has been estimated that the adhesive can cover up to 20% of the surface area of the breathable membrane and may thus have a significant effect on breathability. [10, 11]

Typology of knowledge

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The appropriate decision in the technical fields should be based on the criteria for assessing the economic efficiency of facilities and processes at the time of their study [15]. These studies reveal that the objects have a certain state and characteristics at a certain point in time and are characterized by mechanical

characteristics such as wear, porosity, surface roughness [16, 17, 18]. For a full assessment, the consumption of energy resources and polymeric materials used using systems theory and systems analysis, statistical physics, polymer physical chemistry, metal electrochemistry, numerical methods, and the basics of the theory of algorithms and programs must be taken into account [19, 20].

The problem is solved by obtaining current data from the surface profile of the product and data from the applied polymer layer, which are compared for further adjustment of the feed rate, which is variable with the possibility of dynamic adjustment of feed rate and shutdown while calculating the cost of materials and energy [15, 16].

Analytical research

Method for assessing the quality and cost-effectiveness of applying a polymer coating on products shows in Figure 1. In the technological operation there is a process of feeding the product 1, which will be applied to the polymer coating 2 by means of the device 3. The initial speed of movement and the amount of polymer material to be applied are set. The speed is set by the device 4. The sensor 5 performs preliminary measurements of the thickness of the product until application. After applying the polymer layer 2 on the material 1, the device 3 measures the thickness of the obtained product by the sensor 6. Data from the sensor 5 and the sensor 6 is transmitted to a computer 7, which evaluates the application equipment 3, determines the cost of polymer 2. The algorithm is presented figure 2. In addition to entering data on polymer consumption, the computer controls the device 4, namely, when the deviation from the allowable thickness of the polymer coating is accelerating or slowing down the movement of the product 1. In the absence of product 1 at the technological position, or at the end of the application the computer 7 switches off the device 3 and stops the supply of polymer, which leads to its efficient use. The switching device 4 is also switched off, which saves energy. The obtained cost data are formed in the appropriate tables with a simultaneous assessment of the quality of the coating throughout the application path. When installing a new product, the process of applying a polymer coating on the product may be repeated.

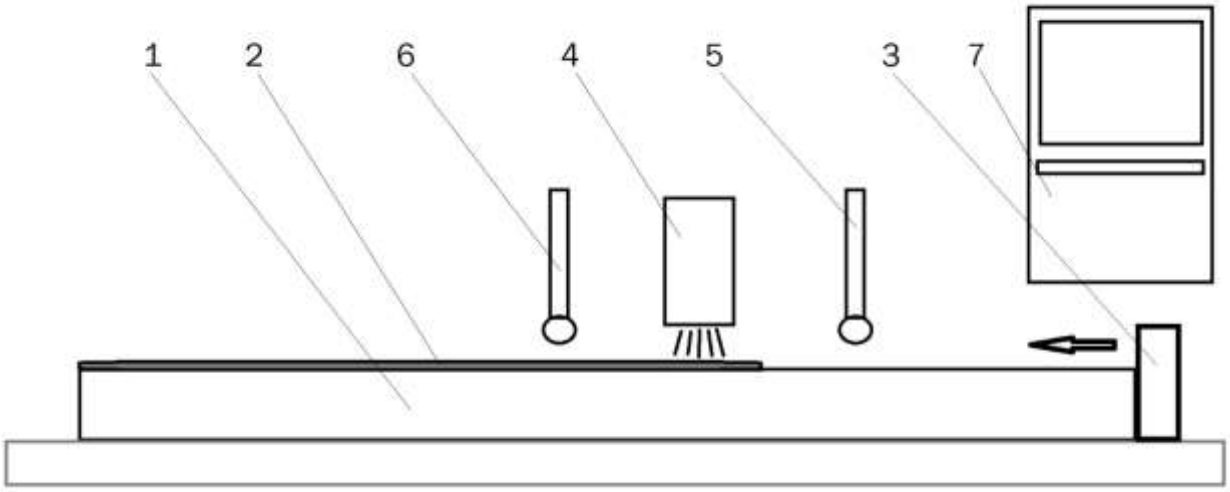


Fig.1. Method for assessing the quality and cost-effectiveness of applying a polymer coating on products

One of the main controls of the thickness of the surface layer of the polymer is to assess the response of the signal reflected from surfaces. The last time an increasing use of laser beams. To measure the signal and its estimation we use PE LabView. Designed by the help of a virtual appliance will enable control surface condition applied in real time. One way of solving this problem is the use of laser distance sensors.The parameters of the laser and features of software to control device was developed for measuring the profile of a layer of the coating.

The developed control device profile by using triangulation laser sensor distance measured during the scanning process layers height of the points. It controlled profile relative to the base of the sensor.

The sensor includes a semiconductor laser for generating radiation in the visible range, which is focused by a lens controllable item. The device also includes a reception sensor optics forming on image of the spot light scattered by the workpiece and the microcontroller can handle data and sends them to the output connector.

Obviously, in the design and development of devices of this type without the computer control of their work and the computer processing of the measurement results is indispensable. This problem can be solved in different ways, will best meet the specified requirements LabView programming environment and technology corporation National Instruments.

Using LabView, a block diagram of frequency converter control and electrical readings was developed. This block diagram is shown in Figure 2.

The principle of operation of the block diagram. The signal coming from the galvanic isolation on the ADC is input to the block diagram by means of the signal input unit 1. Using the calibration unit 3 set the voltage frequency. Next, the signal is delimited by the distributor 2 and then displayed on the graphs 4. All values are written to files using the recording unit 5 when you press the button 6 (record). Use button 7 to enable writing to the next file. For clarity of results of carrying out experiments values of two signals are also deduced on the graph 8. By means of the button 9 there is a program stop.

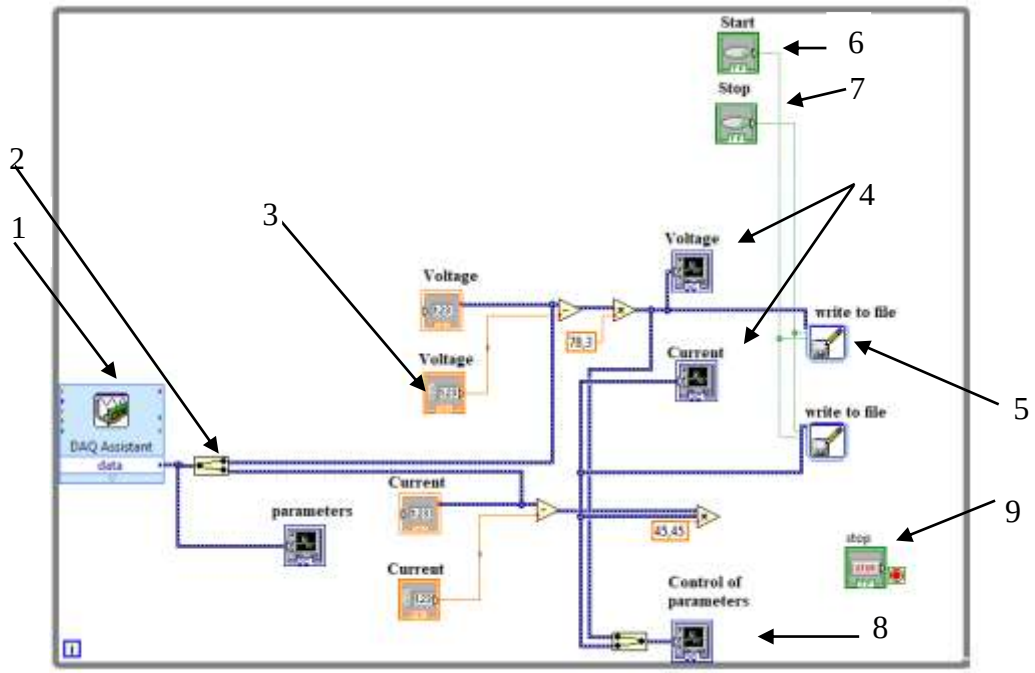


Fig.2. Block diagram of the LabView virtual device for frequency conversion control

In this regard, we have the basis for the creation of software controlling motors of device. Namely, the we have upper and lower boundary layer thickness. In the event of rejection system gives the value of error and stops the process.

Summary

Software for control prosess was developed, has significantly accelerate the process of non-destructive testing of parts with complex profile and improve the accuracy of such control. Features of the software that is based on LabView, provide enough high level of comfort in the operator and easy access to the various options of the equipment.

Thus, this method allows you to assess the quality of the polymer coating during its formation on the surface of the product, to estimate the total cost of the polymer for each product and to save resources. The obtained cost data are summarized in tables that can be easily processed in the future. This system helps not only to control the quality, but also to provide an estimate of the cost of technological operation for each product.

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DESIGN METHODS FOR REDUCTION OF FORCED VIBRATIONS OF HORIZONTAL ROTARY MACHINES

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DOI: 10.31891/monograph/2021-10-56

1. Introduction

Rotary mechanisms are used in many areas of modern industry, from mechanical engineering to computer and household appliances. Since these mechanisms often have to operate at high speeds, strong vibrations caused by the rotor's center of gravity shift can become a serious problem and even lead to damage to the mechanism. The issues of reducing vibration excited by rotating rotors are among the most important in the design, manufacture and operation of almost all types of modern rotary machines.

The washing machine as an object of study of dynamics and reduction of vibrations and noise is of particular interest due to the constant presence of randomly located and wandering imbalance of laundry in the drum and low requirements for the accuracy of its manufacture and assembly of parts and assemblies so as not to increase the cost.

2. Literature Review

The solution of problems related to the problems of reducing rotor vibration is based on the linear theory of mechanical vibrations. The theory also indicates the main directions of the fight against vibration: vibration isolation [1]; damping [2]; dynamic vibration damping [3]; improvement of methods for balancing rotors [4], including taking into account their flexibility [5]. Many papers investigate electromagnetic balancing devices in the form of electromagnetic bearings [6] and electromagnetic rings [7]. A synchronous radial force can be applied to the shaft to balance the imbalance [8]. Methods of optimal vibration control are widely used [9]. Most of the scientific robots are devoted to the study of the phenomenon of passive automatic balancing using ball, pendulum autobalancers [10] and due to the free movement of fluid.

Although researchers have recently made significant progress in developing active and passive methods and tools to reduce the vibration of washing machines, the level of unwanted vibration can also be reduced by the optimal layout of the components of the machine, which studies this work.

3. Vibration isolation system mathematical model

Consider the oscillations of an elastically suspended tub containing a cantilevered rotating unbalanced drum. Such a scheme is typical of machines with a horizontally located laundry tub, for example, "LG", "Electrolux", etc (Fig. 1, 2). The tub-drum system generally makes six-link oscillations.

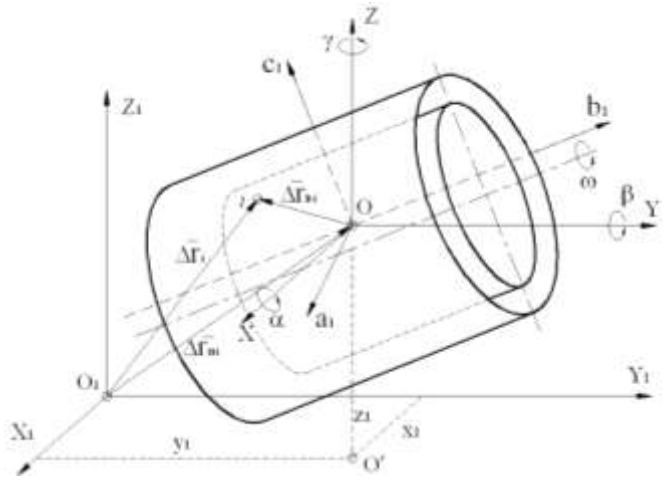


Fig. 1. Scheme of the tub-drum system

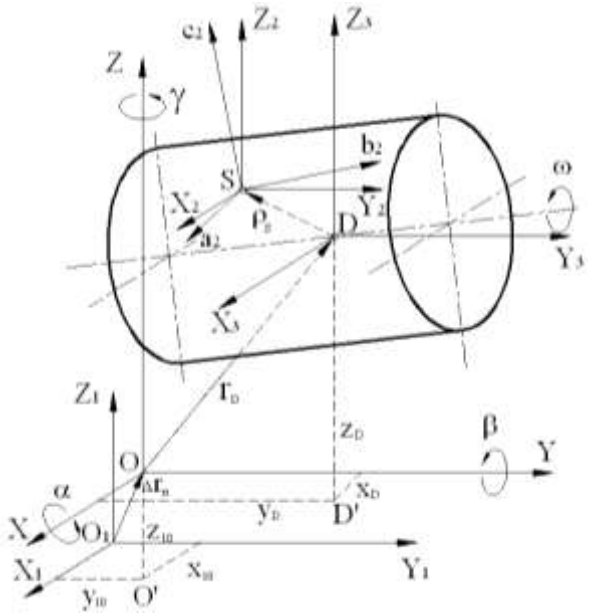


Fig. 2. Moving the drum in general

The system obtained by the authors of six differential equations in matrix form has the form:

$$\mathbf{M}\ddot{\mathbf{q}} + (\mathbf{G} + \mathbf{D})\dot{\mathbf{q}} + \mathbf{A}\mathbf{q} = \mathbf{Q}, \qquad (1)$$

where **M** is the matrix of inertial coefficients; **G** is the matrix of gyroscopic coefficients; **D** is the damping coefficient matrix; **A** is the stiffness matrix; $\mathbf{q} = \left[x, y, z, \alpha, \beta, \gamma\right]^T$ is the matrix-column of generalized coordinates; $\mathbf{Q} = \left[Q_x, Q_y, Q_z, Q_\alpha, Q_\beta, Q_\gamma\right]^T$ – is the matrix-column of generalized force factors.

4. Experimental verification

The efficiency, adequacy and accuracy of the developed mathematical model were checked by means of field tests. For this purpose, a laboratory stand containing a household washing machine was used). The theoretically calculated natural frequencies of the oscillating system of the washing machine differed from

the experimentally obtained no more than 10%. The calculated amplitude of vertical oscillations at an artificial imbalance of the drum 1800 g·mm was 3.7 mm, and experimentally measured at the same imbalance 4 mm.

5. Dynamic simulation and analysis

The verification of the formulated design requirements was performed by modeling the behavior of the suspended part of the washing machine using the interactive tool *Simulink*. The dynamic model of the machine is presented in fig. 3. The suspended part of the car is fastened by means of two springs and two dampers. The dynamic characteristics of the washing machine are presented in table 1. In practice, due to the random nature of the distribution of loaded laundry in the drum, the center of mass of the drum will always lie not on the axis of rotation. It is established that the greatest eccentricity during the decomposition of linen in the drum is $e = 0.08R_б$, were $R_б$ is the drum radius. For the studied model of the washing machine is accepted $e = 14{,}8$ мм.

In fig. 4 presents the Frequency response function (FRF), obtained for vertical oscillations of the suspended part of the washing machine, taking into account that the center of mass of the tub lies on the axis of rotation of the drum and the drum has only static imbalance, characterized by eccentricity e and $Q_y = Q_\alpha = Q_\beta = Q_\gamma = 0$, and $Q_x, Q_y \neq 0$. Due to the force perturbation along the axes *OX* and *OZ* there are transverse oscillations in the plane *XOZ*.

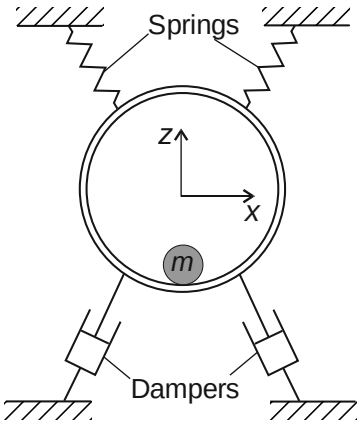


Fig. 3. Dynamic model of the washing machine

Table 1. Dynamic characteristics of the washing machine

Tub weight m_1, kg	48.2
Drum mass m_2, kg	12.5
Stiffness of each of the two suspension springs c, N/mm	6,0
The angle of the springs	75°
The damping factor of each damper h, N·s/m	175
The angle of the dampers	70°
Eccentricity e, мм	14,8
Drum length $L_б$, mm	190

Due to the random arrangement of the laundry, the center of mass of the

loaded drum in addition to the eccentricity may have a longitudinal displacement y_D along the axis *OY*, which causes a imbalance of the rotor. For values y_D =0...90 mm model was simulated in the entire operating frequency range. The increase in angular oscillations causes an increase in the displacement of the suspension part.

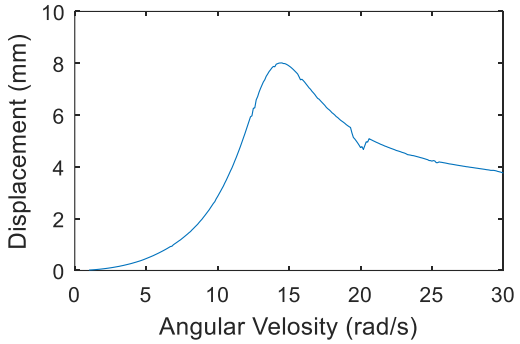


Fig. 4. FRF transverse oscillations in the direction of the *OZ* axis

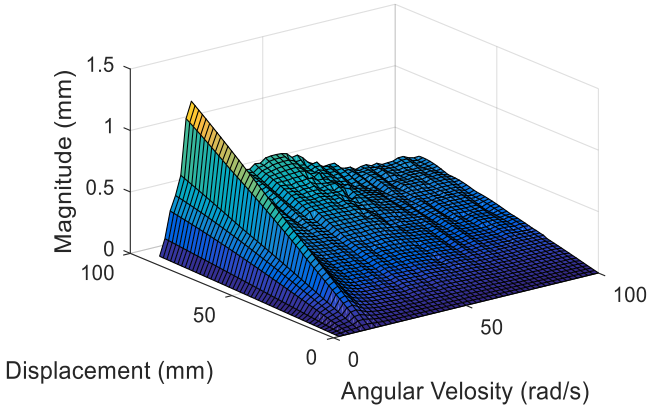


Fig. 5. The magnitude of oscillations in the longitudinal direction *OY*

In fig. 6 and 7 show the results of the simulation of the tub-drum system at different values of the deviation l_c of the position of the center of rigidity of the elastic supports of the suspended part from the center of gravity of the tub (vertical oscillations).

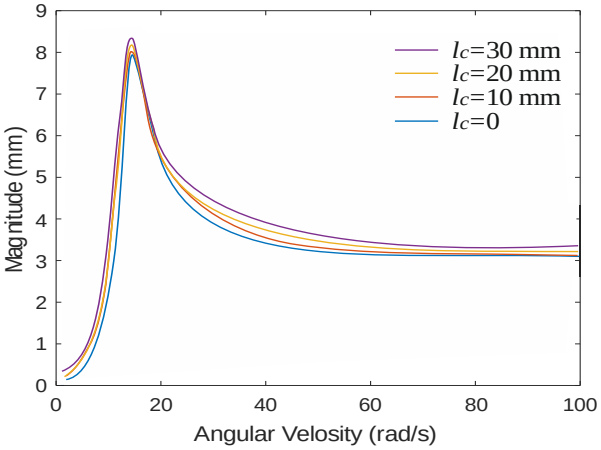


Fig. 6. FRF ($y_D = 0$)

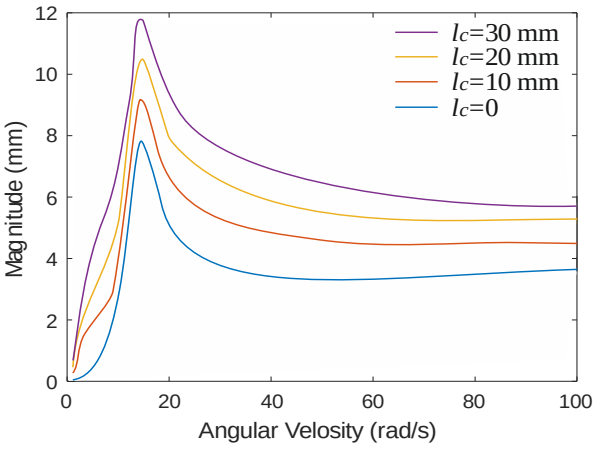


Рис. 7. FRF ($y_D = 90$ mm)

In the case of rotation of the elastic (damping) support at an angle φ relative to the plane *XOZ* the support system is non-uniformly rigid, and the stiffening matrix (damping) is non-diagonal. For the spring support of the tub with axial stiffness *C*, the relations are fulfilled

$$C = \sqrt{C_x^2 + C_y^2 + C_z^2}\,,\ C_x = C\cos\chi\cos\varphi,\ C_y = C\cos\chi\sin\varphi,\ C_z = C\sin\chi\cos\varphi,$$

were χ is the angle of the spring, φ is the angle of rotation of the spring relative to the plane *XOZ* (Fig. 8, 9).

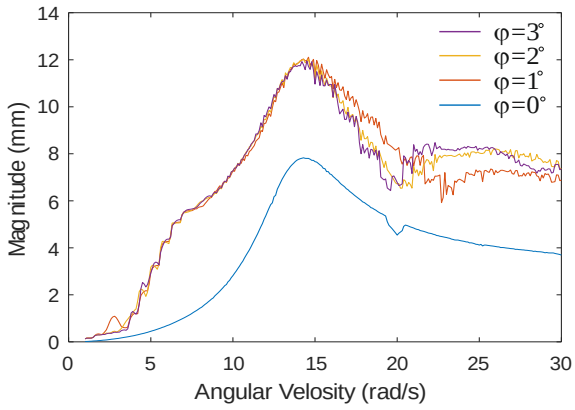


Рис. 8. FRF at $y_{D\max}$ for different angles φ of rotation of springs

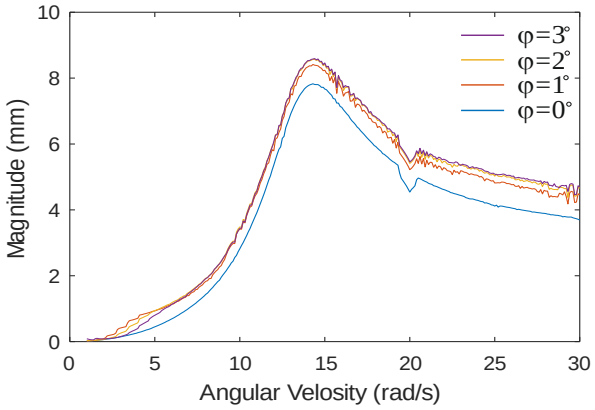


Fig. 9. FRF at $y_{D\max}$ for different angles φ of rotation of the damper

Liquid auto-balancing was used to reduce the vibrations of this machine. To do this, on the basis of mathematical modeling, we will consider the operation of an autobalancer of the Leblanc type.

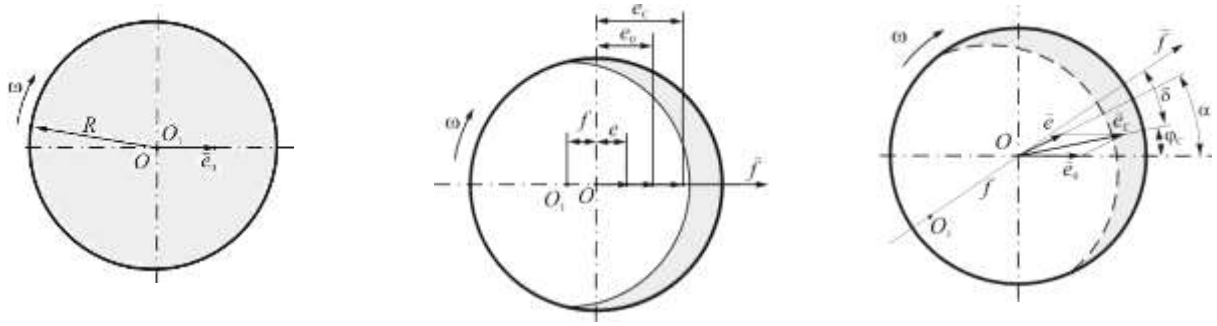
6. Physical content of fluid balancing

In the absence of an Automatic Balancing Device (ABD), the value of the system imbalance remains unchanged in magnitude and direction, and since there is a relationship between the deflection of the shaft, the magnitude of the imbalance and the angular velocity of rotation:

$$f = e_0\left(\omega / \omega_{кр}\right)^2\left(1-\left(\omega / \omega_{кр}\right)^2\right)^{-1}$$

then, obviously, with the increase of the angular velocity ω, the deflection f is continuously increases by subcritical rotation of the shaft.

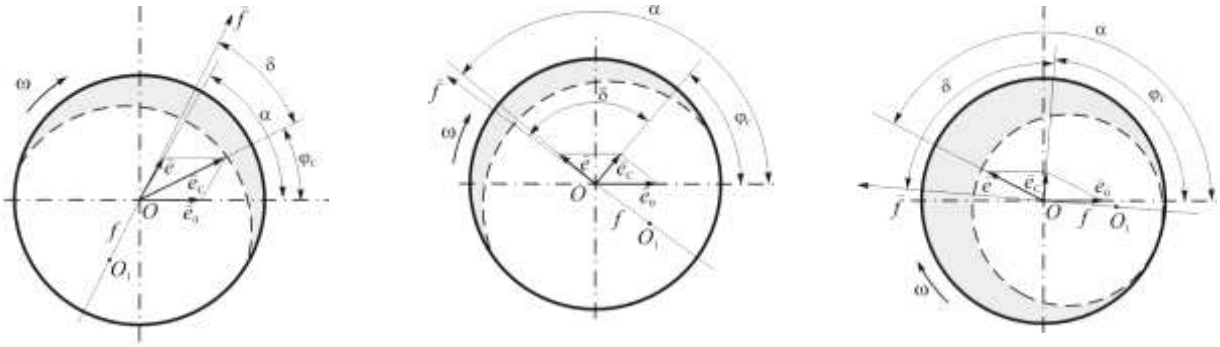
In the case of an ABD, the imbalance of the system $\bar{e}_c$ consists of a stationary imbalance created by the unbalance $\bar{e}_c$ of the shaft, and an imbalance created by the liquid $\bar{e}_c$. At ω =0, the liquid imbalance is zero (Fig. 10 a))



a) b) c)

Fig. 10. Vector model of process of auto-balance liquid

At the initial moment of rotation, the unbalance of the shaft results in a deflection f, which coincides in the direction with the rotor imbalance (Fig. 10 b)). The centrifugal forces reject fluid to the walls of the ABD and its bulk is concentrated in the deflection, as shown by the established law of pressure distribution in the liquid. With an increase in the speed of rotation of the rotor, the direction of the deflection begins to lag behind the direction of the imbalance at the angle δ (in the presence of fluid in the ABD chamber, the angle δ should be deducted from the total imbalance of the rotor) (Fig. 10 c)). The liquid tends to occupy the position at the furthest point from the axis of rotation, namely in the trough, and moves along with it from the imbalance. This in turn leads to a change in the total imbalance of the system in terms of direction and magnitude (increases as the value of the total imbalance is defined as the geometric sum of the vectors $\overline{e_0}$ and $\bar{e}$ and depends on the angle between these vectors α). This change leads to an increase in deflection, and an increase in the speed of rotation results in an increase in the angle δ. The fluid following the deflection changes the total imbalance by increasing the angle α and decreasing the total imbalance (Fig. 11 d). That in turn leads to a decrease in the value of the deflection. Consequently, with an increase in the speed of rotation due to the decrease e_C, we have a decrease in the deflection by magnitude even in the subcritical rotor rotation mode. Because $tg\delta = 2n\omega\left(\omega_{res}^2 - \omega^2\right)^{-1}$ then when the speed of rotation approaches the critical δ, it increases and goes to 90 °.



d). e) f)

Fig. 11. Vector model of autobalancing process (continued)

Because δ is the angle between the deflection and the total imbalance, and φ_C is the angle between the stationary and total imbalances, the angle between the deflection and the stationary imbalance when rotating the rotor with the angular velocity is equal to $90° + \varphi_C$ (Fig. 12). In the case where the stationary imbalance and the imbalance created by the liquid are equal to the magnitude of $e_0=e$, then φ_C will be approximately equal to δ (Fig. 13). And so the angle between the deflection and the stationary imbalance will be directed to 180 °.

With a further increase in angular velocity, a balanced system is rotated without changing the relative position of the liquid and stationary imbalance.

With a small imbalance created by the liquid $e<<e_0$, the total imbalance of the system will mainly be determined by the magnitude and direction of the stationary imbalance and will not change significantly with the increase of the angle δ (Fig. 13). Consequently, the size of the deflection of the shaft, due to the total imbalance of the rotor, will not be significantly reduced.

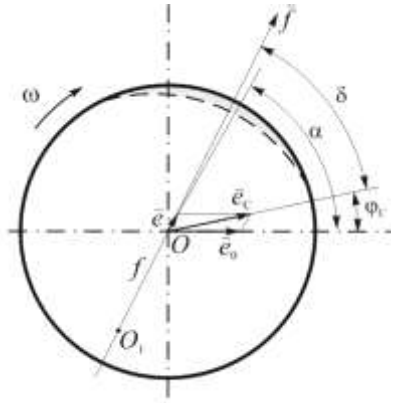


Fig. 12. Vector model of autobalancing process (continued)

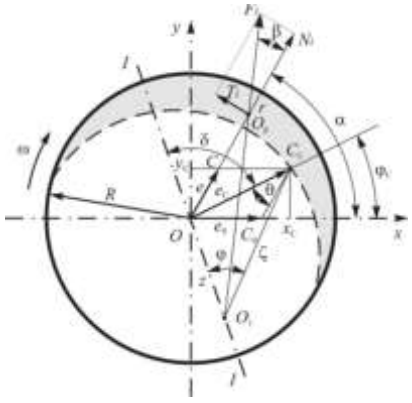


Fig. 13. Forces acting in the SBD in the presence of resistance

The basic idea is that at rotation velocity of the system $\omega < \omega_{rot}$ external resistance (friction forces in bearings, friction forces of cylinder against the air etc.) conditions bend plane (I-I) delay against total imbalance plane (OC_c) for the phase angle δ (Fig. 13) and appearing in this condition tangential force T of centrifugal inertial force F, and specific properties of liquid (fluidity, ability of any liquid volume to freely change its shape being forced by irrespectively low force, viscosity forces are considered only for quite fast motion when liquid displacements change quite fast) enable drawing liquid in ABU chamber to position that reduces the total imbalance of the system even at pre-critical rotation velocity. Analysis of geometric model (Fig. 13) shows that when external resistance is sufficient liquid that is in stable balance can balance rotor at pre-critical angular velocity. It will be shown analytically.

Total rotor eccentricity with liquid is defined as:

$$e_c = \sqrt{x_c^{\,2} + y_c^{\,2}} = e\sqrt{1 + 2k\cos\alpha + k^2}.$$

where $k = D_0 D^{-1}$ – relation of rotor and liquid imbalance.

Analysis of geometric model (fig. 15) shows that balance condition that doesn't take into account tension forces is missing tangential force:
either tg β=0, or

$$f\left[tg\alpha\cos\left(\delta+\phi_c\right)-\sin\left(\delta+\phi_c\right)\right]=0.$$

The last equation is decomposed into two conditions (zero index corresponds to angles for liquid balance (β = 0)):

$$f = 0; \qquad (2\text{ a})$$

$$tg\alpha_0\cos\left(\delta+\phi_{0c}\right)-\sin\left(\delta+\phi_{0c}\right)=0. \qquad (2\text{ b})$$

Condition (2 a) corresponds to no deflection condition that contradicts condition of the problem of elastically strained rotor. If liquid is in balance

$$tg\alpha_0 = tg\left(\delta+\phi_{0c}\right)$$

what comes from condition (2 b).

Taking into account values of e, e/e_0, e_c and $\theta = \alpha - \varphi_c$

$$\sin\alpha_0 = k^{-1}\sin\delta\sqrt{1+2k\cos\alpha_0+k^2}\,. \qquad (3)$$

It appears from equation (3) that if external resistance is missing in the system ($\delta = 0$, $k \neq 0$) liquid balance coincides by the angle with rotor imbalance ($\alpha = 0$), what is approved by the conclusion that liquid increases imbalance in system without external damping.

The expression for angle α_0 corresponding liquid balance ($\beta = 0$) is obtained through algebraic transformations of expression (3) when $\delta \neq 0$, $k \neq 0$:

$$\alpha_0 = \pi - \arccos\left(\sin^2\delta + \sqrt{\left(\sin^2\delta - 1\right)\cdot\left(\sin^2\delta - k^2\right)}\right). \qquad (4)$$

Analyzing expression (4) gives positive arccosine argument and that's why even in pre-critical frequency of the rotor when $\delta \in \left(0, \frac{\pi}{2}\right)$ angle $\alpha_0 \in \left(\frac{\pi}{2}, \pi\right)$.

Effectiveness of balancing is characterized by relation of misalignment with rotational axis of mass center of the system with liquid and without it λ_0:

$$\lambda_0 = \frac{\sqrt{1+2k\cos\alpha_0+k^2}}{k}; \qquad (5)$$

if $1+2k\cos\alpha_0+k^2 = 0$ balance will be complete, therefrom the only solution will be $k = 1$ if $\cos\alpha_0 = -1$, and if $\alpha_0 = \pi$. Hence, the greatest balancing effect will be reached when imbalance of liquid that is involved into balancing is close to initial imbalance of the rotor ($k \approx 1$). Liquid which takes part in balancing makes concentric circles what has no influence on total imbalance of the system.

Expressions (3) and (5) contain relations of angular velocity to critical one, external resistance factor, relation of initial imbalance to liquid imbalance and relative dimensions of ABU. Obtained analytical relationships between these parameters allow solving applied problems to select optimal parameters of liquid ABU for particular rotor system, find effect of varying parameters of the system

rotor – ABD – liquid on effectiveness of balancing. Theoretical results were proved by experimental researches.

Created plant allowed to make experimental researches of self-balancing of the rotor with horizontal rotation axis and to observe fluid behavior in ABD. Research of self-balancing process and fluid behavior in ABD were made on described plant with using next special devices: inductive sensor, marker of turns; - ADC (analog-to-digital converter); - Notebook computer.

By filling in each camera of ABD with 10 ml of water, without changing position or mass of imbalance, the plant was turned on again. Rotor vibrations were recorded on computer in text file in conditions of smooth rotor acceleration from 0 to 2000 rpm. Simultaneously were made video record of fluid behavior in ABD. FRF of rotor when passing through resonance are illustrated on Fig. 14.

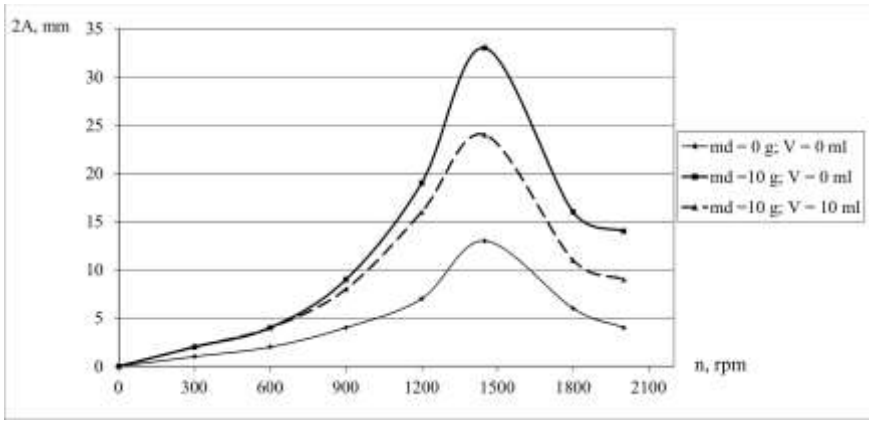


Fig. 14. Frequency response function

7. Conclusions

Theoretically, the basic requirements for the layout of washing machines were obtained and experimentally confirmed. It is proposed to implement it using liquid automatic balancing of the rotor.

The results of experimental and theoretical research of fluid behavior in passive self-balancing devices, which are installed in rotors with horizontal rotation axes when passing the resonance, are given in this article. Received relations showed that automatic balancing by fluid is effective for elastically deformed rotors or (and) rotor on elastic supports, where exists the difference in phases between the direction of centrifugal force and flexure (or movement) of the rotor. As experimental results showed, this difference in phases occurs when rotor reaches resonance speed and increases up to 180º when passing the resonance. In this case the tangential force occurs, under the influence of which the fluid moves to the side of flexure, opposite to imbalance, and further equilibration of the rotor already at resonance rotation frequency.

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DETERMINATION OF BULK DENSITY OF MIXTURES OF FRACTIONS OF CRUSHED POLYMERIC MATERIALS

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DOI: 10.31891/monograph/2021-10-57

1. Introduction

The purpose of the experimental study is to obtain the dependences of bulk density on the fractional composition of the crushed material.

Bulk density or bulk density of bulk material $\rho_н$ is called the mass of material that is per unit volume occupied by it. The value of $\rho_н$ is used in determining the required volume of hoppers, crushers, mixers in the calculation of energy consumption for the processing of bulk material [1, 2]. The bulk density of bulk material depends on the size of its constituent particles, their average density, humidity, the density of the particles in the layer [3, 4]. It does not remain constant even at rest of loose material. Under the influence of vibrations of walls of a vessel loose material in due course is condensed and its bulk density reaches some limiting value $\rho_{\max}$. In the process of movement, movement, mixing, on the contrary, there is a loosening of the material. The bulk density decreases, approaching the limit value $\rho_{\min}$. The $\rho_{\max} / \rho_{\min}$ ratio for some materials reaches values of 1,52 [1].

2. Research results

According to the particle size distribution of bulk material, the quantitative distribution of its constituent particles by linear dimensions is estimated. Most bulk materials have irregularly shaped particles, for which the conditional diameter d_i, calculated by three measurements of the particle (length, height and width of the particle) as the arithmetic mean or geometric mean.

Bulk material only in some cases consists of particles of the same size. More often in it the value of d_i changes discrete from some minimum size d_{min} to the maximum d_{max}. The d_{min}/d_{max} atio in some bulk materials can be very large. The particle size distribution of polydisperse materials can be characterized by a series

of distribution of the discrete random variable d_i in which the measured values of this random variable are listed: in which the measured values of this random variable are listed: d_1; d_2; d_n with the corresponding probability p_1, p_2 ..., p_n or frequencies n_1, n_2,... n_n. Determining the whole series of discrete random values of d_i for polydisperse materials with a large ratio d_{min}/d_{max} is difficult, so this series is replaced by a discrete series of classes (fractions) of values of d_i. To determine the particle size distribution of bulk materials used methods of direct measurement and sieve analysis [5].

Materials and equipment used in the study:

- measuring cup with a volume of 1000 cm3;

- laboratory scales with a weighing limit of 500 g and a weighing error of not more than 0.5 g;

- laboratory vibrator 028-M with a set of sieves.

In the sieve analysis, the powder residue on the sieves after sieving was quantified, followed by the calculation of its content as a percentage of the total weight of the sample taken for sieving.

A set of sieves with different hole sizes with shells with a diameter of 200 mm and a board height of 50 mm was used for sieve analysis. The value of the size class of the material fraction was determined by the size of the holes of adjacent sieves. For example, if the lower sieve has an opening equal to 0.5 and the upper 0.7 mm, then between these sieves after sieving will remain a fraction of bulk material of class (0.5 ... 0.7) mm.

The research was conducted in the following order.

Waste materials were ground on a rotary crusher using grids with different hole diameters. Using a set of sieves, the crushed materials were divided into fractions by particle size (Fig. 1).

A mixture of different fractions in a certain ratio was prepared. Using a measuring cup and a weight, the bulk density of each fraction of powder and mixture was determined.

Waste of polymeric materials of shoe production was used as the investigated material.

The study used the method of simplex-lattice planning of the experiment [6].

Mixtures of crushed rubber were formed by three sieved fractions (Table 1), the mass fraction of which varied at four levels: 0; 0.33; 0.66, 1.



A B C

Fig. 1. Fractions of crushed rubber: A - 10 mm; B - 5 mm; C - 2 mm

The bulk density of the investigated bulk material was calculated by the formula:

$$\rho_H = \frac{G_1 - G}{O_{cm}}, \quad (1)$$

where G_1 and G – respectively, the weight of the glass with the material and without it; O_{cm} is the volume of the glass.

The experiments were performed in triplicate. The results of the experiment to determine the bulk density of the crushed polymer waste are presented in tables 2.

Table 1. Particle size distribution of the fractions of the studied materials

Rubber particle size, mm	10	5	2
Denotation of quantity content	X1	X2	X3

As a result of processing the experimental data, it was found that the bulk density of mixtures of fractions of crushed materials with sizes from 10 to 2 mm varies within 15% (Fig. 2), so the obtained experimental data were approximated depending on the average particle size in the material mixture. by the formula:

$$\overline{d} = d_1 X_1 + d_2 X_2 + d_3 X_3, \qquad (2)$$

where d_1, d_2, d_3 - particle size in the fractions of the mixture, X_1, X_2, X_3 quantity content of fractions in the mixture.

Table 2 The results of the experiment

№	X1	X2	X3	Y1	Y2	Y3	Ymid
1	1	0	0	471	470	471	470,7
2	0	1	0	497	497	495	496,3
3	0	0	1	408	409	408	408,3
4	0.33	0.33	0.33	468	473	473	471,3
5	0.33	0.66	0	456	463	462	460,3
6	0	0.33	0.66	435	433	431	433
7	0.66	0.33	0	471	469	470	470
8	0.33	0	0.66	458	459	454	457
9	0.66	0	0.33	504	493	496	497,7
10	0	0.66	0.33	462	462	462	462

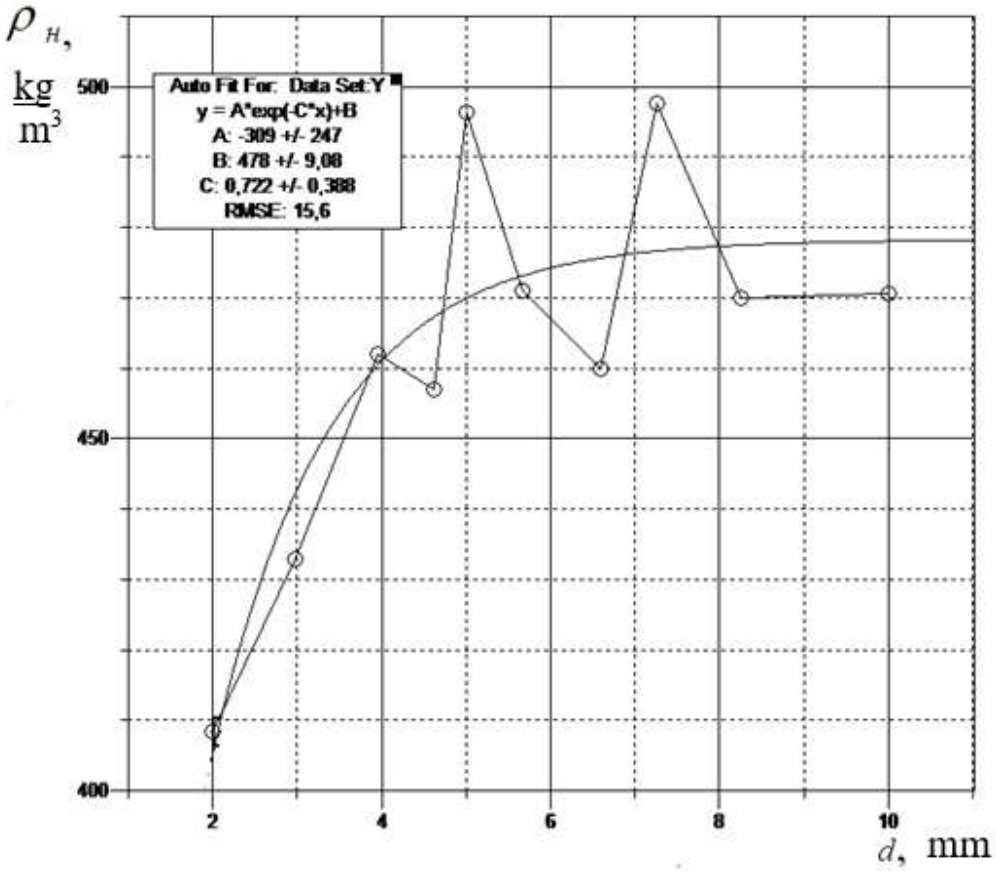


Fig. 2. The results of data processing of experimental research of forced rubbers from the average particle size of compatible fractions

3. Conclusion

The obtained functions for calculating the bulk density of polymeric materials depending on the average particle size are presented in table. 3.

Table 3 Functions for calculating bulk density depending on the average particle size of polymeric materials

Material	Density, kg /m^3	bulk density of the mixture of fractions 10…2 mm, kg/m^3
PVC plastic	1250	$\rho_н = 519 - 423\exp(0{,}834\bar{d})$
Rubber	1100	$\rho_н = 478 - 309\exp(0{,}722\bar{d})$
Polyethylene	950	$\rho_н = 398 - 257\exp(0{,}672\bar{d})$

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INFORMATION TECHNOLOGIES FOR VISUALIZATION OF THE DIAGNOSTIC RESULTS OF THE FORMATION OF THE COMPETENCIES OF FUTURE ENGINEERS IN MULTIDIMENSIONAL NON-METRIC SPACES

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DOI: 10.31891/monograph/2021-10-58

1. Introduction

Formulation of the problem. In modern conditions of socio-economic development, there is a need to train a specialist who demonstrates the acquired professional competencies from the first days and does not require a long process of adaptation to work in production. The team of authors insists on the position, that identifying the level of competence is a time-based process that is not limited to the final diagnosis, but requires the development of innovative forms and methods of teaching, which can bring the educational process closer to modern production and provide professionally oriented training of specialists, as well as objective diagnosis of the formation of a particular competence during training.

Analysis of recent research and publications. Diagnosis of professional competence is a new task for domestic professional pedagogy, although pedagogical diagnosis of acquired knowledge and skills is a well-developed problem of higher school pedagogy. Thus, the didactic foundations and practice of pedagogical diagnostics are reflected in the works of I. Gernichenko [1], I. Kankovsky [1], L. Kataeva [2], I. Pidlasy [3] and others. Issues of diagnosing professional skills and abilities of students using information and communication technologies (ICT) were considered in the works of V. Bykov [4], M. Zagirnyak [5], O. Trifonov [6], O. Petkov [7], O. Chorny. [8] and others. Possibilities of ICT in monitoring educational achievements in the course of e-learning were studied by I. Vorotnikova [9].

The analysis of the scientific literature showed that the problem of systematic diagnosis of professional competencies of the future engineer in higher education has not been considered in its entirety yet and is relevant.

The transition from assessing the knowledge of the applicant in certain disciplines to assessing the formation of a particular competence causes an avalanche of complications in the assessment process and criteria. Competence is formed under the influence of a group of disciplines, the teaching of which may not coincide in time. The average value of assessments in the disciplines that form the competence also cannot be an indisputable indicator of its formation, as the issue of the importance of the impact of individual disciplines on this process has not been resolved.

Similar problems arise at the final stage of assessing the quality of training according to hypothetically obtained assessments of the formation of individual competencies. Since their real level in the practice of modern free economic zones is not revealed. In technology, such a rapid combination of components and the creation of various ways of interaction between them leads to the formation of so-called "complex" systems that have properties that are not inherent in any of the constituent elements.

The presence of numerical characteristics of the formation of individual competencies does not eliminate the problem of assessing the quality of training in general. From a purely mathematical point of view, this leads us to the need to consider sets with vaguely defined values of individual components and weakly determined metrics, or even to consider multidimensional nonmetric sets.

The aim of the article is to identify the possibilities of information technology for data visualization in multidimensional non-metric spaces on the example of identifying the level of competence of future electrical engineers.

2. Research methodology

The work was based on the competency approach, which determines the use of the proposed methods of visualization to verify the formation of professional competencies of specialists in electrical engineering; design and research, which provided the opportunity to implement the author's ideas: the development of software for data visualization in multidimensional non-metric spaces on the example of the formation of the competence of future electrical engineers.

The following methods were used to achieve this aim. Theoretical - analysis and synthesis of research related to pedagogical diagnostics, the use of ICT in diagnostic activities, works in which methods of information visualization are analyzed; development of a program-designer of faces Chernov in MATLAB.

Empirical - expert assessment to identify criteria and diagnostic tools for the formation of professional competence, common among teachers; survey of students to create an optimal image of Chernov's faces.

3. Research results

The initial data were obtained as a result of experimental studies performed at the Kremenchug Mykhailo Ostrogradsky National University. Based on the expert assessment of 132 teachers of higher technical education, two main criteria for the diagnosis of professional competencies are identified:

Cognitive (knowledge of fundamental and professional disciplines);

Operational (testing skills and abilities necessary to work in real production).

The proposed diagnostic tools are determined on the basis of the experience of teachers of the Educational and Scientific Institute of Electromechanics, Energy Saving and Control Systems of Kremenchug Mikhail Ostrogradsky National University: test tasks [11], work with virtual laboratory complexes (simulation of real physical objects created by computer systems that can act as substitutes for real production devices and processes; detection of skills with real equipment), work with physical laboratory stands (detection of theoretical knowledge, analytical skills, operational and motor skills with equipment), professionally-oriented tasks linking real possible production situations to identify the student's ability to assess the situation, make an adequate decision) [12, 13].

The result of the diagnosis is a fairly branched characteristic, which should reflect the type of competence, the level of its formation, dynamics, recommendations for improvement and so on. Absolutely convinced of the need to detail each result for each indicator, which will present a holistic picture of academic achievement and further make the student a successful strategy of self-development. If you reflect the dynamics, you should collect a diagnostic material of at least three, and preferably five control measurements during the semester. Thus, the characteristic will be difficult to perceive, will require some time to study, understand, determine the conclusions and prospects of their own development. Assessment in points, unfortunately, does not reflect the quality of training of students, which has been repeatedly noted by domestic and foreign researchers [14, 15, 16]. The content of the paradigm of modern assessment consists in demonstrating to the student possible ways of further development and improvement, generalization of acquired knowledge, updating skills, formation of

professional competencies. In this context, it is extremely important to offer a convenient, effective form of assessment that would allow you to understand quickly your own learning achievements.

Studies of modern research by R. Araujo, S. Bull, B. Wasson, F. Dorch, R. Cattelan, S. Kostromina, G. Molodtsova, H. Ferreira, D. Chedykh, A. Yarovoy, allow us to identify visualization as a possible, effective method of assimilation of information [17, 19, 22]. The cognitive value of visualization is enhanced by the sensory-image mechanism of human intelligence. As A. Yarov noted, "sensory-image (and in this is its fundamental difference from the rational) is focused on the reflection of the individual (singular) in the subject, while the rational reaches the reflection of the general (typical) through the development and operation of abstract-logical (conceptual) forms "[16].

The need to search for imaging techniques that are not only able to visualize the results of diagnostics, but also to solve a set of important tasks has become an increasingly relevant:

- ease and speed of human perception of the necessary information;
- structuring data into a holistic image;
- the ability to analyze the visualized information according to specific criteria and indicators;
- emotional color and aesthetic appeal;
- ease of demonstrating the relationships between the various indicators analyzed;
- prevention of information overload;
- maintaining attention, activating thinking and memory;
- the possibility of cluster analysis.

An interesting method of visualizing the level of student achievement can be the method of "Chernov's face". His main idea is based on the ability of a person to "automatically" record complex relationships between many variables, if they are manifested in a certain sequence of elements. Sometimes the realization that some elements are "somewhat similar" to each other comes before the analyst can explain which variables caused this similarity. That is, the analysis of information using this method of display is based on a person's ability to intuitively find similarities and differences in facial features [26].

The types of coding of information in faces can vary from simple to the most complex. In order to identify the most expressive, easy-to-understand image of the students, a survey of fifty people was conducted, which allowed us to note the following: 90% of respondents preferred a real model with a bright emotion. 10% would prefer a symbolic image (for example, a smiley). 100% believe that the dynamics of change should be encoded in the change of size and shape of the face. A standard image is developed separately to track the most elementary changes in the image and to carry out a clearer analysis. For it we accept a high level of formation of certain competencies. The reference image will have classic facial features with the emotion of pleasure and positivity.



Fig. 1. Chernov's face for a student with a high level of professional competence (reference image)

If the level of formation of indicators is less than the standard, the oval of the face is stretched, the eyes are narrowed, the corners of the mouth are lowered to the bottom, making a grimace of dissatisfaction. The conclusions of A. Soboleva, who identified several difficulties in constructing faces, were chosen as a basis: scaling of facial features (for example, the nose cannot be larger than 2/3 of the face), which requires calculation of the average value and proportions of facial features; the difficulty of displaying not numerical but determinant values and bringing them to an interval form [28].

In our work, the task was to visualize the diagnosis of the formation of professional competence, which is a complex process that can be done by checking twelve indicators. To simplify the process of constructing a visual image of the diagnosis of acquired competencies, four levels were identified and characterized: "Unsatisfactory", " Satisfactory ", "Medium", "High".

"Unsatisfactory" - lack of thorough knowledge of professional fundamental disciplines, low level of analytical skills and the ability to summarize information, opinions and draw conclusions. Inability to make mathematical models of

electromechanical objects, read diagrams, graphically reproduce them, misunderstanding of the principles of electromechanical equipment, inability to use software tools for modeling, measuring instruments for the study of control systems of various technological objects, solve practical problems and make decisions about analysis of production situations.

"Satisfactory" - the formation of shallow superficial knowledge of professional disciplines, the ability to reproduce them according to the sample or the provided algorithm; low level of analytical and synthetic abilities. Students with a satisfactory level of professional competencies can make simple mathematical models of electromechanical objects, read diagrams, reproduce them graphically, but at the same time make significant mistakes. Partially understand the principles of electromechanical equipment, are able to use software tools for modeling, measuring instruments for the study of control systems of various technological objects, to solve simple practical problems. However, they have difficulties in analyzing production situations and making adequate decisions.

"Average" - a sufficient level of basic and professional knowledge, the ability to use them to solve problems of a certain class or type, to demonstrate analytical and synthetic abilities, mastery of the principles of electromechanical equipment, software tools for modeling. Students with an average level of professional competence can study the characteristics of operating modes, static, dynamic and energy processes of DC and AC electric drives, based on the recommendations of the teacher; can eliminate simple problems in the work of production process equipment, make decisions about situations in production.

"High" - a high level of fundamental and professional knowledge, the ability to use them flexibly in atypical situations, to establish interdisciplinary and interdisciplinary links, to demonstrate a high level of analytical and synthetic abilities, mastery of the principles of electromechanical equipment, software tools for modeling, ability to compose programs; to carry out research of characteristics of operating modes, static, dynamic and power processes of electric drives of a direct current and alternating current; on the basis of results of measurements to reveal and eliminate problems in work of the production technological equipment, to make decisions concerning situations on manufacture.

This is what we were guided by in the development of visual characteristics. Coding of indicators is presented in table. 2. To construct a face that will

correspond to the levels of formation of relevant competencies, we created a program based on the MATLAB software package, which "stitches" (compiles) facial features, superimposing visual elements (Table 2) on each other.

Table 1. A fragment of the table of coding indicators through facial features

Competence group	Features			
knowledge of fundamental and professional bases of discipline	Oval face			
				
ability of analysis and synthesis	Hair			
				
mastering the principles of electromechanical equipment	Mouth			
ability to solve practical problems with the use of mathematical methods	Right ear			
				
skills and abilities to work with measuring instruments, devices, computer equipment, technological equipment	Left ear			
				

Files with facial features form an array. Compliance with professional competencies according to the received assessments is established by software. Moreover, the level of formation of the relevant competence corresponds to the range:

"Unsatisfactory" <60;

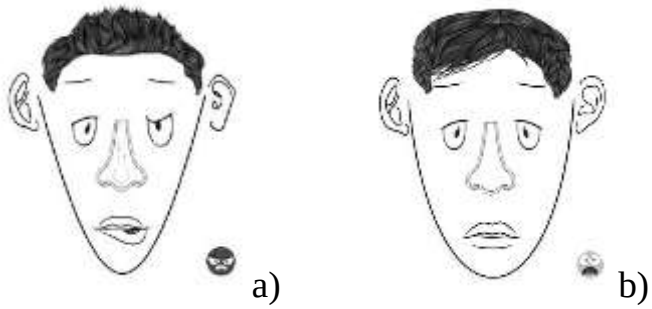
60≤ "low" <74;

74≤ "average" <90;

90≤ “high” ≤100, assessed by the ECTS system.

"Stitching" of the face taking into account the established conformity of estimates to files with facial features is carried out on the basis of the MATLAB software package.

Based on the results of the diagnostic section on 12 key competencies, Chernov's face was constructed for a student with unsatisfactory (Fig. 2, a) and satisfactory (Fig. 2, b) levels of professional competence.



a) b)

Fig. 2. Chernov's face for a student with the appropriate level of professional competence: a) - unsatisfactory, b) – satisfactory

In Fig. 2,a, facial features are distorted (elongation of the face, crooked mouth, disproportionate eyes, disheveled hair), which indicates problems in mastering a particular competence. Perception of the visual image allows you to instantly find differences with the ideal, which encourages the student to improve their own work, activate it in accordance with the solution of problems identified in the diagnostic process and reflected by visualization of Chernov's face.

Despite the originality of this method of visualization, we should note certain difficulties in its use: the need to compare correctly the studied indicators with parts of the face, because if you make a mistake, important characteristics may go unnoticed. Among the disadvantages of the method should be clearly defined the impossibility of displaying the minimum deviations from the reference image.

4. Conclusions and prospects of further research

Visualization of results of diagnostics of formation of competence by information and communication means expands possibility in carrying out the qualitative analysis of readiness of future experts, allows to present (for example, Chernov's face) data in multidimensional non-metric sets on an example of aggregated results of estimation of formation separate competences of future engineers; provides ease and speed of perception of the result, allows to establish the relationship between different competencies and levels of their formation, avoids information overload, provides emotionally positive perception of diagnostic results.

Comparing the results of current, thematic, modular diagnostics will provide the opportunity to build visual images, identify similarities and differences

between them and with the standard will identify problems in mastering certain competencies and adjust students their learning activities. Teachers, who analyze images on each student in the group, can find problems in mastering the content of the discipline in general and its individual topics. This will provide an opportunity to change teaching methods and the choice of appropriate methods and forms of work.

Prospects for further research are seen in the use of visualization tools at different stages of the educational process from motivation to perception and assimilation of the content of educational information, which is useful for obtaining feedback on the quality of learning. As well as software improvements in the direction of developing a mobile application for smartphones and tablets.

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FORMATION OF QUALITATIVE PROPERTIES OF TEXTILE SHOES BASED ON TECHNICAL HEMP

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DOI: 10.31891/monograph/2021-10-59

1. Introduction

At present, the efficiency of light industry enterprises in Ukraine is quite low, the goods produced by enterprises in this industry are significantly inferior in quality and quantity products of developed countries [1]. Lack of domestic raw materials leads to inflated prices, encourages the sale of products made synthetic and chemical fibers of low quality. The increase in prices for natural foreign raw materials leads to an increase in the cost of finished products at the initial stage of its manufacture. Given the economic instability, not all segments of the population can afford to consume quality products from natural raw materials, as there is a pattern: improving product quality leads to an increase in its value.

To create environmentally friendly goods with high consumer characteristics at an affordable price, it is necessary to have high quality domestic raw materials. An additional source of raw materials for Ukraine is technical hemp. Hemp is an unlimited textile opportunity. Hemp fiber differs from other fibers by its strength, resistance to rot, sanitary and hygienic properties, durability, ultraviolet resistance, etc. The use of hemp fiber only in twisted products does not reveal the full potential of raw materials that can be used for the production of environmentally friendly textiles [2].

The needs of modern consumers in environmentally friendly goods stimulate entrepreneurs to produce more and more new products from raw hemp fibers. Clothes and footwear made of hemp fibers are in great demand. Technical hemp shoes are increasing in demand among consumers every year. After all, this type of textile footwear has an advantage in quality properties.

Ukrainian producers and entrepreneurs adopt the experience of foreign producers and supply the domestic markets with ecological goods, which are produced using fabrics of foreign production.

The use of imported fabrics leads to the identification negative factors that affect the quality of the resulting shoes. To analyze the most negative factors identified by consumers during the operation of finished textile footwear,

consumer feedback was analyzed on the websites of well-known manufacturers of technical hemp shoes and a schedule was built for greater analysis.

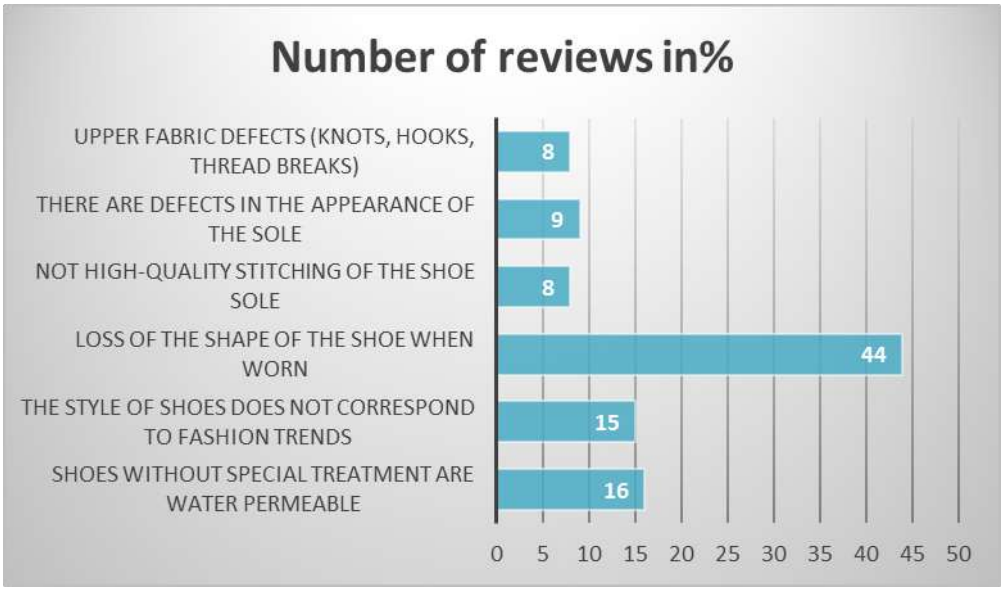


Fig. 1. Analysis of the existing effects on the quality of textile footwear made from technical hemp

Thus, the use of imported raw materials in domestic production has both positive and negative aspects. Analysis of consumer feedback in this group of products showed that the greatest impact on the quality of footwear has a loss of stability during the operation of textile footwear made of technical hemp. To eliminate this problem, it is necessary to analyze the life cycle of shoe manufacturing.

Therefore, the problem of developing and implementing a scientific concept, methods for assessing the quality, safety, consumer value, reliability and durability of textile footwear made of technical hemp fibers is very important.

2. Formation qualitative properties of textile footwear at the expense of hemp raw materials

Hemp is known to contain ultra-strong and long fibers. The use of such a fiber in the yarn, without modification, does not impart the softness of a cotton fiber to textiles. The leading manufacturers of hemp fiber textiles in the world have solved this problem long ago and widely use modified hemp cottonin. Modern equipment for processing hemp fiber into a modified one is produced by the companies "Laroche" (France), "Temafa" (Germany), "HempFlex" Romania, as well as the technology of the Institute of Agricultural Engineering named after V.I.

Leibniz (Germany) [3]. The essence of the fiber modification process consists in special processing of bast fibers to transform them into a material similar in structure to cotton, in order to obtain the possibility of processing it using cotton technology [4]. When preparing bast fibers for spinning, attempts are made to remove cellulose satellite substances from them, which can have a negative effect on the spinning process and yarn properties. For example, fats and waxes have a positive effect in the spinning process, the influence of proteins, ash and pentosan can be neglected, but the encrusting substances must be removed. The task of modern technologies for cottonization of hemp fiber is to obtain cottonin with an insignificant degree of contamination, the linear density of which is close to the linear density of the fibers, intended for mixing or for obtaining multicomponent yarns [5]. Known methods of cottonization: mechanical, chemical, biological, physical and mechanical.

At Ukrainian enterprises for the production of clothing and footwear, hemp cotonin of mechanical processing is used. But products made from it, especially shoes, have some disadvantages. After few time of usage, footwear loses its dimensional stability [6]. Therefore, the scientists of the Kherson National Technical University were tasked with identifying the causes of this defect and finding ways to eliminate it.

Scientific research on improving the quality properties of footwear was highlighted in the works of domestic and foreign scientists L.I. Baidakova, I.A.Dudla, V.P. Konoval, V.P. Libi, V.P. Nesterov, I.I. Polovnikov. , Rybalchenko V.V. in general or specific aspects. Basically, these studies are devoted to the anthropomorphological features of the feet of the population, materials science (leather, or imitation leather), the design and technology of footwear production [7-9].

Criteria for the suitability of fibers for further technological processing on spinning equipment are indicators of length, thickness and breaking load, which together assess the spinning ability of the fiber. The analysis of the existing normative documents showed that hemp cotonine should be evaluated according to the following physical and mechanical parameters: breaking load, breaking elongation, linear density, fiber length. These indicators make it possible to classify fibers by functional purpose.

The length of hemp cotton was determined by the method of measuring individual fibers, which is to determine the greatest distance between the ends of the fiber in the straightened state [10]. Since cotoneasted hemp fiber has a significant non-uniformity in length, to assess its non-uniformity used summary characteristics of groups of fibers, which were divided into maximum, average and minimum length. The research results are shown in table 1.

Table 1.The main groups of lengths of hemp cotonine

Minimum length 50-10 mm	The average length is 80-60 mm	Maximum length 120-90 mm
15%	55%	30%

The analysis of research revealed that hemp cotton has an average length of approximately 70 mm, which is much longer than the staple length of medium-fiber cotton, which according to this indicator does not allow the use of this cotton for yarn production by cotton spinning system.

In addition to length analysis, studies of the strength and linear density of hemp cotonine were performed. Due to the fact that hemp cotonine has a high strength due to the high percentage of lignin (up to 8%), more than other bast crops, and also has a large elongation, due to the high fat content of 3% , as shown in table 2, so to determine it by the regulatory documentation for hemp fiber does not make sense.

Table 2. Chemical composition of hemp raw materials

Hemp raw material	Part of the stem and type of fiber	The content of basic chemical components, %				
		mass fraction of cellulose	mass fraction of lignin	pectin substances	mass fraction of ash	mass fraction of resins and fats
Straw	fibrous part	74,0-77,0	3,4-4,3	9,0-12,1	5,8-6,1	1,1-0,8
	wooden part	37,1-42,9	21,0-32,9	12,1-15,2	3,2-2,2	0,7-0,1
Fiber	cotton	71,9-91,2	3,7-8,0	0,9-0,1	0,5-0,6	1,2-3,0

Analysis of the results of chemical studies of hemp raw materials showed that all tests should be carried out in accordance with the regulatory documentation for cotton. The test results are shown in table 3.

Table 3. Qualitative indicators of hemp cotonine

№ з/п	Indicator	Indicator value
1.	Breaking load of one fiber, dN	0,042
2.	Absolute breaking elongation, mm	10,6
3.	Relative breaking elongation, %	17,2
4.	Linear density, tex	6,8

It is known that the equipment of cotton processing enterprises in the carded spinning system uses fibers with a linear density of 0.16 - 0.33 tex with a cross-sectional size of 15 - 19 microns. The resulting cotonin fiber has a linear density of 6.8 tex, which is 20 times higher than the standard tone of cotton. Therefore, the hemp cotton obtained by this technology in terms of thickness does not correspond to the indicators of medium-fiber cotton and can not be used to obtain fine and soft yarn.

Analysis of the strength of hemp cotton fibers showed that the breaking load of cotton is 0.039 dN greater than the maximum value of the breaking load of medium-fiber cotton fibers. The elongation at break of hemp cotonine is 17.2%. Therefore, one hundred percent use of this raw material in yarn for shape-resistant products is not recommended.

In order to reduce the specific elongation, the scientists steamed the raw material in a laboratory autoclave. Steaming of the material was done in the following modes:

- steaming pressure 1.8-2.3 kgf / cm2;
- steaming temperature 140-1210C;
- the duration of the steaming operation is 20 minutes

After the experiment, repeated studies of the physical and mechanical properties of technical hemp fiber, the results of which are presented in table 4.

Table 4. Indicators of strength and tonnage of hemp cotonine after steaming

№	Indicator	Indicator value
1.	Breaking load of one fiber, dN	0,033
2.	Absolute breaking elongation, mm	5,3
3.	Relative breaking elongation,%	9,3
4.	Linear density, tex	5,5

Studies have shown a reduction in rupture elongation by approximately 50%. This is due to the reduction of fat deposits to 1% in chemical composition.

3. Formation of properties mixed yarn on the basis of technical hemp.

The analysis of literature sources allowed us to conclude that mixtures of hemp fiber with additional fibrous components can give the shoes new operational and environmental properties [11]. To obtain a mixed yarn, it is best to use polyester in different percentages. Mylar fibers have high strength and low elongation at break, so in the composition with hemp fibers can positively affect the performance of the fabric for the upper of the shoe.

Using mathematical planning of the experiment to determine the optimal composition of the mixture with the desired quality properties, a mixed yarn of 20% mylar and 80% hemp cotton was obtained. The experimental sample is presented in Fig. 2.



Fig.2. A sample of mixed yarn based on hemp cotinine

4. Formation of fabric properties for shoe uppers

After obtaining the experimental blended yarn, a study of imported fabrics used in shoe factories for shoe uppers was conducted. Studies have shown that the weave in all samples of imported fabrics is plain. Also, cotton and wool fibers are used in a mixture with hemp fibers [12].

The conducted results plus the critical analysis of literature sources gave the chance to form rules manufacturing of fabric for an upper of footwear with high properties of dimensional stability:

- in the report of weaving on a basis there were threads of cotton, and on a weft above the hemp-mylar mixture is offered. The addition of cotton fiber to the composition of the base will give the fabric for the upper of the shoe a more uniform weave pattern, the fabric will be soft and elastic, which will have a positive effect on the appearance of the product during operation;

- twill weave in different variations (classic, reinforced) is used to determine the most relevant, in order to increase the stability. After all, as you know, twill weave - is the most durable and form-resistant, so it is usually used in the manufacture of denim.

As a result of this work, a raw fabric was obtained without bleaching, dyeing and processing. This fabric was tested for basic consumer characteristics in the testing laboratory of PJSC "Edelvika" according to the regulatory documentation for fabrics shoe uppers. The main consumer properties and methods of determining indicators are fully presented in table 5.

The results of studies of the obtained fabric on the basis of technical hemp showed that the rate of rupture elongation was reduced by 20% compared to imported fabric used in footwear production.

The next stage of work was to make modern models of shoes from the obtained fabric for experimental wearing of shoes and the final determination the stability of the obtained sample. The obtained fabric sample was sent to the shoe factory of the company "Alain Group" where two pairs of sneakers of male (42) and female (38) models were obtained, which are presented in fig. 3.

Table 5. Consumer properties of fabric for shoe uppers

№	Characteristic	Test method	Factual data
11	The content of the components raw material composition,%	DSTU 4057-2001	58 Hemp 27 Cotton 15 Polyester
2	Fabric width, cm	DSTUEN 1773:2009	157,3
2	Linear density, m r	DSTU EN 12127:2009	639
3	Surface density, g / m2	DSTU EN 12127:2009	406
4	Number of threads per 100 mm on the basis on the weft	DSTU ISO 7211-2:2008	 248 176
5	Breaking force of a strip in the size of 50x200 mm, N on the basis on the weft	DSTU EN ISO 13934-1:2018	 832 862
6	Elongation at the time of rupture,% on the basis on the weft	DSTU EN ISO 13934-1:2018	 14,8 17,0
7	Hygroscopicity,%	Method M-02-19 (DSTU GOST 3816:2009)	15,5
8	Number of abrasion cycles, cycles	Method M -06-19 (GOST 18976-73)	6052



Fig. 3. Experimental samples of shoes with hemp fabric uppers

The concept the following researches consisted in definition of operational and ecological properties the received samples of footwear by a method of experimental experimental operation. From the analysis of questionnaires offered to participants of experimental wearing, it was found that the manufactured shoes have a pretty good appearance, easy to use, due to the twill weave almost does not allow water, is not contaminated, and most importantly, almost does not lose shape. Participants of the experimental wear also noted that during the operation of the shoes the size and fullness did not change, the comfort of the shoes did not decrease, the shoes ensured normal foot function under different conditions and throughout the service life, which is confirmed by no irritation and excessive sweating.

The results of laboratory studies confirm the estimates of the participants of the experimental wear: the size in dynamic conditions for the entire period of operation increased by 5%, and completeness by 1% from previous measurements to experimental wear.

5. Conclusion

Thus, drawing conclusions from the above, we can note the following that the use of domestic raw materials such as technical hemp in footwear production allows to enter the Ukrainian markets of safe, environmentally friendly and competitive products of high quality.

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PHYSICO-CHEMICAL AND TRIBOLOGICAL PROPERTIES OF NITROGENED LAYERS OF STRUCTURAL STEEL

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DOI: 10.31891/monograph/2021-10-60

Introduction

The presented work is a continuation of the problem of solving practical and theoretical principles of vacuum-diffusion gas-discharge processes, in which the mechanisms of processes of formation of modified surface layers of metals under the interaction of regime (temperature, medium saturation, medium pressure in gas-discharge chamber and saturation time) and energy (current density) and voltage at the electrodes of the discharge chamber) parameters. On the basis of the obtained experimental data it is planned to formulate the position of practical use of a fundamentally new technological process with optimization of combining its mode and autonomous saturation parameters, which would fully correspond to the formation on the surface of structures corresponding to increasing reliability and durability of machine parts. The authors rely on the developed fundamentally new energy model of the nitriding process in the glow discharge, the main feature of which is the priority of those subprocesses in strengthening the surface layers of metals, which in specific operating conditions of parts are most appropriate [1].

Analysis of the literature [2, 3, 4] showed that all known theoretical models of ionic nitriding processes are largely hypothetical, because the hypotheses underlying them are not always and not fully confirmed experimentally. A number of such models do not have an analytical justification, there are no criteria for optimizing nitrided surfaces, and thus methods of managing the nitriding process in order to achieve the required performance characteristics. The accumulation of a large amount of technological data, which do not have a generalized theoretical basis, not only does not contribute to the development of practical application of ion-plasma hardening of parts, but often leads to opposite consequences, because the accumulated results do not take into account real operating conditions.

In the planned cycle of works, fundamentally new provisions of the theory of diffusion gas-discharge processes of ionic nitriding of metals are formed, which are based on the priority of energy approaches [1]. From such positions theoretical processes of diffusion gas-discharge methods of ionic nitriding were not

considered by domestic and foreign researchers, but they open absolutely new opportunities of studying of the thin mechanism of the phenomena and their practical application in the field of strengthening of metal surfaces.

Materials for research

To study the effect of BATR, structural steels of the following grades were selected: 45 - high-quality carbon, 40X - chromium and 38HMUA - chromium-aluminum with molybdenum of high quality, as the most commonly used for nitriding in the glow discharge.

Research methods

Anhydrous nitriding in the glow discharge was carried out at the industrial plant UATR-1 of the Podolsk Scientific Physical and Technological Center (PNFC) of Khmelnytsky National University. The installation belongs to the model of diode type on a direct current and was in addition completed with heating elements placed in the gas-discharge chamber that gave the chance to change arbitrarily energy parameter - size of voltage U, and value of current density I (the relation of current to the total area of details a combination of arbitrarily set voltage and pressure of the gas mixture and nitriding time (τ = 4 hours).

Nitriding modes

Since the impact on the structure, phase composition, and hence on the performance characteristics of nitrided steels temperature, composition of the gaseous medium and nitriding time has been comprehensively studied in the works of many authors, for example, [2, 5, 6], and based on many years of experience materials and parts in PNPTC accepted: duration of nitriding - 4 h, the composition of the gas mixture - 80% N2 (nitrogen) + 20% Ar (argon) and temperature - 833K. Voltage and current are selected experimentally, based on the experience of previous studies. The current density was found as the ratio of the current to the cathode surface area, ie took into account the sum of the surface areas of the samples and the suspension. Technological modes of BATR are given in table.1

The specific power of the glow discharge in the gas discharge chamber was determined by the formula:

$$w=UxI/S=Uxj,$$

where S is the surface area of the cathode.

Table 1. Parameters of BATR modes

Mode parameter value	Sequence number of the experiment								
	1*/1**	2	3	4*/4**	5	6	7*/7**	8	9
Pressure p, Pa	P1=53,2			P2=106,4			P3=159,6		
Strain U, B	1100/680	820	515	840/610	515	300	700/540	515	300
Current density j, A / m2	11,0/15,3	7,2	3,2	13,2/16,4	7,2	2,8	15,8/17,2	12,8	7,2
Specific power of the glow discharge w, kW / m2	12,1/10,4	5,9	1,65	11,1/10,0	3,71	0,84	11,1/9,3	6,6	2,2

* The results of experiments without additional heating of the samples

To verify the position of [6] that "each power and discharge corresponds to a certain pressure of the gas medium" was conducted a second series of experiments with the same mode parameters as experiments 1 *, 4 *, 7 * of the first series, but using suspension of other sizes (cathode surface area), which led to changes in voltage and current density (modes 1 **, 4 **, 7 **; see table 1).

Metallographic research.

Cylindrical samples after BATR were cut on a diametrical plane (received two half-cylinders). The obtained planes were ground and polished by washing with distilled water and subjected to etching in a 3% alcoholic solution of nitric acid (HNO_3).

Measurement of the thickness of the nitride zone was performed on a microscope MIM-10, which allows quantitative analysis of the phase and structural composition of nitrided surfaces.

Microhardness was determined on a microhardness tester PMT-3 at a load of 0.98N with fixation of microhardness values both on the surface and at a distance from it 0; 25; 50; 100; 200; 300; 500 μm.

X-ray phase analysis was performed on a DRON-3 diffractometer in the filtered radiation of the iron anode in the range of angles θ from 20^o to 100^o with a

scanning step of 0.1º and an exposure time of 10s. X-rays were taken from the surface to the depth of the nitrided layer.

Tribological research.

Experimental studies of samples for wear resistance were performed on a universal machine for testing materials for friction model 2168UMT.

Analysis of literature sources [2, 5] allows to determine as factors that have the most significant impact on the course of tests and their results, the following characteristics: friction scheme - "disk - finger"; friction without lubricant; counter body material - steel SHH15 with hardness of the base HRC61; pressure in the contact zone p = 16 MPa; the controlled parameter is the linear wear h, which was defined as the change as a result of the passage of a section of length l of the linear size of the sample, measured along the normal to the friction surface.

As the friction path passed, the step of fixing the test results changed (Table 2).

Table 2. Periodicity of measurement of test results

Friction path section L, m	0 – 50	50 – 200	200 – 400	400 – 1000	more 1000
Measuring step l, m	5	10	25	50	100

The tests were stopped in the event of catastrophic wear.

Influence of BATR energy parameters. For greater clarity, the set of technological processes is represented by the scheme (Fig. 1), where the numbers near the points correspond to the number of the corresponding mode, and the lines connecting them correspond to the same pressures of the gas mixture: p1 = 53.2 PA, p2 = 106.4 Pa and p3 = 159.6 Pa. Points 1, 4, 7 correspond to the modes carried out without an additional heating source, ie with interdependent ATP parameters (each pressure of the gas mixture corresponds to a certain combination of voltage and current at the electrodes of the discharge chamber).

Analysis of the obtained dependence shows (Fig. 1) that with increasing pressure of the gas mixture p3> p2> p1 for BATR without additional heating increases the current with decreasing voltage in the discharge chamber, and the specific power w is approximately the same 11.1… 12.1 kW / m2 (modes 1 *, 4 *, 7 *). and 9.3… 10.4 kW / m2 (modes 1 **, 4 **, 7 **) when changing the shape of the suspension (cathode surface area). The latter is achieved by automatically

changing the current density j and voltage U according to the change in gas pressure.

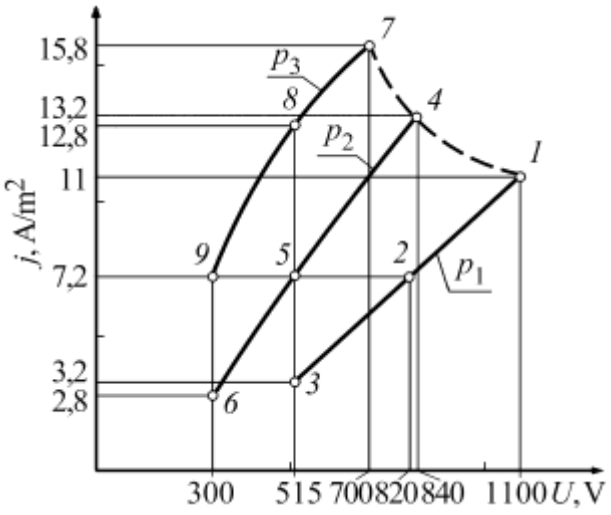


Fig.1. The nature of changes in energy parameters U and j

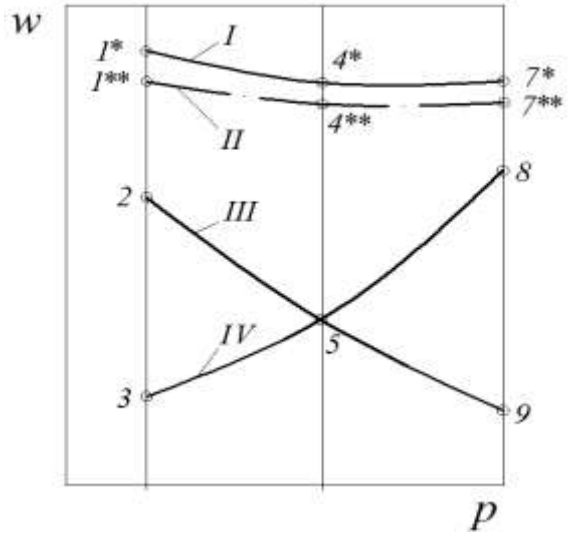


Fig.2. Dependence of the specific power of the discharge W on the pressure of the gas mixture: I, II - without additional heating; III, IV - with autonomous modes (with additional heating of the camera)

In the case of BATR with independent energy regimes, much smaller values of j and U are required to maintain the glow discharge in the chamber, for example, modes 9 and 7 at pressures p3 and modes 6 and 4 and 3 and 1 at pressures p2 and p3, respectively. In this case, when U = const (modes 3, 5, 8) to maintain the glow discharge requires an increase in j, and when j = const (modes 2, 5, 9), on the contrary, decreases U with increasing pressure of the gas mixture. It follows that the energy parameters are closely related to the pressure of the gas mixture. Therefore, Fig. 2 shows the dependences of the change in the specific power of the glow discharge w from the pressure of the gas mixture of the river. Curves I, II in Fig. 2 II - additional series of experiments, less energy losses). We have completely different dependences for BATR with autonomous energy parameters (Fig. 2, curves III, IV). In this case, at U = const with increasing pressure (modes 3, 5, 8 in Fig.1 and 2) w increases, and at j = const (modes 2, 5 and 9 in Fig.2), on the contrary, decreases. Figure 2 also shows that the use of energy parameters of BATR can significantly reduce the energy consumption of the nitriding process.

The results of research presented in [6] indicate the existence of an extreme relationship between the specific power of the discharge and the pressure of the gas mixture. The authors note that the pressure of the gaseous medium, which corresponds to the maximum specific power of the discharge, provides a nitrided layer of the greatest thickness. However, it should be noted that such conclusions are based on the results of nitriding copper tubes 30 mm long with an inner diameter of 1.6; 3.6; and 5.7 mm, but the features of nitriding of small diameter holes are associated with the effect of a hollow cathode [8] and it is unlikely that this allows the results to be extended to parts or samples of other configurations. Moreover, the extreme nature of the dependence w = f (p) decreases with increasing inner diameter of the tubes [6].

In our experiments conducted on cylindrical samples, completely different results were obtained (Fig. 2, curves I and II). By the way, similar results were obtained in [9] on samples of ellipsoidal shape, which ensured the absence of field concentrators. In any case, the question of the influence of the energy characteristics of the calf discharge on the physicochemical characteristics of the nitrided layer remains unclear and requires further research. Therefore, the thicknesses of the diffusion zone h and the nitride zone hN were found for the samples nitrided according to the above regimes. The results of the measurements are shown in table 3.

Assuming hardness as a basic parameter to assess the thickness of the nitrided layer (DSTU 20495-2005), we can conclude that it maintains the same trend - with decreasing energy parameters of the BATR process, the thickness of the nitrided layer decreases. This pattern is characteristic of the thickness of the nitride zone (Table 3.)

Analysis of the results (table 3) shows that with decreasing specific power of the electric discharge in the gas discharge chamber, the thickness of the layers h and hN also decreases and at w = 0.84 and 1.65 kW / m2 nitride zone on the studied steels is absent, but there is only the diffusion zone, which is absent only on 40X steel, which is explained by significantly higher energy costs for the formation of chromium nitrides. At the same time at w = 2.2 kW / m2 (mode 9 in Fig.1) there are no nitride and diffusion zones (table 3), which indicates the importance of comparing theoretical models of the formation of the incident particle flux with the real characteristics of the electric discharge in gases which

should include the field voltage in the field of cathodic voltage drop, current density, cathode temperature, pressure and composition of the gaseous medium.

Table 3. The thickness of the modified layer and the nitride zone of steels, nitrided in a glow discharge

Mode	The thickness of the modified layer, mm			The thickness of the nitride zone, μm		
	Steel 45	40X	38X2MЮA	Steel 45	40X	38X2MЮA
1	0,45	0,40	0,20	3,44	5,88	7,86
2	0,40	0,30	0,15	3,33	2,42	6,27
3	0,30	0,075	0,05	0	0	0
4	0,45	0,30	0,20	3,75	3,64	8,00
5	0,35	0,20	0,01	1,73	3,20	3,20
6	0,30	0	0,01	0	0	0
7	0,50	0,30	0,25	5,33	8,76	7,13
8	0,30	0,25	0,15	3,46	6,60	5,96
9	0	0	0	0	0	0

The latter determines the potential of the transition from dark to normal smoldering. The discharge transition potential for nitrogen-argon mixtures (20% N + 80% Ar) are according to the formula [1]:

$$U_{PTR}=(267,525+362,499P)+(24,3+433,2P)K_{PN}$$

where p is the pressure of the gas mixture; K_{PN} = 0.25 is the ratio of the volume fraction of nitrogen.

For modes 3, 6 and 9 U_{PTR}, calculated by this formula is 462 V, 650 V and 838 V, but in fact it was 515 V, 300 V, and 300 V, respectively. That is why in mode 9 due to the absence of a glow discharge nitriding process is also absent and $h = h_N = 0$, and for modes 3 and 6 due to insufficient values of current density and, accordingly, insufficient value of specific power of electric discharge W no nitride layer is formed.

X-ray diffraction analysis data indicate that the structure and phase composition of nitrided steels also depend on the energy parameters of the discharge.

According to the results of X-ray diffraction analysis at the maximum values of energy parameters, a nitrided layer containing ε-, γ'- and α-phases is formed. Reducing the voltage and density of the discharge current leads to an increase in the proportion of γ'-phase (Fe_4N) in the nitride zone of the modified layer and, accordingly, to a decrease in the proportion of ε-phase (Fe_2N). At the minimum values of energy parameters, the formation of nitrides on the surface was not observed, the nitrided layer contained only the α-phase (Fig. 3 and Fig. 4).

It is known that the thickness and phase composition of the nitride zone determine its properties, and hence, ultimately, the properties of nitrided steel. Thus, the nitride zone containing only the γ′-phase is characterized by a sufficiently high ductility, while the zone containing the ε-phase has less ductility but higher corrosion resistance.

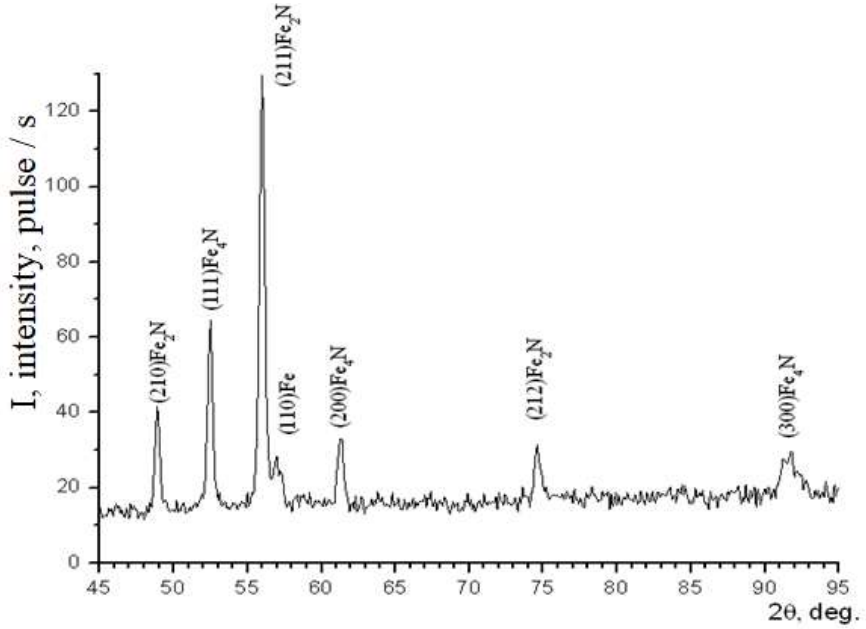
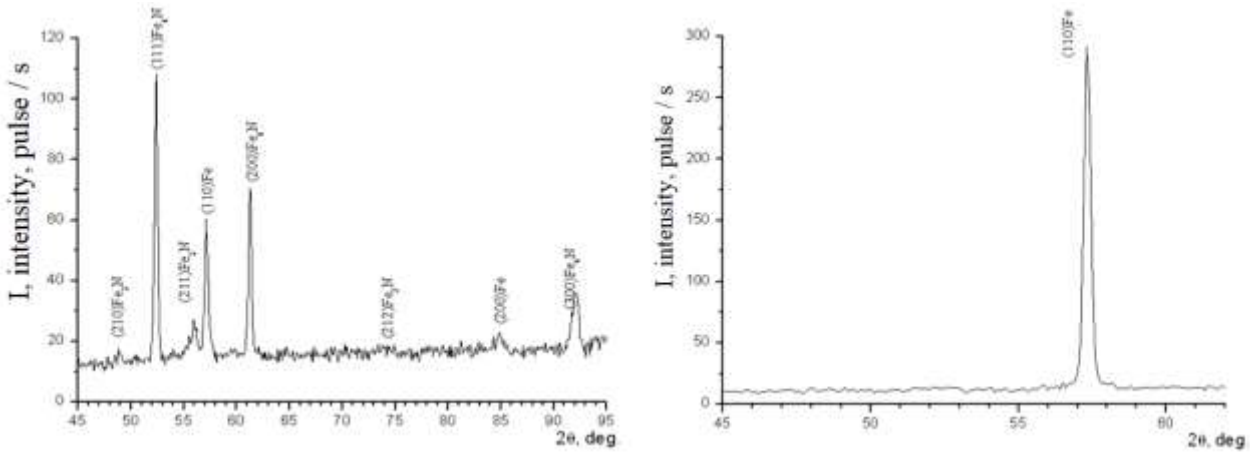


Fig.3. Section of the diffraction pattern of the steel sample 40X (mode 7)

The highest plasticity corresponds to the layer without the nitride zone. In general, the thinner the nitride zone, the more plastic is the nitrided layer, but the lower the resistance to abrasive wear, especially in dry friction [5].



a b

Fig. 4. Section of the diffraction pattern of the steel sample 40X (mode 8 (a) and mode 9 (b))

Thus, for parts operating in a corrosive environment and for wear at low contact loads, the BATR process should be carried out at the maximum possible values of voltage and current density, which will ensure the formation of ε-phase and, accordingly, high corrosion resistance and running friction surfaces. Reducing the values of energy parameters during BATR will increase the proportion of γ'-phase, and therefore can be recommended for parts operating at high dynamic loads under conditions of wear at high pressure; corrosion resistance will be reduced.

The dependence of the wear resistance of the modified surfaces on the energy parameters of the discharge was confirmed during tribological studies. As a result of experiments it was found that under conditions of dry friction for surfaces modified at higher energy values, the wear intensity (Fig. 5) and the run-in period (Fig. 6) decrease, and the period of constant wear increases, and with increasing content of alloyed elements in steel, this pattern becomes more pronounced. Of course, under other experimental conditions (for example, in the study of the obtained samples for corrosion resistance) the dependence of the tribological properties of nitrided surfaces on the current density and voltage at the electrodes of the chamber may be different, but in itself the existence of such dependence is not in doubt. which refutes the provisions of [10], according to which the energy characteristics of the discharge do not have a significant impact on the results of BATR.

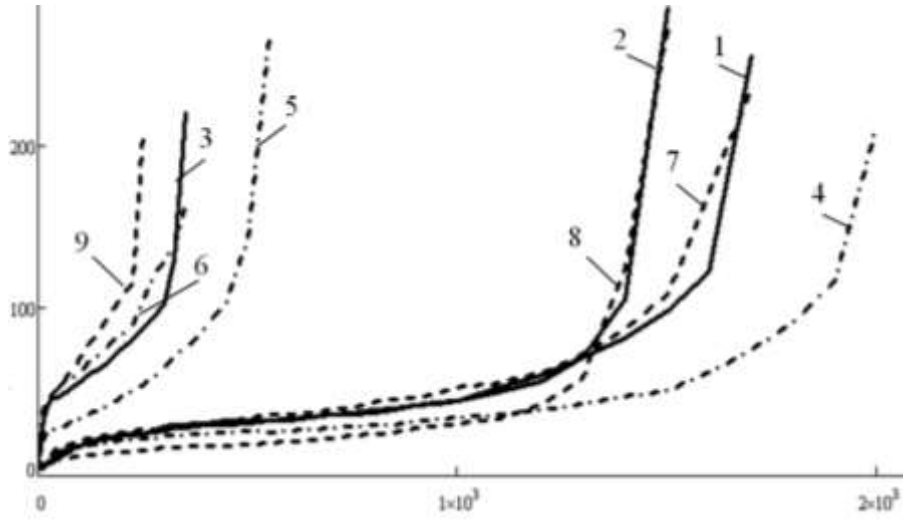


Fig.5. Wear curves of steel 38KHMUA, nitrided in the glow discharge

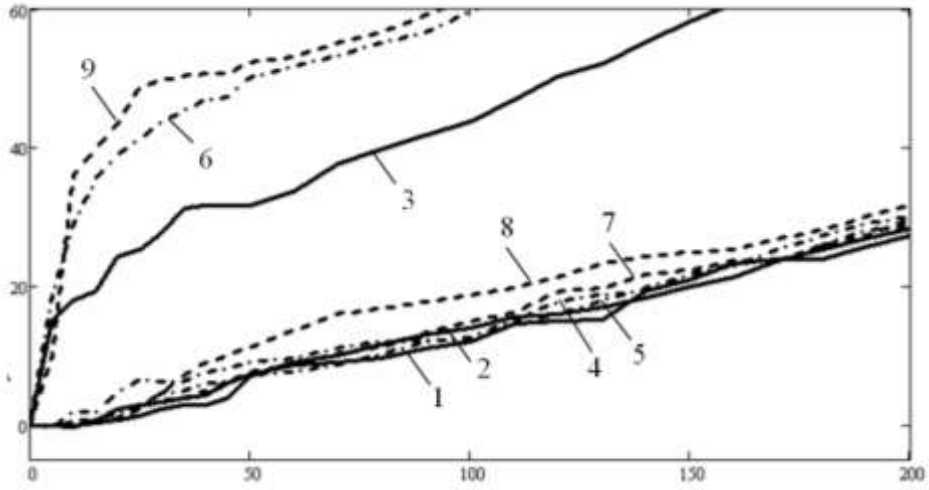


Fig. 6. The running-in zone of the wear curve of steel 45 is nitrided in the glow discharge

These data allow us to draw a very clear conclusion about the influence of voltage and current density on the characteristics of the modified layer, which determine the wear resistance of nitrided steels in the glow discharge, they are not just significant but crucial. Moreover, in the field of energy parameters of the regime there is a certain limit below which the ATP process generally loses its meaning, as it leads to unacceptable results, and this despite the fact that the values of the regime remain constant.

This means, in particular, that the set of traditionally fixed regime parameters (temperature, pressure, gas mixture composition and process duration) does not give an unambiguous idea of the conditions of the BATR process, and therefore cannot serve as a basis for predicting its results.

The list of factors that determine the BATR, given by the American researcher David Pye in [11], includes thirteen names.

Of course, taking all these indicators into account directly would make it incredibly difficult to manage the BATR process. However, they can be taken into account indirectly, because the influence of all these factors reflects the energy parameters of the process.

Conclusions

The paper presents a theoretical generalization and gives a new solution to the design and practical implementation of technological processes of nitriding in a glow discharge with independent parameters. As a result of the performed researches the following conclusions are formulated.

1 The current state of the controllability of the BATR process involves the use as a basic model of experimental developments, in which there are no provisions for establishing links between the input energy characteristics of the processing process and the final results. Provisions for the controlled provision of the necessary tribological characteristics of modified products have not been developed in practice, and those that are used as a result relate to a very narrow range of parameters.

4 The dependence of the main quantitative indicators of the modified layer, its structure and phase composition, as well as tribological characteristics on the energy parameters of the process is investigated. It is established that the increase of energy characteristics leads to: increase of surface hardness of the modified layer, its depth and thickness of the nitride zone; improvement of tribological properties - reduction of wear intensity and running-in zone; changes in the phase composition of steels, characterized by an increase in the proportion of γ'-phase in the nitride zone of the modified layer, which increases its ductility (compared to the nitride zone containing the ε-phase).

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MODELING OF INFORMATION AND ANALYTICAL SYSTEMS BASED ON THE THEORY OF FUZZY LOGIC

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DOI: 10.31891/monograph/2021-10-61

Introduction

Looking for new methodological approaches and methods of mathematical modeling of complex systems, researchers are increasingly paying attention to the world around them, wildlife, discovering new ideas there. Thus appeared the methods of neural networks, fuzzy set theory and fuzzy logic (the mechanism of implementation of formal-logical language structures that reproduce human thought processes, using linguistic categories and logical rules of decision making), genetic algorithms, evolutionary programming, intelligent methods of multiagent optimization, etc. [1; 2].

The main part

When building mathematical models, it is always necessary to follow the rule according to which from two models with approximately equal modeling errors it is recommended to choose the one with a simpler configuration. The new economic paradigm should provide for the use of such mathematical tools, that will allow for financial and economic analysis and forecasting, taking into account all available information about the object of study (including expert knowledge) and effectively adjust economic and mathematical models, based on real statistics [2; 3]. Neuro-fuzzy technology is a mathematical tool that can be successfully used to solve almost any economic problem. They are a methodology and mathematical apparatus that provides an opportunity to set and mathematically solve even such problems for which there is no complete statistics, or when among the informative factors are only qualitative indicators, while providing the ability to adapt economic and mathematical models to changing economic conditions.

Artificial neural networks - mathematical tools, a universal reproducer of complex nonlinear functional dependencies, based on the principles of biological neural structures. This toolkit is used in various sections of modeling, such as data analysis, time series forecasting, signal processing, pattern recognition and many others due to such an important feature as the ability to learn real statistics with or

without a teacher [3]. The suitability of neural networks for solving a wide range of problems, related to the search for hidden patterns in the studied data, has contributed to the rapid development of these tools and the creation of a significant variety of types of artificial neural network structures. Moreover, individual methods of parameter optimization have been developed for each separate type of neural networks, taking into account their structure and peculiarities of functioning. Similarly, the human brain has the ability to organize their own structural components - neurons, so that they can perform specific tasks [3]. We can identify the main characteristics of functional transducers of neurons for the application of these functions in the design of neural networks.

The linear activation function does not convert the signal - that is, with its application, the output of the neuron will be equal to the pulse received at its adder:

$$\psi(s) = s = \sum_{i=1}^{n} w_i \cdot x_i + b \,, \tag{1}$$

where s is the calculation of the neuron adder.

This type of activation function is appropriate to use, for example, for neurons of the source layer of the perceptron, if the resulting variable has no limitations and can take on any values.

Sigmoid activation function. Building a neural network, it is important to ensure its ability to efficiently adjust parameters, which can be done using differentiated activation functions. One of the basic functions often used in the construction of artificial neural networks is the sigmoid, which is analytically represented by expressions (2) and (3):

$$\psi(s) = \frac{2}{1+e^{-ks}} - 1 \,, \tag{2}$$

$$\psi(s) = \frac{1}{1+e^{-ks}} \,, \tag{3}$$

where k is the compression-extension coefficient of the function along the abscissa.

The compression-tensile factor can be used as a gain parameter. The advantage of using the sigmoid function as a nonlinear element is that it has limitations similar to the threshold activation function and exhibits behavior

similar to a natural neuron. Thus, as the value of the compression-tensile coefficient decreases, the activation function becomes flatter, in the extreme case (at k = 0) taking the form of a straight line at the level of 0 for relation (2) and at the level of 0.5 for (3). As the coefficient k increases, the sigmoid function becomes more and more compressed, resembling the threshold function of activation. This leaves the possibility of its differentiation, which allows you to use gradient methods to optimize the parameters of the model (in particular, the method of error backpropagation). With this activation function, the neural network can receive large signals and remain sensitive to weak signal changes. This activation function can be used for both the neurons of the intermediate layers and the source layer of the perceptron. However, considering that this function has a limited range of values, in the case of its application to the original neuron, it is necessary to ensure that the range of values of the resulting variable does not exceed these limits ([-1; 1] for the activation function (2) and [0; 1] for (3)). The value of the resulting variable can be normalized.

The radial-based activation function is also differentiated, but has different properties from sigmoid functions and is used to solve other problems. It is determined by the formula:

$$\psi(s) = \exp(-ks^2)\,. \tag{4}$$

Graphically, the radial-basis activation function (4) is presented in Fig. 1. A similar activation function can be used to solve problems where the values of variables are distributed according to the normal law, or in radial-based neural networks. This function can also be used in self-organizing maps to reduce the effect of the input vector on neurons, that are further away from the winning neuron.

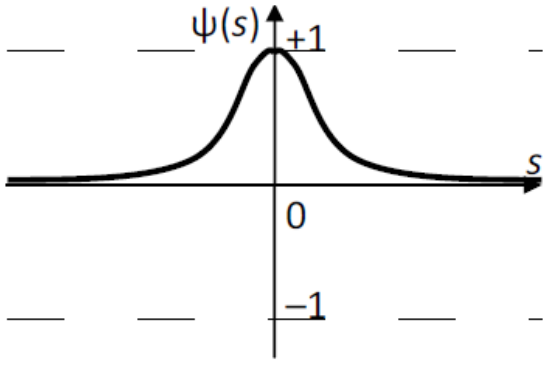


Fig. 1. Radial-basis activation function [3]

It is important to note that such a significant advantage of neural networks as parallelism in performing computational calculations is to some extent offset by the Neumann architecture of modern computers, where information processing is carried out sequentially [1]. If computer systems capable of performing parallel computations similar to information processing in the human brain are created, it is even possible to assume the fundamental possibility of implementing artificial intelligence systems based on artificial neural network technology provided that large groups of neurons are activated simultaneously [2].

The fuzzy set concept was formed in 1965 by Lofty Zadeh in response to "dissatisfaction with the mathematical methods of classical systems theory, which led to the achievement of artificial accuracy, not inherent in many real-world systems, especially the so-called humanistic systems" [4]. The theory is based on the understanding that elements that form a set and belong to it on a certain basis, can be characterized by this feature to varying degrees and, accordingly, belong to this set with varying degrees (unlike classical set theory, when an element belongs to some plural or does not).

With the introduction of fuzzy sets, an attempt was made to formalize linguistic information to build mathematical models. Accordingly, the central concept of fuzzy set theory is the concept of a linguistic variable. According to L. Zade, a variable is called linguistic, the meanings of which are words or expressions of natural or artificial language. An example of a linguistic variable can be a fall in production if it acquires not numerical but linguistic values: insignificant, noticeable, significant, catastrophic. The set of all possible values of a linguistic variable (terms) is called a term set.

For the linguistic variable "Fall in production" the set of values can be formed from the terms {Insignificant, Significant, Significant, Catastrophic}. Linguistic meanings vaguely characterize the current situation and can be obtained as a result of the transformation of quantitative data. For example, a 3% drop in production can be seen to some extent as insignificant and to some extent as noticeable. In this case, the degree that such a fall is catastrophic should be very small, as shown in Fig. 2.

The degree of such confidence can be established with the introduction of a special quantitative feature that determines the affiliation of the rate of decline in production to each of its linguistic terms, and is calculated by the so-called

membership function.

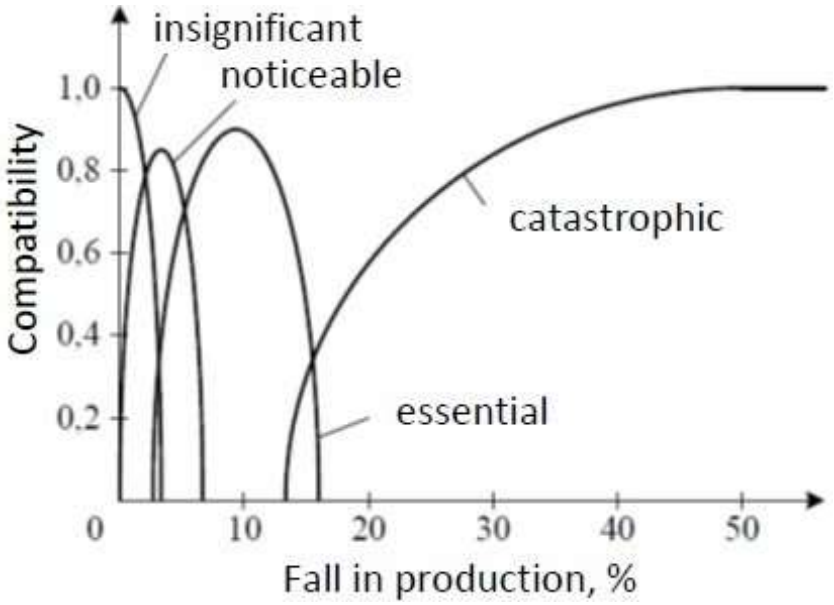


Fig. 2. Compatibility of membership functions [4]

The membership function is a function $\mu^A(u): U \to [0; 1]$, that allows for an arbitrary element *u* of the universal set *U* to calculate the degree of its belonging to a fuzzy set $\tilde{A}$ (which represents the linguistic term *A*). A universal set *U* is a complete set of values covering the entire problem area. In fig. 2 universal set is the set of all possible values of the rate of decline in production (from 0 to 100%).

With the introduction of the membership function, the theory of fuzzy sets expands the classical Cantorian concept of the set, assuming that the membership of an element to the set can be determined by any value in the interval [0; 1], and not only the value 0 or 1. Such sets Zade called fuzzy (fuzzy). A fuzzy set $\tilde{A}$ on a universal set *U* is a set of pairs ($\mu^A(u)$,*u*), where $\mu^A(u)$ is the degree to which the element $u \in U$ belongs to a fuzzy set $\tilde{A}$. The degree of belonging is calculated on the basis of the membership function and acquires a value in the range [0; 1]. The higher the degree of belonging is the more the element of the universal set corresponds to the properties of the fuzzy set.

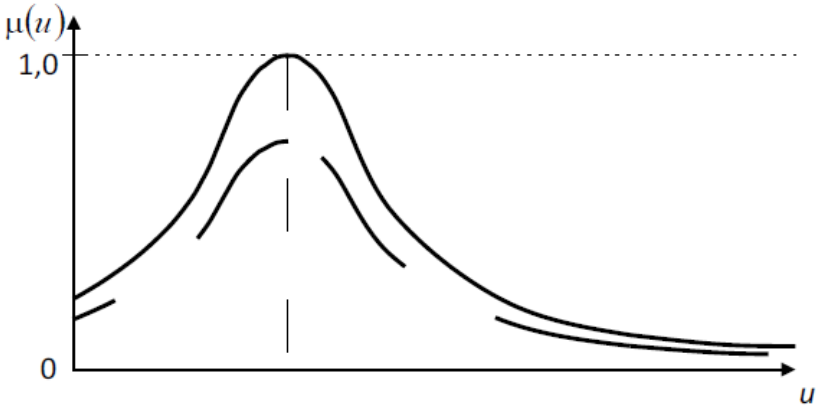


Fig. 3. Functions of belonging to the subnormal (dashed line) and normalized (solid line) fuzzy sets [4]

A fuzzy set is said to be normal if its height is equal to one. A fuzzy set that is not normal is called a subnormal. In fig. 3 shows a subnormal fuzzy set (dashed line) and a normal fuzzy set (solid line) obtained as a result of the procedure of normalization of the subnormal set. The fuzzy set can be convex or concave. Calculations in fuzzy set theory are based on the application of membership functions, that determine the degree of correspondence of an arbitrary element of a universal set to a fuzzy set, which is a subset of a universal set and is described by a certain linguistic term. There are several common approaches of constructing membership functions, that are used depending on whether the universal set is discrete or continuous.

For a discrete universal set U in the construction of membership functions approaches are usually used according to which all or some elements u_i, i =1, k , of the universal set are matched to the value of the membership function, $\mu^{A}(u_i)$, i =1, k , to a fuzzy set $\tilde{A}$, thus forming set of pairs $(\mu^{A}(u), u)$, i =1, k . Setting the appropriate values of membership functions is usually done expertly. For a continuous universal set U, it is convenient to set the membership functions in parametric form. In this case, the construction of the membership function is reduced to choosing the type of function and setting its parameters.

After an analytical description of the linguistic variable, the establishment of operations on fuzzy sets and sets of equivalence sets, it is possible to use them as a mathematical object in problems with incomplete information or under the influence of subjective factors.

One of the distinguishing features of artificial intelligence systems in the classical formulation is the usage of symbolic language to present general

knowledge about the subject area and specific knowledge about ways to solve the problem [5]. Accordingly, the key point in the design of intelligent systems is the presentation of knowledge, their interpretation and processing. Since the basis of artificial intelligence systems, according to the generally accepted Newell-Simon hypothesis, is the language of thought, the linguistic structure of which is characterized by a symbolic representation of knowledge, this justifies the creation of intellectual symbolic systems to generate intelligent solutions. Fuzzy logic is one of the most adequate approaches to the implementation of artificial intelligence on the principle of "top down" (semiotic approach) by constructing expert systems, knowledge bases and systems of logical inference, which reproduce the decision-making process of the expert in the subject area. Thus, if the rules of decision-making are unknown, then you can first form all possible combinations of all linguistic terms of the input variables, which will correspond to each of the terms of the resulting variable [5].

As a result, we obtain a knowledge base with $K = m \cdot q_1 \cdot \ldots \cdot q_i \cdot \ldots \cdot q_n$ rules, where m is the number of linguistic terms of the performance indicator, q_i is the number of terms i - of the input variable, and n is the number of input variables. Next, the model is optimized on fuzzy logic only by the weights of decision-making rules. At this stage, all other parameters of the model (parameters of all membership functions of the input and result variables) remain unchanged. After adjusting the model to real data, the weights will indicate the rules, that correctly determine the term of the performance indicator, based on a given combination of terms of the input variables. As a result of such optimization, the rules will be eliminated in such a way that each conditional part is matched with only one conclusion, for which the weighting factor was the largest among the same rules.

Conclusions

Fuzzy knowledge bases are a convenient way to formalize the causal relationships of the behavior of the modeling object, as they contain descriptive sequences of its functioning in the form of expressions in natural language. These statements combine input and output indicators, given in the form of linguistic terms. The methods of fuzzy logic provide an opportunity to model any socio-economic systems, even for which there are no full-fledged statistics, or among the informative factors there are only qualitative indicators, and also allow to take into account expertise in the subject area.

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MODERNIZATION OF ENERGY BLOCKS AS AN ALTERNATIVE IN PRO-ECOLOGICAL POWER SUPPLY PROCESSES

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DOI: 10.31891/monograph/2021-10-62

Abstract: The tightening regulations related to the emission of greenhouse gases to the atmosphere contribute directly to changing trends in the energy mix, bringing about a number of political and social changes. A sudden reduction in the exploitation of fossil fuel deposits carries the risk of a "carbon gap" that could destabilize energy supplies. The paper presents the technological development of countries against the backdrop of energy infrastructure, along with the specification of the percentage share of a given energy source in their domestic production. Many countries, including Asian economic powers, decide to build modern coal-fired power plants. This is done with a view to become independent from a single source of energy and to eliminate the need to import energy from neighboring countries. The development of modern equipment for the modernization of coal-fired power plants can significantly reduce the amount of emissions affecting the biosphere and ensure a sustainable energy transformation. Pro-ecological activities consist in converting carbon dioxide emitted by coal-fired power plants into synthesis gas and then into CNG gas in the process of compression. The gas synthesis process is performed at night and the energy necessary to power the process comes from the surplus produced by RES. The compressed gas produced in this way can be used to supply means of transportation. In the discussed object of study, two buses with different power source were compared – diesel and CNG. The tested operational parameter was the emission of nitrogen oxides on the same distance covered by both means of transportation. The emissions of a CNG powered bus are 21.95% lower as compared to a compression-ignition vehicle, which directly translates into a reduction in the concentration of nitrogen compounds in crowded urban agglomerations.

1. Introduction

A sizable portion of the raw materials consumed by society comes from non-renewable resources. At the beginning of the 19th century, during the bustling industrial revolution, coal, despite the difficulties with its extraction, was not a limitation in industrialization. This raw material had numerous deposits enabling powering machines. One of the things that hampered development was a limited access to raw materials supporting agriculture. Saltpeter and guano were highly efficient fertilizers, which were necessary to obtain high yields. The extraction of

natural fertilizer components was accomplished in only a few locations off the coast of America. Increased demand and constantly rising prices contributed to the development of alternative substances supporting agriculture. Transition between different energy sources used can only be smooth when information about the potential depletion of the resource is made public in order to prepare for a change in the trend. The combination of all these factors contributes to the manipulation of energy material prices. Conventional materials for energy production, such as oil, natural gas, and coal, currently do not have a global substitute that would be able to meet the energy demand. Due to the changing rules and the emergence of new regulations on the emission of harmful substances into the atmosphere, authorities of many countries began to put more emphasis on the development of "green energy". In many cases, the user of renewable energy installations becomes a prosumer, i.e., due to the limitations resulting from the inability to fully use and accumulate energy, the user sells surplus production to the grid, thus supporting the global conventional energy grid. The amount of substances emitted into the atmosphere by conventional power plants results from the applied design solutions and the modernization of the facilities [1-4].

2. Technological development of countries against the backdrop of energy infrastructure

The fuel and energy industry is a key branch of the economy of any country because all activities aimed at technological development of a given country are based, directly or indirectly, on the exploitation of fossil fuels. The energy necessary to power devices and machines is a measure of economic development [5].

The largest recorded increases in electricity production in the world belong to Asian countries due to the dynamic economic and technological development resulting from the opening of factories in these countries by foreign concerns. This contributes directly to the development of new, more effective sources of acquiring energy and to reducing the negative impact on the environment [5].

The energy production from available sources has a very diverse structure compared to the analyzed countries. The exploitation of various raw materials depends, among others, on the geographical location, the number of deposits in a given area and the level of technological development [5].

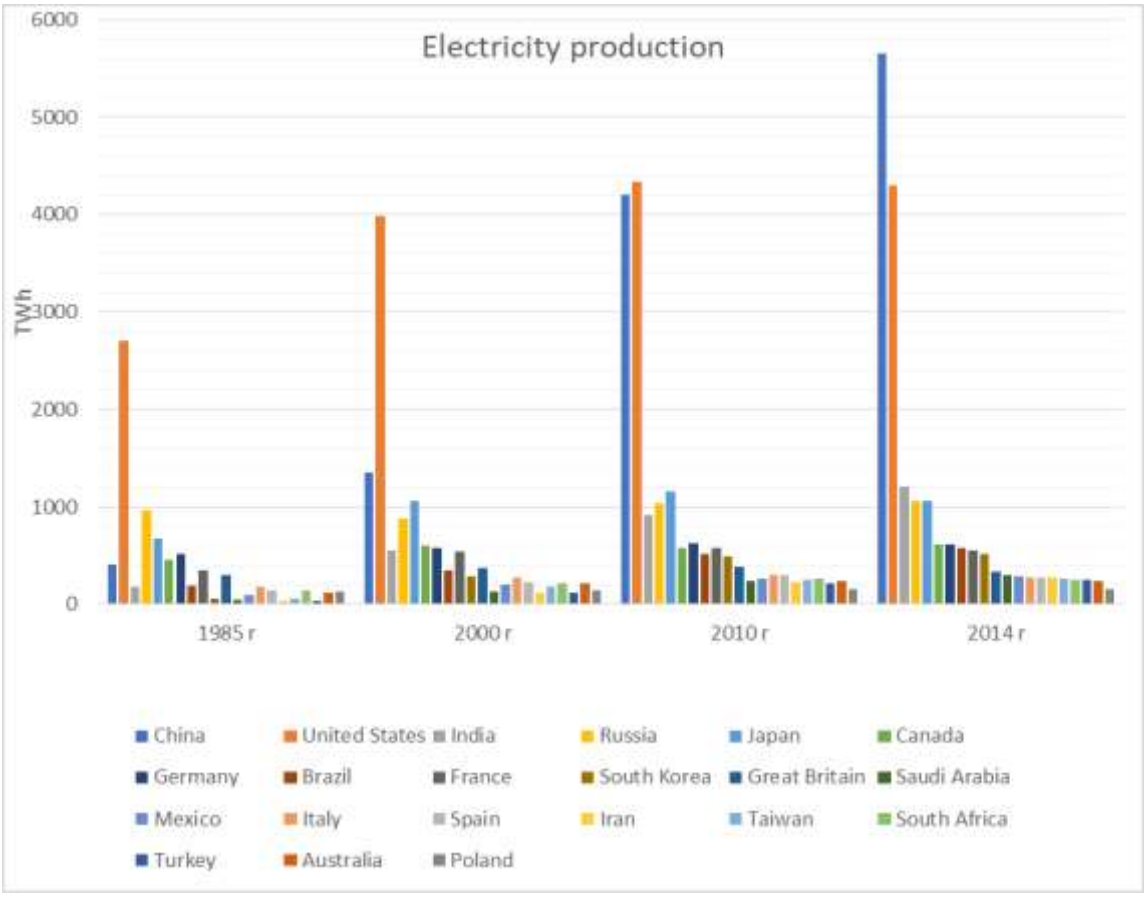


Fig. 1. Diagram of electricity production by individual countries in selected years [5]

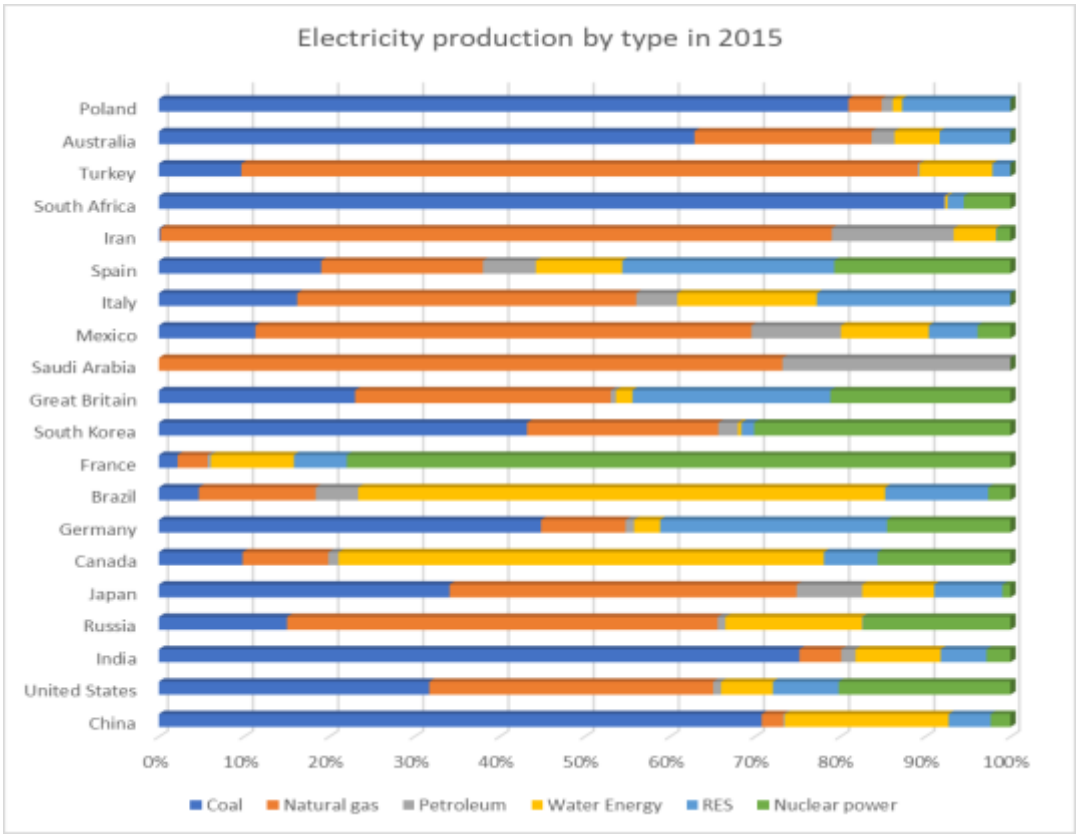


Fig. 2. Electricity production chart by type for selected countries [5]

A global problem, apart from technological possibilities, is a psychological factor aimed at emphasizing the actions of a single individual on the global ecosphere. Poland is an example of introducing systemic mechanisms aimed at reducing energy consumption. At the end of the 20th century, despite its significant and visible economic development, there was a 10% drop in energy consumption [6].

Following the trends related to the area of energy entails a number of changes also on the political and social grounds. The authorities of many countries are striving to increase the share of renewable energy sources or reduce the impact of energy on human health and the climate. Building modern business models is aimed at introducing changes in the energy mix. Due to the risk of a "carbon gap" that would arise as a result of a sudden reduction in the use of fossil fuel deposits by power plants, thus potentially destabilizing the regularity of energy supplies [7]. The economically leading Asian countries such as China and Japan are investing in the construction of modern coal-fired power plants. In 2020, the Chinese put into active operation new power units with a production capacity of 38.4 GW. More power plants with a total capacity of 247 GW are also scheduled to be built [8]. Seeking to be independent of one energy source, Japan is planning to build 22 coal-fired power plants in 17 different regions. High-efficiency blocks would be aimed at reducing carbon dioxide emissions to the atmosphere, and the estimated amount of gases from newly built power plants is to be comparable to the emissions generated by all passenger vehicles moving within the United States over a period of one year [9]. The creation of new low-emission power plants is possible thanks to the use of equipment that allows for the capture of carbon dioxide from exhaust gases. The gas captured in this way can be used as a raw material for synthesis gas and methanol production [10]. Syngas (SNG) will be produced by reacting with hydrogen resulting from the electrolysis of water. The process of supplying hydrogen production equipment is to come from the surplus energy generated by renewable energy sources and to be carried out at night when the demand for energy is lower. The resulting synthetic natural gas can be pressed into the existing network and used by gas turbines during production peaks. This concept is technologically and logistically simpler because there are no costs related to transport and storage, and the process of processing and recycling takes place within one company. The synthesis of SNG yields a byproduct, oxygen,

which is also used in technological processes such as coal gasification or oxygen combustion [11].

3. Analysis of the use of synthesis gas as a fuel supplying means of transport

Political directives aimed at the complete decarbonization of the energy sector contribute to the imposition of certain ideologies related to climate protection. These activities also have social consequences because the mining industry and numerous cooperating entities employ many people who feel anxious about losing their jobs. This is caused by the constantly increasing costs of carbon dioxide emissions into the atmosphere, as a result of which energy gets more expensive, negatively affecting the competitiveness of the economy and directly the end consumer. This puts pressure on research and construction teams to develop modern equipment for capturing carbon dioxide, which can be ecologically processed into a power source [12].

The perspective of climate neutrality, which is to take place by 2050, means a number of changes and consequences. Immediate closure of the available production capacity from lignite and hard coal may rapidly inhibit the development of computer technologies and production areas due to insufficient energy. The development of alternative energy sources is a positive and key process, however, a reserve of production capacity from conventional power plants should be kept due to the risk of a blackout, i.e., a sudden and unexpected system failure resulting in the interruption of energy supply over a large area. All these activities will contribute to getting rid of energy security, which is defined as supplying energy in a continuous and undisturbed manner at possibly competitive prices, considering environmental protection issues. Depriving a country of energy sovereignty may lead to the need to import energy produced in a manner acceptable to the authorities. However, for political reasons, the supply of this energy may be disrupted. Each country's energy policy should be subject to a sustainable transformation. Due to various management methods, the funds that can be allocated to the development of technology and modernization of the existing fuel and energy complex are mostly used for the purchase of additional carbon dioxide emission packages to the atmosphere [12].

Due to the multitude of areas with the potential for anthropogenic warming, there are many gases defined as greenhouse. The carbon footprint characterized as a measurable indicator encompasses the emission of carbon dioxide and other chemical compounds given as an equivalent CO_2. Due to various physicochemical properties, the warming potential is determined for a given time period because it does not decrease exponentially [13].

All fossil fuels we use today were created in natural biological processes over millions of years. Due to the limited amount of raw materials occurring in various states of aggregation and the progressing degree of urbanization, it is necessary to adapt technologies that support and slow down the utter depletion of deposits [14].

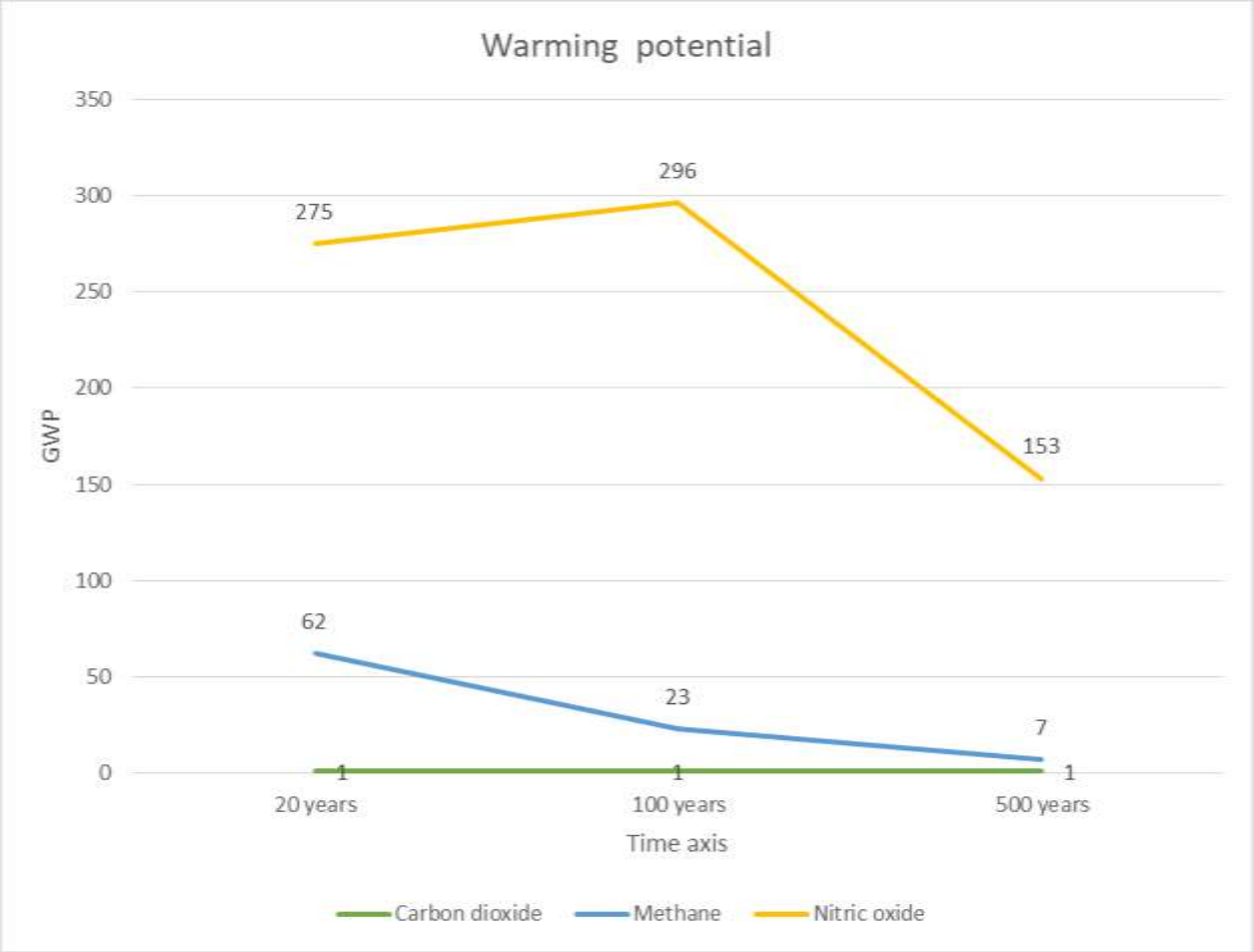


Fig. 3. The warming potential of selected greenhouse gases [13]

Pro-ecological activity aims to transform the CO_2 produced by coal-fired power plants to gas capable of propelling a vehicle. The emission of harmful substances by means of transport in crowded urban agglomerations contributes to

the formation of the so-called alarming air quality conditions. In many cities, we can observe exceeded permissible concentrations of benzo(a)pyrene, PM10 and PM2.5 suspended dust and nitrogen dioxide. Many modern buses operated in urban centers are powered by CNG, i.e., compressed SNG gas. For example, there are approximately 400 natural gas-powered buses in operation in Poland. Pursuant to the new regulations, research is conducted on the adaptation of a larger number of units in the rolling stock serving these journeys, and the actions taken are to promote the ecological performance of public transport [14].

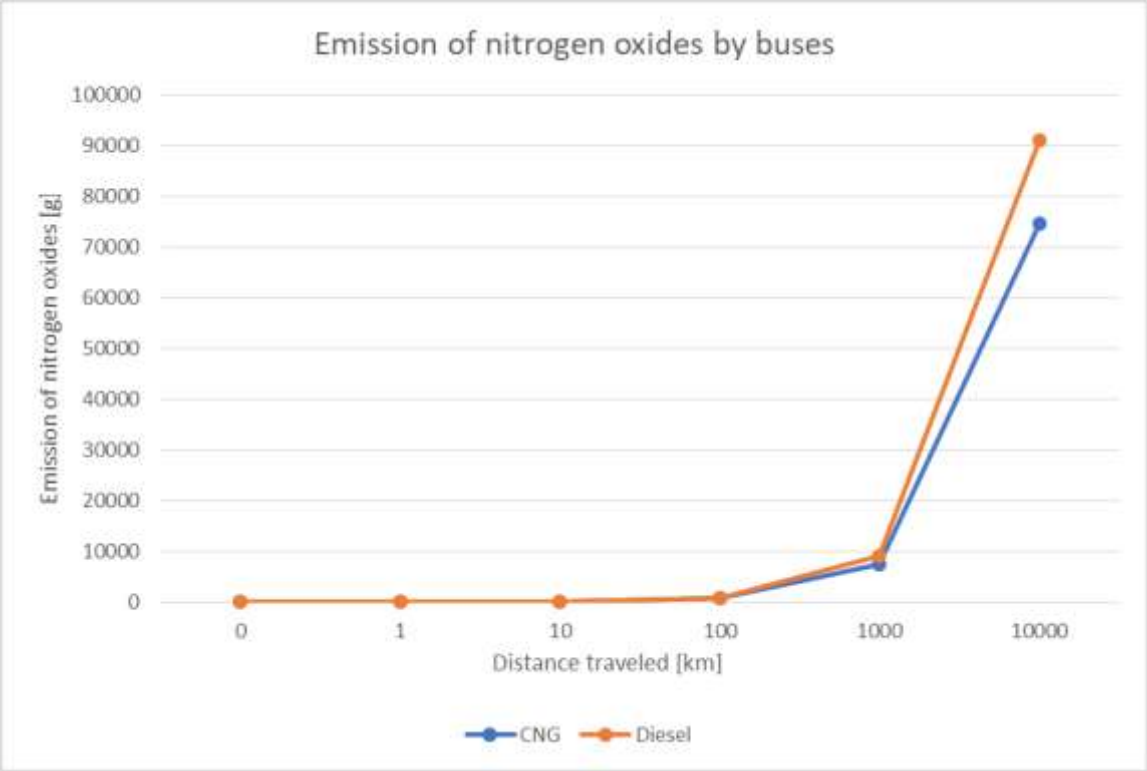


Fig.4. Graph of carbon monoxide emissions emitted by rolling stock powered with diesel oil and CNG gas [15]

On the basis of the conducted research on the diesel and CNG-powered bus fleet, it is possible to observe an increased emission of nitrogen oxides by 21.95% by the diesel unit. Fuel consumption over a distance of 100 km for a compression-ignition engine was 28.20 liters, and for a gas-powered engine – 30.38 cubic meters of CNG [15].

Based on the conducted analyses of operational tests, the companies indicate an existing problem regarding the availability of infrastructure enabling refueling. In the analyzed case, based on the example of Poland, there are only 26 public access points capable of compressing the gas to approximately 200-250 bar. It is estimated that there are about four thousand CNG-powered vehicles in the above-

mentioned country, which means that the costs of developing this infrastructure are significantly higher than in the case of stations offering LPG for sale [15].

4. Conclusions

The introduction of legal regulations aimed at reducing greenhouse gas emissions by conventional coal-fired power plants has contributed to technological development and the introduction of numerous modernizations aimed at improving efficiency and reducing or completely eliminating carbon dioxide from the combustion process. Thanks to these measures, Asian countries are intensively developing coal technology, planning the construction of new power units. Recovering carbon dioxide from the combustion process and carrying out water electrolysis for the process whose energy comes from the surplus RES production, brings about a number of ecological benefits. The synthesis gas formed this way can support energy production in peak hours and subjected to the compression process, it can power vehicles. City buses powered by CNG gas, based on operational tests, mean a lower nitrogen oxide emission by 21.95% compared to a bus powered by diesel oil, which translates directly into a reduction in the concentration of nitrogen compounds in the air in crowded agglomerations.

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CREATION THE INNOVATIVE TECHNOLOGIES OF PRIMARY PROCESSING OF BAST CROPS

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DOI: 10.31891/monograph/2021-10-63

1. Introduction

The issue of modern development and functioning of the domestic industrial crops market, which comprises the market of flax and hemp products, now requires significant analysis and revaluation, due to significant destructive changes in the processing industry of Ukraine.

Of all the agricultural plants, bast crops are the most difficult to process, and when harvested, they produce seeds and straw or retted straw. The efficiency of fiber production under modern conditions cannot be ensured without the use of machines with low metal and energy consumption, which indicates the inexpediency of using existing large-sized technological equipment at domestic enterprises. The lack of specialized machines produced in Ukraine and required for harvesting and post-harvest operations, equipment for primary processing of industrial crops, and the high cost of foreign equipment hinder the re-equipment adopting the industry to the latest technologies. The low efficiency of processing enterprises now allows to obtain only 20-30% of scutched flax from the total amount of produced flax fiber, and the lack of flax mills for processing raw materials into marketable products forces flax producers to look for consumers of raw materials abroad [1, 2].

Currently, the processing of fiber plants is dominated by the cultivation of oilseed flax, which is due to the growing demand for these crop products and significant profits from the export-oriented production of flax seeds. With the expansion of sown areas of this plant, the question of processing the stem material arose, as the seeds are exported, and the stem part remains unclaimed by the domestic industry. Currently, the stems are simply left in the fields or burned, which can lead to environmentally hazardous situations [3-5].

So far, no effective universal methods of obtaining natural fiber have been invented, and the equipment used in industrial enterprises requires modernization, as it consists of a significant number of components, is obsolete and physically

worn out, which reduces equipment efficiency and the profitability of the industry [1-2, 6-7].

So far, these issues have not been ultimately resolved, so the development and implementation of modern technologies for processing bast crops using effective development of components and nodes of the breaking and scutching unit parts, which due to innovations can significantly improve the separation and purification of fiber from non-fibrous parts of recyclable material are relevant and need to be addressed.

Since oilseed flax differs from common flax by anatomical and physical-technological properties, the processing of stem material of oilseed flax using the technology applied to common flax is impossible, although in its processing, similar techniques – breaking, scutching, and butting – can be used [6; 7]. However, the design features of technological equipment and the order of its application should be different. Therefore, the processing of oilseed flax is carried out according to the technology of obtaining monotypic fiber. Various methods and equipment are used for the production of monotypic fiber, the characteristic feature of which is that they are intended for the processing of heckling waste and are not suitable for the direct processing of stem material of retted straw.

Therefore, the task is to develop an effective innovative technological line for processing domestic fibrous raw materials with a chaotic arrangement of stems in the crop mass, which, using effective nodal connections and minimized mechanical action, makes it possible to obtain monotypic fiber cleaned from shives and other non-fibrous impurities out of the stem material. Thus, the main purpose of the paper is to show the ways to solve the urgent issues facing the production process of in-depth processing of technical bast crops.

2. Processing the stems of bast crops by means of the innovative technology

Currently, the possibilities of using natural fiber are significantly expanded due to the effective in-depth processing of the fibrous material, which significantly affected the scope of its use. Short flax and hemp fiber are widely applied in the textile industry, where, in combination with other types of fibers, they are used for the production of various textiles, modern composite materials, cottonin, batting, insulation, and other purposes. All this has caused changes in the technology of harvesting and obtaining fibrous products aimed at saving resources.

The development of technological equipment, assembly units for efficient processing of bast material without division into long and short fibers simplifies the technological processes of raw material harvesting and further mechanical processing, as well as provides increased productivity and improves working conditions and overall production culture. The possibility of forming monotypic fiber raw material significantly reduces the cost of its harvesting, retted straw preparation, transportation, and processing, which reduces the metal and energy consumption of equipment and reduces the cost of the output fibrous products.

System analysis of works [2-3; 5-9] revealing the technology of in-depth processing of bast raw materials allowed identifying modern trends in existing technologies. Based on the analysis, an algorithm of design and technological solutions for optimizing the processes of primary processing of bast crops was developed, which is shown in Fig. 1.

It is known that bast fibers are characterized by different chemical and physico-mechanical structure. Therefore, to determine the processing equipment and technological modes of its operation, it is necessary to accurately identify the type of raw material and its initial input characteristics (variety, degree of aging, quality). These operations must be performed regardless of the choice of the technological scheme of its further mechanical processing. All technological factors vary within a fairly wide range, so the number of different processing modes that can be applied in the assembly unit is very large. Technological outcomes of processing monotypic fiber raw materials in different modes often differ greatly. The analysis of the influence of each of the technological factors on the processes of shives removing and destruction of the fiber allows us to state that during the establishment of the optimal mode it is necessary to strive for the maximum possible mitigation of mechanical actions applied to raw materials while increasing their number. Violation of this principle of technological processing can lead to excessive fiber loss.

Considering the peculiarities of advanced technical and technological directions of producing high-quality bast fiber mass and the experience in processing bast fiber crops, creation of a technological innovative line for producing purified fiber from the retted straw of bast raw material and, on its basis, modernization of technological equipment was carried out according to the scheme of fiber production from polydisposed retted straw stems (Fig. 2).

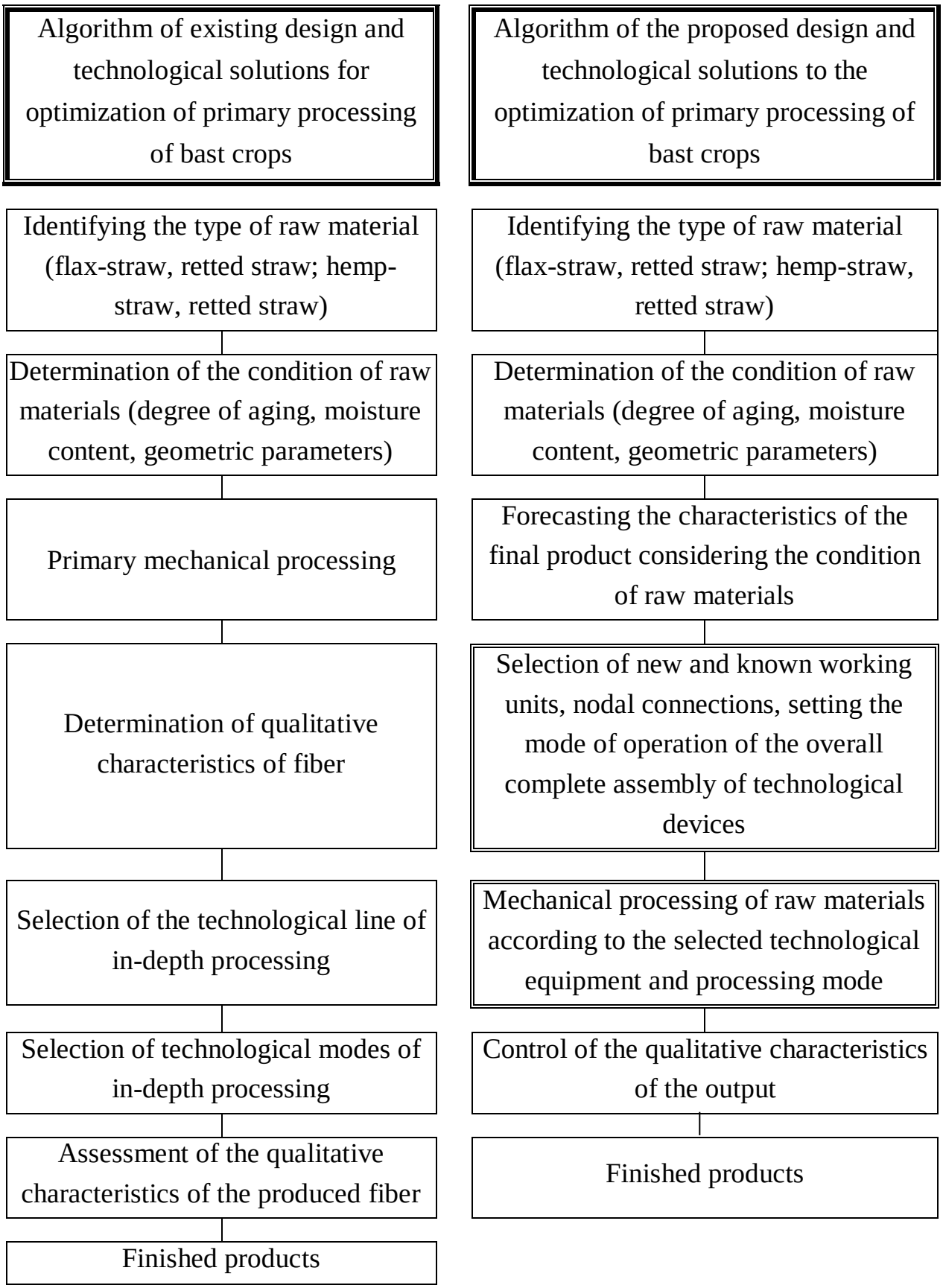


Fig. 1 – Algorithm of the existing and proposed design and technological solution to the optimization of primary processing of bast crops

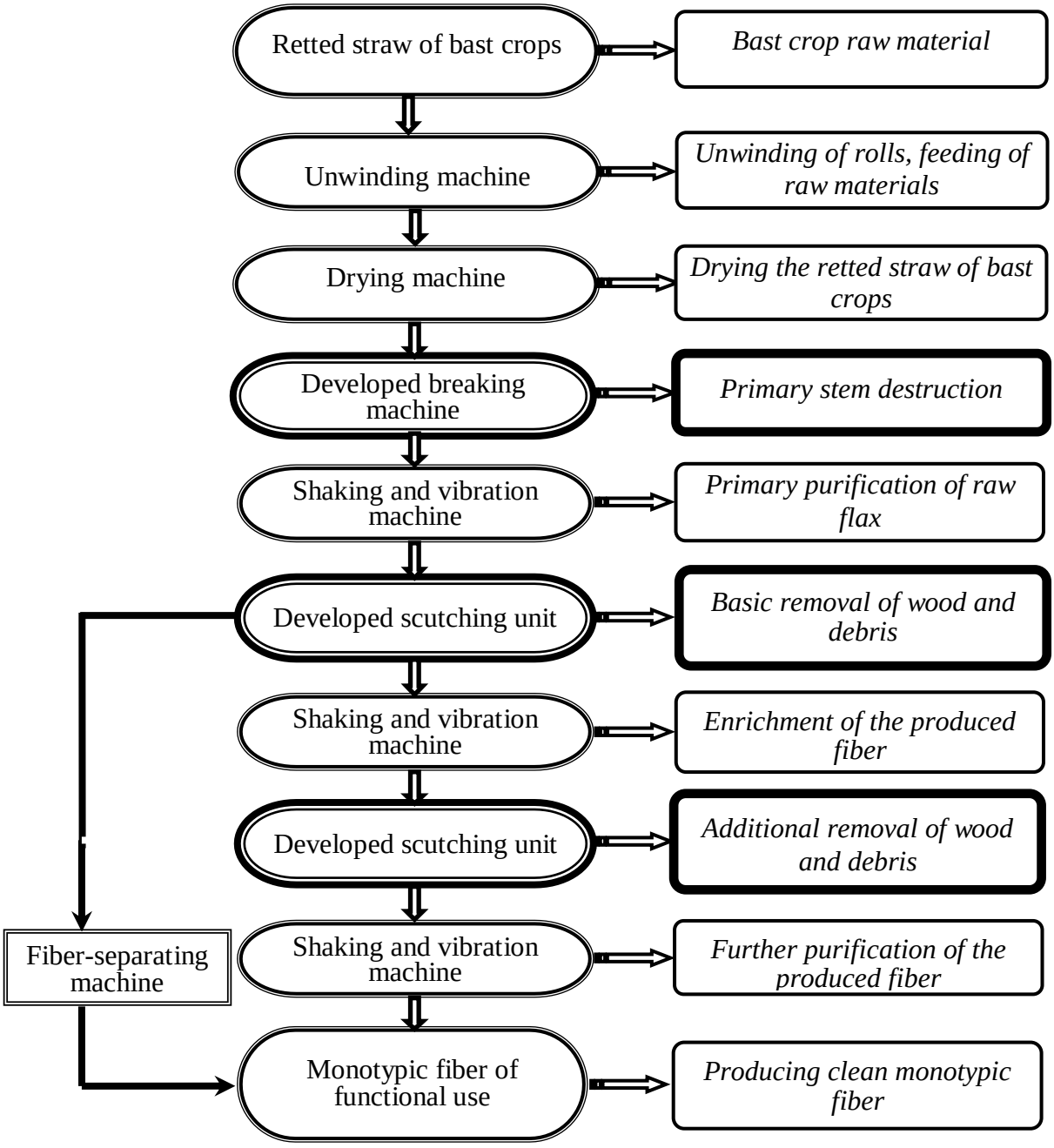


Fig. 2 – Schematic diagram of the processing bast crop retted straw using innovative technology

The presented diagram shows the feasible mechanical processing of bast crop raw materials enabling full separation of non-fibrous stem tissues from fiber: wood, the remains of epidermis, parenchyma, and inorganic impurities. This ensures the preservation of natural fiber strength, length, minimal damage, and maximum fiber yield.

Since it was found that the most problematic stages of processing of stem material are the processes of breaking and scutching, which contribute the most to

the efficiency of the overall processing of bast raw materials, the authors designed high-performance technological equipment and its components; they equally developed the prospects for their further industrial application.

Development and further implementation of modern technical and technological solutions were carried out on the basis of the efficient designs of components and units of breaking and scutching of the assembly, which, due to innovations [10-19], significantly improve the process of separation and purification of fiber from non-fibrous parts of the processed material and contribute to the expansion of the scope of fibrous products.

The set task is solved by developing a method that involves unwinding rolls on unwinding machine, breaking with rollers with simultaneous drawing, scutching, and final cleaning of the fiber from shives on shaking machines.

According to the proposed design, the raw flax material is arranged in the breaking unit, simultaneously carrying out the scraping, thinning of the raw material layer by means of the stripping rollers of bar, disk, and comb type in complex interaction with the shaking-vibration device, which is placed between the breaking and scutching processes, carried out by simultaneous action of beater bars and scutching drum blades [10].

The essence of the presented development is explained in Fig. 3, which shows a flow diagram of an experimental assembly for producing monotypic fiber from bast crops, where *I* is an unwinding unit; *II* – a drying unit; *III* – a layer-forming unit; *IV* – a breaking unit; *V* – shaking unit, and *VI* is a scutching unit. The assembly consists of the following equipment: an unwinding machine 1, if necessary, a drying machine 2, a spiked mechanism 3, a breaking machine 5 with a pair of rollers of enlarged diameter 4 and a set of rollers of various types, a shaking machine 6 for primary cleaning with a vibration device, scutching units 7 and shakers 8 equipped with a vibration device [10].

The operation of the proposed design is carried out in the following way. Bast-fiber raw material after unwinding of rolls on unwinding machine 1 is directed, if necessary, to a drying machine 2, then by means of a spiked mechanism 3 is fed to the first pair of rollers of enlarged diameter 4 of breaking machine 5, which provide efficient drawing of stems with different physical and mechanical properties and pass the raw material to a set of rollers of various types of breaking machine 5, where parallelization takes place, arrangement of raw flax stems,

intensive breaking with simultaneous drawing, scraping, and thinning of the layer of raw materials which is sent to the shaker 6 of primary cleaning from shives and other non-fibrous impurities equipped with a vibration device.

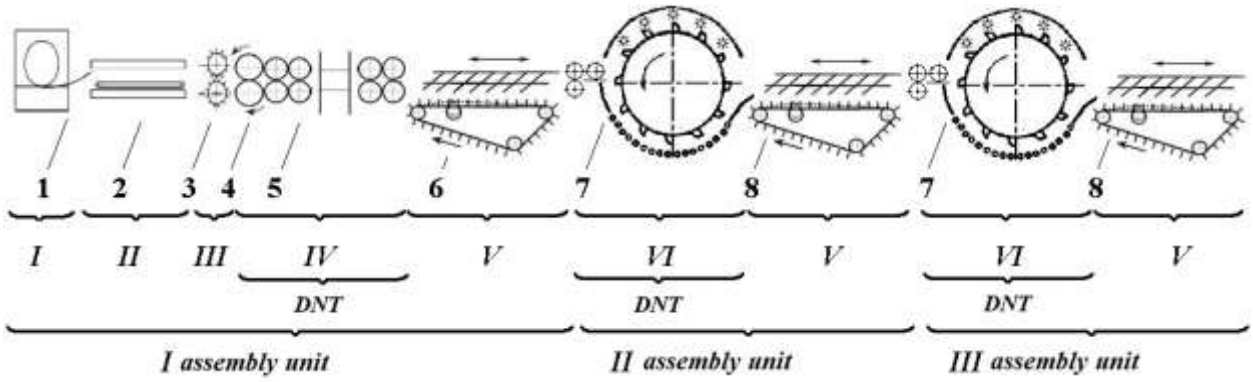


Fig. 3 – Process flow diagram of the experimental assembly for producing monotypic fiber from bast crops and equipment for its implementation: *DNT* – device of a new type; *I* – unwinding unit for rolls; *II* – drying machine; *III* – layer-forming unit; *IV* – breaking unit; *V* – shaking unit; *VI* –scutching unit; 1 – unwinding machine; 2 – drying machine; 3 – spiked mechanism; 4 – pair of rollers of enlarged diameter; 5 – breaking machine; 6 – shaking machine for primary cleaning with a vibration device; 7 – scutching node; 8 – shaking machine equipped with a vibration device

The raw material, beaten and partially cleaned from shives is fed to the scutching unit 7, where an intensive process of separation of the bulk containing shives and other non-fibrous impurities takes place. Depending on the type of bast raw material, its condition and quality, it is possible to adjust the gaps between the beater bars and scutching blades and between the grid and the scutching drum at the unit 7. For the final cleaning from residues of shives and other non-fibrous impurities, the fiber mass from the scutching unit 7 goes to the vibration machine 8 equipped with a vibration device for the final cleaning of the fiber from shives and impurities.

Implementation of the complex interaction of the stripping rollers of bar, disk, and comb type of breaking process with shaking-vibration device of the shaking process, which is placed between the breaking and scutching processes after arrangement, the breaking of the layer of bast raw materials allows for preliminary cleaning from shives and other non-fibrous impurities, which helps to remove free shives, which is formed during the passage of material through the breaking machine.

The application after scutching of beaten and pre-cleaned material of the shaking machine equipped with a vibration device allows additional shaking, cleaning of the fiber mass from shives and other non-fibrous impurities. Due to the oscilations of the needle feeder vibrating under the influence of the vibrating device, an intensive separation of the residual shives occurs, which significantly improves the degree of purification of the fiber.

The process of double treatment of bast raw materials by means of a scutching unit and shakers equipped with a vibrating device provides the most effective cleaning of fiber mass from shives and other non-fibrous impurities. Depending on the type and physical and mechanical quality indicators of the bast material, one or more scutching units can be installed in the proposed bast processing equipment to effectively clean the raw material from shives and other non-fibrous impurities. The proposed design developments of the scutching unit allow increasing its versatility for processing stem material due to the possibility of processing different types of domestic bast raw materials.

Mobile version of the assembly for processing bast crop stems. Based on the carried out research, a mobile version of the assembly for processing the bast crop stems was also developed (Fig. 4), the components being placed on a single mobile platform, which allows moving the assembly to the places of concentration of raw materials, which contributes to economic efficiency of flax stems and hemp processing [19].

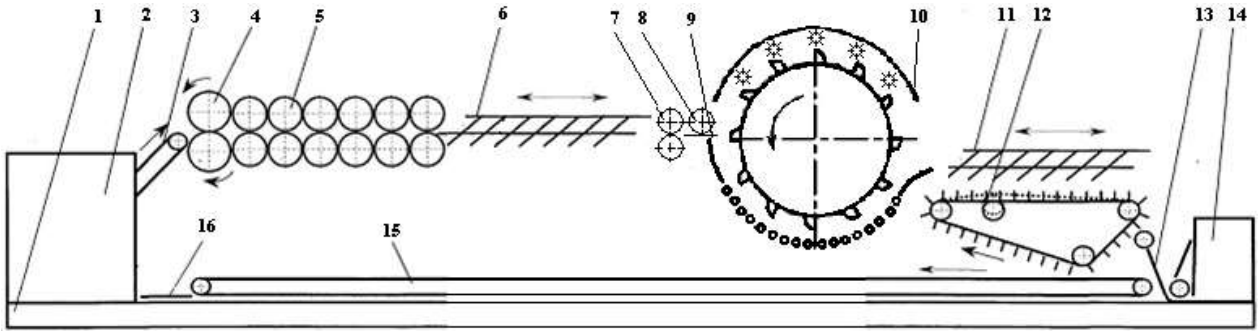


Fig. 4 – Schematic diagram of the mobile assembly for processing bast crop stems:1 – mobile platform; 2 – unwinding unit for rolls; 3 – feed conveyor; 4 – first pair of rollers of enlarged diameter; 5 – breaking unit; 6 – shaking machine; 7 – smooth rollers; 8 – feeding roller; 9 – feed track; 10 – scutching unit; 11 – shaking machine; 12 – vibration device; 13 – fibrous mass accumulating unit with a dosing device; 14 – rotary baler; 15 – belt conveyer; 16 – tray for collecting shives

The proposed mobile design of the assembly for processing the stems of bast crops provides ultimate conditions for breaking the links between wood and bast fiber, sufficient separation of the wood part of the stems from fibrous part, effective purification of the fiber from wood and other non-fibrous impurities, which, in general, has a positive effect on the performance of the entire assembly for processing the stems of bast fiber crops and provides for the versatility of its use due to the possibility of processing different types of bast fiber raw materials in different production conditions.

3. The innovative technology for producing fiber from bast crops has been developed based on the simultaneous use of highly efficient mechanical actions of breaking processes with drawing, scraping, and thinning of the raw material layer, as well as the scutching with heckling and shaking with the vibration of fibrous material, and the equipment for its implementation allows increasing the efficiency of breaking the residual bonds between wood and fiber of beaten bast raw material, separation of fiber from shives, the productivity of processing various types of bast raw material, producing fiber of high quality with low content of shives and non-fibrous impurities. It was found that the feasibility of the proposed innovative technologies for processing bast crops is due to the high quality of the monotypic fiber, reducing operating costs for its production by decreasing metal and energy consumption of equipment, which provides the minimal expected annual effect of using the assembly to produce monotypic fiber at the amount of 2,820,217 UAH, or 2.91 UAH per one kilogram of the obtained fibrous products.

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FORMATION OF THE MECHANISM OF COMMERCIALIZATION OF INTELLECTUAL TECHNOLOGIES ON THE BASIS OF THE FUNCTIONAL APPROACH

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DOI: 10.31891/monograph/2021-10-64

1. Introduction

Today innovative activity as the most important component of scientific and technological progress is extremely important direction of development of industrial production in any country. It is activity that allows for the constant renewal of industrial production based on the latest achievements of scientific and technological progress.

Successful commercialization of the results of intellectual work is the most important component of the innovative development of the economy in any country in the world. Business organizers are always faced with the question: how to create a rational scheme for making innovative products and their effective commercialization. The main goal of such a scheme is leading market positions and achieving the greatest possible commercial result from its production and commercial activities. Each country in the development and commercialization of innovations has its own characteristics, and these features are most show in countries that are not part of the European Union.

The results of the research carried out make it possible to identify a certain pattern, which manifests itself in the timing of fundamental and applied scientific research. Most often, fundamental research is ahead of applied research, which affects the terms of commercialization, which can be carried out only some time after the completion of fundamental research. In some cases, society even exerts an inhibitory effect on the process of carrying out fundamental scientific developments to create practical opportunities for the application of fundamental scientific developments.

At present, the commercialization (transfer) of the results of intellectual work is presented in the world as an independent branch of the economy. According to expert estimates, the annual volume of the world market for intelligent products is estimated at 6 trillion USD, the annual growth rates of this market exceed 10…12%. The results of effective commercialization of innovations

have allowed many countries of the world to take leading positions in the market of intelligent technologies. For example, the share of the international market for high technology products is 35% for the United States, 29% for Japan, 7% for China, while the share of Ukraine and Poland does not exceed 0,1%, for the Russian Federation – 0,5% [1, 2, 4].

2. Analysis of the existing practice of commercialization of intelligent technologies

To achieve their own effective indicators of innovation, the developed countries of the world are pursuing an active innovation policy. In different countries, the commercialization process has its own characteristic features, which are expressed mainly by different institutional conditions.

It seems necessary to consider foreign experience in the creation and use of mechanisms for the commercialization of intelligent technologies.

The most popular in the practice of innovation are such programs as "The Small Business Innovation Research - SBIR" and "The Small Business Technology Transfer Program - STTR", developed 40 years ago in the United States. The SBIR program serves to attract innovative ideas from small businesses to solve scientific and technical problems on the topics of the largest federal ministries and national agencies in the United States. The STTR program enables small businesses to receive financial and technical assistance in the creation of joint ventures and / or temporary associations focused on the development of new technologies from the initial idea to their full implementation [2, 4].

Similar programs are used in other countries as well. For example, in Japan, the SBIR program focuses on attracting financial resources and technical capabilities of the state in the form of grants, loan guarantees, soft loans, and outsourcing services. The purpose of these programs is to help start-ups of industrial enterprises that involve the development of intelligent technologies for their subsequent commercialization [2, 5]. In Canada, the analogue of the SBIR and STTR programs is the Industrial Research Assistance Program - IRAP. In Austria - "Cooperation and Innovation - COIN".

Less effective smart technology commercialization programs are being used in Sweden - The Innovation Bridge, which specializes in supporting the commercialization of research results; in Finland - The Center of Expertise Program - OSKE, which is designed to organize innovation management processes

in the regions of the country; in France - the “Agence Nationale de Valorisation de la Recherche - ANVAR” was created to provide assistance and financial support for innovative activities in the French industry, mainly in the small and medium-sized business sector; in Switzerland, opened the "National Centers of Competence in Research - NCCR" [2, 6].

National innovation programs that are used in the Republic of China are intended to a greater extent not for the development of processes and mechanisms for the commercialization of the results of innovative activities, but to a greater extent support the rapid innovative development of the entire country. For example, the 863 innovation program contributes to the development of national scientific and technological potential in the most important areas of scientific and technological progress. In China, these include space, nuclear and non-traditional energy, etc., which ensure stable growth of the entire national economy in the medium term. The Torch program is aimed at introducing advanced foreign and domestic developments into production. The Spark program is aimed at the development of agricultural enterprises and agriculture based on the use of scientific and technological achievements.

In European countries, private structures, which are intermediaries between the creators and consumers of new intelligent technologies, have also become somewhat widespread. These include various centers for the transfer and commercialization of innovations, including those created within the framework of research institutions.

An important mechanism for the effective commercialization of intelligent technologies is various methods of state support and stimulation of innovation. In the developed countries of the world, the following tools are effectively used to stimulate the transfer and commercialization of innovations [3, 8]:

a) direct financial support - subsidies, loans, loans on concessional terms without payment of interest and gratuitous. Their volume reaches 50% of the total expenses of developers of intelligent technologies (Germany, Great Britain, India, Denmark, China, USA, Norway, Sweden, France);

b) reduction of state duties for independent (individual) inventors, granting them tax incentives, payment deferrals or complete exemption from payment (Austria, Germany, Great Britain, India, Greece, Spain, Ireland, China, Poland, Norway, France, USA, Japan);

c) permission for employees of state research institutes and organizations to take part in commercial activities for the commercialization (implementation) of intellectual developments, as well as to work part-time, to own shares in an enterprise, to take part in the management of enterprises (Austria, Great Britain, Denmark, China, France, Greece);

d) simplification of taxation for organizations and enterprises that work in the field of commercialization of innovations: preferential taxation of universities, exemption from taxation of research and development costs (UK, USA, China, India, Japan);

e) legislative support for the protection and protection of intellectual property and copyrights, the creation of an economic and legal infrastructure for their insurance and economic support (Germany, Great Britain, Denmark, USA, India, China, France, Norway, Sweden);

f) creation and state support of a wide network of business incubators, science parks, technological development zones (Japan, USA, Denmark, Germany, China, India, Sweden);

g) methodological and informational support of the subjects of the innovation sphere: the formation of information resources and the creation of direct access to them, the simplification of the procedure for obtaining grants, the formation of special arrays of information (databanks) about patented inventions, etc. (UK, USA, Germany, European Union, China, Sweden).

Thus, for the effective market commercialization of intelligent technologies, a sufficiently developed complex of various organizational, economic and stimulating mechanisms is required. The study of foreign experience in the commercialization of innovations allows us to generalize examples of balanced state regulation of the sphere of innovation activity both through its direct participation in innovation activities and using methods and techniques of indirect support, including the creation, development and support of innovation infrastructure.

Some measures to support and improve the conditions for conducting innovative activities have also been implemented and implemented in Ukraine. Among them are tax and in-kind preferences; stimulation of contract research; state support for innovative activities of small and medium-sized enterprises; stimulation of researchers creating scientific results, etc. Unfortunately, most of

these mechanisms have not yet achieved the expected results. For these measures to be fully implemented, a long period of time is required. For the innovation sphere of Ukraine, such a low level of financing of the scientific and technical sphere threatens to catastrophically lag not only in the sphere of innovation, but also in the socio-economic development of the country.

Therefore, there is an urgent need for the development and implementation of new, scientifically grounded mechanisms for the commercialization of intelligent technologies, which, with a minimum amount of funding, could provide the necessary efficiency in their practical use.

3. Research results

There are various definitions of the term "commercialization", which, despite the existing differences, they all have one thing in common - commercialization is always considered as a sequence of certain actions. The successful activity of the developer of innovations in this area presupposes the timely selection of the most effective commercialization project. This allows him to rationally use (distribute) resources (primarily financial), as well as predict possible positive or negative changes in the target market for a given technology. With a functional approach to assessing commercial prospects for commercialization, the main task of an intellectual technology developer is to substantiate the form or scope of technology commercialization. The practice of commercialization has developed three main forms of using the results of innovative activities: internal commercialization (the use of technology only in its production), full sale of rights to the technology to another consumer (transfer of the right to use the technology on the basis of an exclusive license, which excludes the possibility of its use by the licensor in the area designated by the license) and the assignment of only a part of the exclusive rights to the technology (on the basis of a single or non-exclusive license, which does not exclude the possibility of its use by the licensor in the area indicated by the license). A detailed analysis of these forms of technology commercialization made it possible to identify and substantiate their advantages and disadvantages (Table 1).

The developer of intelligent technology can receive the greatest income only in the case of independent use of this development at his enterprise. In this case, there are real opportunities to create a completely new or significant modernization of existing production using this technology. However, this is the costliest method

of commercialization (creation and support of production processes, additional equipment, retraining of personnel, a new marketing program and advertising campaign, market revision of a new product, etc.). The technology developer does not always have sufficient resource capabilities for his own production, so he is forced to use other functional methods of commercialization.

Table 1. Advantages and disadvantages of functional forms of commercialization of intelligent technologies

Functional form of technology commercialization	Basis for use	Advantages	Disadvantages
Full transfer of exclusive rights to technology	Top management decision or based on intrapreneurship	- low costs; - a project with little risk of failure; - fast payback; - high level of profitability	- the level of income is limited by the license; - strengthening the positions of potential competitors; - weakening of their competitive advantages
Partial transfer of exclusive rights to technology	Single or non-exclusive license	- minimal risks; - low costs; - short payback period of the project; - opportunities for the development of new markets; - additional funds from the licensee; - development of the brand policy of the developer	- the minimum level of income from innovation; - high risk of counterfeit products; - the risk of unauthorized violation of exclusive rights
Use in own production	Exclusive license	- strengthening of competitive advantages; - the opportunity to get a very high income; - own control of production and sales; - opportunities for the development of their production; - no risks of violation of exclusive rights	- high risks of commercial failure; - long investment payback period; - great need for financial resources; - possible lack of the necessary facilities, equipment and specialists

The transfer of a part of exclusive rights, as a rule, is possible only to a potential competitor. This kind of operation provides the technology developer with a relatively low income, because the developer will receive only a part of the potential profit that will be received by the licensee.

The complete transfer of exclusive rights to intellectual technology is characterized by the lowest cost to the developer. At the same time, the developer could receive a fairly large income immediately (with a lump-sum payment for a license) or a stable income over a certain period of time (when using royalties). But it should be borne in mind that the developer completely refuses scientific and production activities in this area, which is usually stipulated in the text of the exclusive license.

The initial assumptions, which are proposed to be used as the basis for a functional approach to the commercialization of intelligent technologies, include a set of actions that involve the transformation of scientific research results into innovations. Innovations are formalized in the form of new goods or services, goods that are displayed in a market environment that combines the processes of material production, commercialization and the use of the results of intellectual labor (Fig. 1).

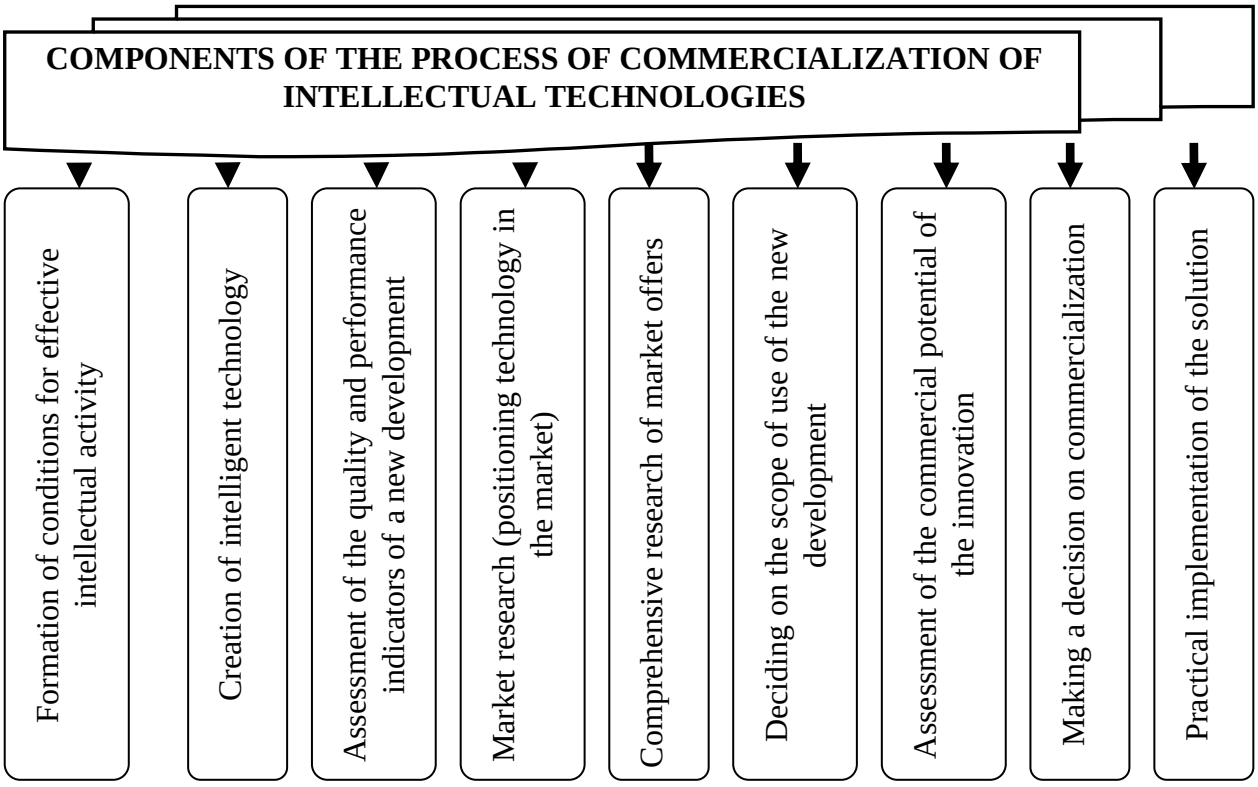


Fig. 1. Organizational components of the commercialization of intelligent technologies

The presentation of the organizational process of the commercialization of intelligent technologies in the form of a sequence of stages in the transformation of an innovative idea into a scientific product, brought to its consumer, provides a real opportunity to stage-by-stage analysis of the results of the innovation process,

to assess the amount of required resource (primarily financial) support, to choose the most effective commercialization scheme and financing methods. The approach to the commercialization of intelligent technologies as an investment project provides all the possibilities for accounting for financial risks, which allows taking certain measures to minimize financial losses.

During the process of commercializing smart technologies, income can be obtained from all commercial offers that:

- are directly related to the use of intelligent technologies;
- reflect the performance of research work to bring the technology to the level of market application;
- imply the sale of licenses for the use of technologies to third parties;
- create prerequisites for the practical implementation by developers of start-up companies or joint ventures with strategic partners for their own production of products, using the developed technologies.

The results of the research allow us to distinguish three functional groups of key participants in the process of commercialization of intellectual technologies: authors (copyright holders) of intellectual technologies; investors (buyers, consumers) of intelligent technologies; subjects of the infrastructure of the market of intelligent technologies. Each of these groups has an independent meaning and performs its main tasks within the framework of the tasks facing it [7]. However, each of these groups is in close relationship with other groups, as it is also subordinated to the successful solution of the ultimate strategic task - the effective commercialization of intelligent technologies.

The functional relationships between the three key groups - participants in the commercialization of intelligent technologies are shown in Fig. 2.

It seems appropriate to consider in more detail the group of copyright holders, which is the most important and intellectually strongest part of the technology commercialization mechanism.

The group of developers (authors) of intelligent technologies is most actively represented by several, to a certain extent, independent subgroups. The first subgroup is proposed to include research organizations and institutions that have achieved international funding (grants or foreign direct investment). These are successful representatives of intelligent technology developers, who, as a rule, account for the largest amount of new innovative technologies and know-how.

Note that in this case, the process of commercialization of innovations is carried out not by the institution itself, but by its owner (the customer of the innovative development). The state, a large firm (corporation), or a private investor can act as the owner (customer), which is usually secured either by legal means (registration of ownership or the conclusion of a certain agreement), or by transferring the results of scientific research to the customer (funding party) in the form of scientific reports.

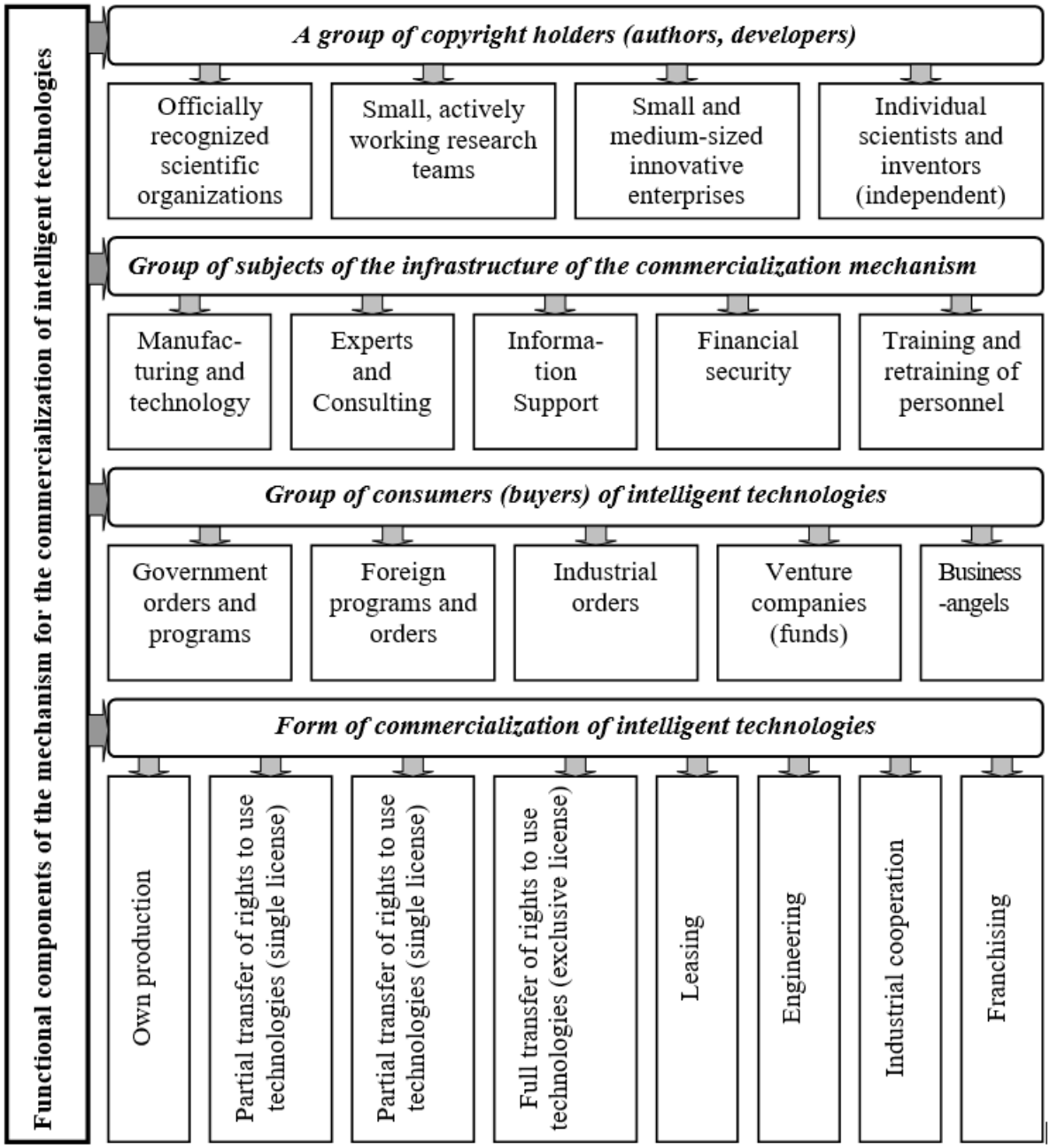


Fig. 2. Components of the mechanism for the commercialization of intelligent technologies based on the functional approach

The second subgroup of technology developers should also include research organizations (teams), which experience serious limitations in the resources

necessary for successful scientific work. Funding is provided in the form of small grants, scientific activity and its effectiveness largely depends on the enthusiasm of scientists. This subgroup of developers, as a rule, owns a large number of intelligent technologies, which are often not brought to the final stage and are not prepared for the commercialization process. At the same time, in our opinion, the commercial potential of this group of developers is the greatest.

The third subgroup includes small innovative enterprises that already have some experience in the commercialization of their own and borrowed scientific developments and most often specialize in small segments of the target market. This subgroup most often needs to expand its production and commercial activities, it has an urgent need for additional working capital. To this end, representatives of this subgroup are looking for strategic partners and investors, pay great attention to the development of their enterprises and expanding the scope of innovative projects.

The fourth subgroup is proposed to include scientists and inventors who, for certain reasons, are not members of scientific teams and do not actively participate in the work of organized teams. They are very limited in resources, often own a large number of patents, but in most cases they do not have the opportunity to bring their developments to market use [7].

4. Conclusion.

A detailed study of the components of the mechanism of commercialization of intelligent technologies based on a functional approach made it possible to formulate the following areas of their close interaction:

- it is necessary to improve the legal framework for financing innovations, to develop simplified mechanisms for financing the creative activities of small research teams that carry out effective innovative activities;

- an urgent task is the formation of a mechanism for reinvesting income from commercialization in new intellectual developments (projects);

- the participation of the state in the formation of cluster associations, their use as a base platform for the commercialization of technologies is very important;

- it is necessary to legalize the creation of infrastructure for the development of public-private partnerships in the field of commercialization of innovations;

- an important direction is the formation of a system of incentives for participants in the mechanism of commercialization of technologies that have a dual purpose.

Thus, a functional approach to the commercialization of intelligent technologies is designed to create favorable conditions using a system of material and moral incentives for all participants in the commercialization of intelligent technologies.

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INNOVATIVE TRENDS IN INDUSTRIAL MACHINERY ENGINEERING AND EDUCATION

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DOI: 10.31891/monograph/2021-10-65

1. Introduction

Given the dynamics of changes in production, mankind has experienced three industrial revolutions [1]. The fourth Industry 4.0 is a revolution of the near future, which is based on the latest information and communication technologies (Cyberphysical systems, Internet of Things, Physical Internet, Internet services, etc.), which form a high level of flexibility of production from mass to individual, increasing productivity by connection of production systems, their monitoring and diagnostics with the use of digital engineering and in real-time.

The transition to Industry 4.0 in the field of industrial machinery engineering on the example of knitting equipment is in its infancy and requires appropriate adaptation of engineering education in preparation for Industry 4.0. Thanks to the latest advances in science and technology, and especially in data processing, communications and digital integration of concepts and processes, innovative solutions for automation, digital visualization, computerization and electronics are being tracked in the field of industrial machinery engineering, aimed at expanding technical and technological potential of the latest equipment, which is confirmed by information from the exhibitions ITMA ASIA + CITMA-2018 [2], ITMA-2019 [3], the work of the European Committee of Textile Manufacturers [4] and sites of well-known manufacturers.

In recent years, a significant amount of work has been published on education in the context of Industry 4.0 [5-7], which examines the inconsistencies of the competencies of graduates of higher education institutions to the new qualification requirements "headhunters" and disparate concepts for their elimination. Therefore, the aim of the work is to analyze competitive technical innovations in knitting equipment according to the requirements of the transition to Industry 4.0 and to consider the adaptation of industry engineering education to the new qualification requirements in the era of Industry 4.0.

2. Research results

Digital engineering as a set of services of digital organizational and technological design, production and logistics chains and modes of operation of equipment is the key to the successful introduction of Industry 4.0 in knitting production. This allows you to develop new concepts of equipment management and expand technological capabilities on the demand of increasing individualization of knitwear. Digitization of the manufacturing sector using embedded sensors allows you to create closed digital images of both product components and processes and production equipment through cyber-physical systems and analysis of data sets. This expands the capabilities of electronic control systems and control of knitting processes, provides high reliability of equipment, limiting the intervention of service personnel, extreme accuracy and stability of positioning of executive mechanisms, expanding technological capabilities, implementing a rapid transition to a new range of patterns, sizes, weaves. For example, the use of digital technologies for sock machines allows you to implement non-standard technical solutions in the design of drives, control systems and needle selection, which reduces the number of mechanical components by 35… 40% [8], in particular using stepper motors. It also changes the amplitude of rotation of the needle cylinder to a given angle, which reduces the idling of the cylinder on the reverse when knitting heel pockets and the manufacturing time of the product as a whole. Digital support on the Ange 14 W model from Uniplet allows you to implement electronic knitting of the heel and bowl without the use of devices to change the number of needles, which increases productivity by (15… 25)% compared to the traditional approach. Manufacturers of sock machines are mainly inclined to electronics of their own production, which allows you to choose non-standard self-sufficient solutions in both hardware and software for production needs. Examples are the development of electronic technologies by Dinema for Lonati Group machines [9], electronic control system 2900SL on Rumi machines from Stäubli [8], an improved version of Art-Gen software on Busi Giovanni machines, Deimo microprocessor devices on Nova D knitting machines. and Lucia D, etc. A typical computerized control system for modern knitting machines is the SEVEN-R machine model from RUMI, which is equipped with a UPS device to support program memory and knitting process in case of power outages, a device for forming a heel due to knitting density

adjustment, Dream Box Solis pneumatic device for product orientation, high-speed modern WAC drive made in Japan, electronic adjustment of elastic thread feed and movement control of cams of the locking system, etc. An integral part of modern knitting equipment is the presence of electronic needle selection and switching thread carrier, which provides a quick change in the range and helps to expand the color scheme, patterns and weaves on the socks. In addition to independent developments of manufacturers, a wide range of high-speed electromagnetic needle selection units (actuators) and pneumatic systems from a specialized company Matrix [10]. On the example of Ange and Dera machines, the innovative Matrix technology provides high dynamic performance (extremely fast switching time), stable reliability, reduced energy consumption and a high level of accuracy even in adverse production conditions. Compactness, the highest level of reliability and performance at high knitting speeds are guaranteed by piezoceramic boxes for selection of knitting needles from WAC, Siemens and Matrix. A completely innovative solution is the device for selecting needles on the principle of a monomagnet, which is presented by Lonati on DC88 and GX series machines.

An example of the evolutionary advancement of computing capabilities on knitting equipment is the XT Machine from Santoni [11]. The equipment is equipped with a new automatic system, which is controlled by a microcomputer and a revolutionary needle selection system, which allows you to knit unprecedented three-dimensional weaves with the original 3D Intarsia technology. The main uniqueness of the XT Machine is the ability to knit the top of sports shoes in a pre-selected shape and with a perfect fit to the foot with unlimited patterns and color combinations. The footwear which is made on XT Machine automatic machines, in comparison with traditional, differs in ease, convenience, a possibility of creation of special individual characteristics and the highest quality. The main strategic advantage of the Santoni innovation is the ability to efficiently and quickly design and manufacture footwear, which significantly reduces the overall production time and production waste. Sock machines on the way to Industry 4.0 are equipped with software, systems for product development and related manufacturing automation technologies. As an example, Rumi machines model Seven-R [12] implemented a version of SD software based on the well-known graphics program Rudidraw for image creation and program preparation and management editor, which is implemented in the Windows 95/98/2000 / IU /

XP operating system, has specific control functions to simplify the work of operators (quite intuitive creation of drawings, the ability to work with multiple open drawings, high bit size with convenient scaling for viewing small details), allows remote operation of the scanner and printer when transmitting images in different graphics formats. On Lonati Group products, product creation and knitting process control is performed by the Digraph 3 Plus software package, which contains a complete collection of styles and helps the operator to combine them to achieve the desired results. On the machines of Uniplet A.S. the graphic design system is composed of two programs Stayler 4, Stayler 5 (developer Deimo) and SuperGraphic (developer Sunrise) based on PIC and BMP formats. S-Paint and SKMon software for sock product design and production monitoring are used on Busi Giovanni's Idea Terry machine models, respectively. The updated version of the Art-Gen software of this company provides customers with the implementation of individual programs of knitting socks of their own design on the basis of intuitive functions, with subsequent sending and installation on the equipment via the network. Lonati offers an operating system that allows you to remotely control the control of machines using mobile devices (smartphones, tablets, smart watches).

The use of electronic systems on advanced machines allows for full automation of knitting socks with a closed bowl without the use of sewing operations. Suturing of socks with closing of fingers is carried out on models of automatic machines Seven-R (manufacturer Rumi) by the D4S device from the Swiss company Stäubli [8] which provides high efficiency thanks to minimization of idle time at independent operation of the device and the automatic machine. Among others, Lonati Group's GK line machines stand out, which use the SbyS automatic bowl sewing system (Stitch-by-Stitch) [13], the Toe Closer system, which is presented by Matec on the HF Super 4.7 PBT [14] and Star-D models, a device Lin-Toe® machine Jumbo company Sangiocomo SpA, a number of machines from Uniplet. A fully automatic connection with the "Classic kettle bowl of socks" function is provided on Busi Giovanni machines with the Rimaglio automatic device, which is located next to the machine and works separately [15]. It is obvious that in the near future, fully automatic knitting of socks will become a global standard in the industrial machinery engineering, given the high cost-benefit ratio and rapid return on investment. Autotex equipment is designed to automate

the final operations of packing socks, including: turning the sock on the front side, sewing a label, high-quality thermal printing, marking products with programmable radio tags, applying an adhesive sticker, which eliminates the need to organize a sewing department and manual operations in continuous production.

In the long run, knitting machines should be flexible in the use of additional devices and accessories, especially to tension control and yarn speed control. Innovative solutions for yarn feeders include embedded intelligent systems for noise suppression and erroneous operation. There are Yoyo devices from Dinemo Electronics, which control the supply of yarn in knitting machines (round knitting, sock, flat knitting, etc.) using highly efficient sensors and stepper motor, which are programmed by adjusting and maintaining different tension in the yarn depending on specific knitting process and type of raw material. BTSR International S.P.A. [16] proposed microsystems of active supply of yarn feeding Ultrafeeder 2 with the function of accumulating yarn on the drum and anti-twist system with built-in knot detector, universal device EFS 920 with integrated feed system for both elastic and conventional threads, from the market leader in yarn feeders Memminger-IRO. BTSR offers Smart Matrix 64H terminals with IS4F HTS electronic sensors, which allows programming and control of yarn consumption for real-time production monitoring and, according to the developers, is able to eliminate at least 80% of raw material waste.

With the use of electronic control unit there are possibilities to control the system of vacuum selection of products, pneumatic switching of thread guides, system of automatic change of product density based on stepper motor, anti-twist system, pneumatic device Dream Box Solis for product orientation, independent stepper motors for cam control, position sensors such as Honeywell and Lesikar, etc. One of the latest solutions to increase the durability of machines is the unique Pulsonic 6 lubricator, which provides optimal dosing and distribution of oil through both computer control and a local network of interconnected controllers (Controller Area Network).

Advances in automation, computerization and technology of production and logistics processes together with advances in e-commerce in the near future will create digital enterprises that will produce individual products based on consumer demand and without the need for traditional production and logistics chains, i.e. to implement trends Industry 4.0. Therefore, the movement of knitting machine

manufacturers is obvious regarding the possibility of adapting the product range or developing machines for modular factories, which could be easily modified according to specific customer requests. Smart production facilities are formed by combining production with information and communication technologies that allow manufacturers to seamlessly integrate various intelligent products and processes. An example is the SDS-ONE APEX4 system. SDS-ONE APEX4 from Shima Seiki, which provides integrated support for knitting production from planning to production and sales promotion, i.e. is a Total Fashion system. This ensures the transition of production from mass to "on demand", which eliminates the need for traditional production and logistics chains and maximizes profits from zero losses from stockpiling and lost sales opportunities, timely response to rapid and flexible fashion trends and more. The possibility of making knitwear in networks is a reality. For example, Busi Giovanni is implementing a concept that allows its customers to create individual sock knitting programs with a number of intuitive functions, followed by remote loading on the equipment.

Obviously, adapting to Industry 4.0 increases the need for time, dynamic, flexible and at the same time integrated networks. Large-scale data processing and artificial intelligence networks support the self-organization of machines and autonomously determine the range and quantity of products ordered, i.e. connect all technological and organizational chains from yarn to the final product. Modern information and communication technologies are shaping the business models of future knitwear production using new forms of organization, including virtual ones, in which product development, production and sales are networked in different locations and companies. Concepts, methods and IT systems are being developed that support both the management of global development and production networks and regional players. It provides shared access to data, information and knowledge, coordinates processes and expands the boundaries of cooperation.

One of the important tasks for Industry 4.0 is to create "green" technologies in accordance with the requirements of environmental standards. In the knitwear industry, it is the reduction of production waste, promotion of its reuse, automation of waste sorting by type of fibers and color, recycling of plastic containers, use of solar panels, windmills, clean gas, environmentally friendly dyes, etc. as energy sources.

It is obvious that the consistent implementation of Industry 4.0 requires the latest educational system Education 4.0, which will eliminate the mismatch of competencies of employees to the requirements of the future in the labor market and promote the development of future engineers in the digital world of the future. In [5, 17] consider new requirements, including: Interdisciplinary thinking, decision and problem solving, cultural and intercultural competency, and lifelong learning, etc. and identify the main problem of employees regarding the implementation of cyberphysical systems.

Innovations in the services of higher education institutions and other educational providers include on-line and interactive learning, which provides access to on-line learning, open learning systems, e-learning offers on free access courses at "open" universities, including intersectoral networks in in the spirit of Industry 4.0, regardless of location and time. This allows you to gain knowledge individually with the help of special tools and digital media that regulate the levels of complexity of the material in accordance with the abilities of the consumer of knowledge. Flexibility of learning is manifested in the transition from a traditional education system with the same methods for each to individualization of approaches. In the context of digitization and integration into the Internet, the idea of lifelong learning, for example in the workplace, is being considered. Important are the elements of project-based learning with the ability to apply theoretical knowledge to real projects, which allows you to focus on the end result, collaboration in teamwork and time management. As information technology is a reality of the future, an important competence is the interpretation of data, including the management of virtual systems, the collection and processing of information. One of the key changes in engineering education is the implementation of projects at the interdisciplinary level with the cooperation of teachers of various specialties, cooperation between universities and industry. The role of hybrid teams, which include people and machines working together in a virtual and decentralized (or international) production environment Industry 4.0, was reported in [18,19]. With this perspective, there are requirements for engineering education of the future, such as cooperation in the virtual environment and human teams and robot. Smart machines, machine-to-machine communication (M2M), data security, big data, support systems such as mixed reality systems are areas where the emphasis is on changing learning technologies [20] using virtual

AR modeling and complementary VR realities, remote labs. In [21] an example of a virtual laboratory in an integrated learning environment for students of computer science and automation engineering with the ability to access and control devices via the Internet, in [22] - a modification of teaching students of industrial machinery engineering in conventional simulation games to reproduce key aspects of Industry 4.0. By drawing on real industrial technologies such as ERP systems and barcodes / RFID chips, students can create an Industry 4.0 environment. In [23] methods of teaching industrial networks and their application in production are discussed. The role of mentoring and mentoring in relation to students in their professional development and adaptation to market requirements is reported in [24].

The paper [7] provides information on training programs in a number of engineering specialties, which summarizes the developments of leading foreign universities, related specialties Machinery Engineering and Industrial Engineering - a list of additional disciplines in accordance with Industry 4.0. This primarily applies to artificial intelligence and robotics, the Internet of Things (IoT) and 3D printing, virtual AR and augmented VR realities, statistical methods of data analysis, database systems, IT security, bio- and neurotechnology, etc. - the latest trends in production and society.

Given the trend towards digitalization, there is a growing demand for digital literacy, which is necessary to work in a digital environment, such as virtual AR and augmented VR realities, which will have significant application in future corporate training methods and strengthen their skills in the professional sphere. The shift from low-level programming languages to those related to databases and artificial intelligence (Python and R) is obvious. Disciplines Statistical Methods of Data Analysis and Database Systems lay the foundations for understanding the subjects Machine Learning and Artificial Intelligence. In addition, there is a need to analyze and evaluate data flows between production resources and network systems based on Big Data, databases without SQL no-SQL databases, MapReduce and data management in the cloud, because conventional programming is not able to analyze large volumes of information.

At the same time, issues of information protection system are becoming relevant. To do this, it is advisable to expand the training of students in the areas of Intelligent systems, IT security and hardware systems (industrial applications). In

the area of IT security, security system issues are proposed for consideration and protocols, cryptology, network security, data privacy and security, and security management.

The future era according to the principles of Industry 4.0 is also characterized by mass automation of processes and productions, robotics, introduction of new digital and biotechnologies and renewable energy in industry. Therefore, the required courses Embedded systems, Industrial automation technologies, Industrial robotics and Real time systems. The introduction of the provisions of these disciplines in the production environment will allow you to work independently and autonomously in accordance with the analysis of their own condition and the environment.

An important component of promoting various aspects of Industry 4.0 through intermediary activities between student and production projects are student clubs [25].

3. Conclusion

Priority trends of machine-building companies producing knitting equipment in accordance with the conditions of transition to Industry 4.0 are aimed primarily at production flexibility in setting technological parameters and individualization of product range, improving productivity, quality and efficiency of resources through collection, control and analysis of production information in real-time. The main means of achieving the goal include digitization of information, use of computerization, automation, electronics, organization and support of production processes with the involvement of global electronic networks, taking into account the wishes of customers. This will allow the implementation of business models of future knitwear production using new forms of organization, in which development, production and sales will be combined in a network for joint corporate cooperation of enterprises and consumers of products. Also listed are the requirements for the Education 4.0 education system in the light of Industry 4.0 implementation and relevant innovative solutions from leading foreign universities and other educational providers to provide competencies that will meet the requirements of the future labor market.

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NEW CELLULOSE-CONTAINING MATERIALS FROM HEMP

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DOI: 10.31891/monograph/2021-10-66

1. Introduction

All over the world, annual bast hemp plants are used in three directions – technical (production of oils, fabrics, road surface, etc.), medical (medicines production) and recreational (for non-medical use). The use direction of the plant depends on the content of the psychoactive substance tetrahydrocannabinol (THC). The different countries legislation sets a limit on the THC content, when hemp is considered technical (industrial) and can be freely used in industry, and when is considered narcotic, with certain restrictions or prohibition on distribution. According to Ukrainian legislation, hemp with a THC content of up to 0.08% is technical, and plants with a THC content exceeding this value are automatically considered narcotic. Currently there is no definition of "medical hemp" in Ukrainian legislation.

Hemp is a highly profitable crop, which in its structure has about 200 active substances, 18 of which have been studied. Such substances include, in particular, cannabidiol (CBD) and THC - the most studied cannabinoids.

In agriculture, this plant is used in the production of fiber, the strongest in the world. Technical hemp is part of the process of edible products production (including cakes and sweets), medicines and cosmetics, building materials, and it is also used in the fuel and energy industry as a green environmental alternative. Granules from waste of hemp processing are used even in road construction. A striking example of such construction is the Kyiv-Odessa highway.

This plant is used to make securities, and it is also very often used in the automotive industry to facilitate construction.

2. Modern directions of deep processing of industrial hemp to create innovative products

Detailed study of the properties of modern non-narcotic hemp and development of the newest technologies of their processing, allows to use all components of a hemp stalk - that’s all creates innovative products with new quality characteristics, which is widely used in various industries.

In modern economic conditions, there is an objective need to develop new resource-saving technologies for hemp harvesting, based on the use of powerful adapted machines of general agricultural purposes: combines, harvesters, straw type forage balers etc. As a result, there is a problem of processing hemp raw materials - straw, which remains after harvesting the seed part, and in its mass consists of chaotically arranged stems. Was offered the decision of this question based on allocation of a bast from hemp stalks without dividing the latter into long and short, i.e. in the form of the same type of material. According to the chosen strategy of hemp straw processing the mechanical actions which are applied in primary processing of straw stalks are chosen. For this, the crushing, scuttling, and shaking processes are used, but these actions are used to separate the fiber from the stalks of the hemp straw, where the connection between the fiber and the wood is weakened during its processing. Therefore, for allocation of a bast with stalk straw of hemp in addition other mechanical actions are used, aimed at increasing the intensity of bast separation from wood and other non-fibrous tissues [1, 2].

Today it is possible to use a whole stem of non-narcotic hemp for energy purposes, namely for the production of liquid biofuels, ethanol and biogas. [3].

The leaves of this culture are used as raw material for fodder and mushroom growing.

The fiber content in modern varieties of non-narcotic hemp is 30-35 %. Technical textiles are made of hemp fiber: sea and river ropes, twines, ropes, nets, tarpaulin and sail, also textile products: fabrics, work clothes, shoes, haberdashery. In the world, non-narcotic hemp is used for the manufacture of nonwovens and composite materials, geotextiles, cellulose, paper of various types and purposes.

It is known that in Ukraine from 1 hectare of forest, depending on tree species and climatic conditions, 2.0-2.4 tons of wood are produced, which causes great damage to the environment. At the same time from 1 hectare of non-narcotic hemp sowing for 90 days it is possible to receive 7,0-9,0 t of cellulose-containing raw materials. [4-7]. The conducted economic analysis showed that it is much more profitable to get cellulose from hemp fiber than from bast and shives. With a stem yield of 7,0-9,0 t / ha, an average of 5,3 t of shives and 2.8 t of hemp fiber are obtained. The yield of cellulose from hemp fiber is 82 %, and from shives – 40 %. Therefore, from hemp fiber get 2,3 tons of cellulose, and from shives – 2,1 tons, but obtaining cellulose from the shives requires more stringent boiling regimes.

The hemp shives are 65-70 % of the total mass of the bast stem and consist mainly of cellulose (45-58 %), lignin (21-29 %) and pentosans (23-26 %). Building and heat-insulating plates, paper, fuel, etc. are made of shives. Shives can also be a good substrate for mushrooms growing, material for soil mulching, and due to its high hygroscopicity it is used as a litter for animals. In composted form, it can be used for growing vegetables indoors. In addition, from the shives you can get adsorbents that effectively remove various toxic substances from the body.

Hemp is a much better raw material for the hempcrete production than flax. The good strength of hempcrete on Portland cement using hemp shives are explained by the fact that in hemp plants, to isolate bast fibers hemp, stalks are subjected to long-term hydrothermal treatment (soaked for 20-30 days, then dried). This allows to significantly reduce the content of easily hydrolyzed substances that inhibit the hardening of Portland cement. Hempcrete – lightweight concrete, a type of arbolite with the use of hemp shives as an organic filler is made from a mixture of shives, binder (usually cement), mineral filler (sand) and water. To mineralize the shives and accelerate the curing of the mixture, calcium chloride, alumina sulfate together with slaked lime or other additives are added to it. The bulk density of hempcrete is from 400 to 700 kg / m. The material has low thermal and acoustic conductivity, easy to handle, does not rot, is an unfavorable environment for rodents and insects. It is used for construction of internal partitions in apartments, and also for heat and sound insulation. The main producers are France, Australia, Ireland, Germany and Ukraine [8].

Hemp shives fuel, the main producer of which is the Ukrainian JSC «Technovolokno», is produced in the form of briquettes that burn with a bright flame, practically do not smoke and leave almost no ash after combustion. In terms of calorific value, hemp straw is slightly inferior to coal, but is superior to softwoods and peat (table 1).

It should be noted that the development of new technologies for biofuel from domestic raw materials, in particular hemp shives, which meets modern requirements of European quality standards, is currently a priority in the field of resource and energy saving in Ukraine.

Table 1. Energy indicators of different fuel types

Energy indicator	Non-narcotic hemp	Coal	Soft tree species	Peat
Calorific value, kcal / kg	3760	4800	2700	2030
Initial combustion temperature, °C	-	620-700	500-650	500-650

On the basis of Kherson National Technical University the basic scheme of a laboratory sample of an extruder for processing of a flax and hemp shives was developed. The proposed scheme is a simple and easily changeable design of the controller mechanism. For change of physical and mechanical parameters of the received production, the possibility of change of an initial cone is provided, that allows to form both pellets, and briquettes on the same equipment. [8].

Qualitative characteristics of biofuels obtained on a laboratory auger extruder from flax and hemp shives, are given in table 2.

Table 2. Qualitative characteristics of biofuels obtained from flax and hemp shives

Characteristics	Testing method	Unit of measurement	Shives	
			flax	hemp
Diameter	Measurement of 10 random samples	mm	5-8	5-8
Length	Measurement of 10 random samples	mm	< 20	< 20
Calorific value	DSTU ISO 1928:2006	MJ / kg	19,0	18,5
Ash content	GOST 11022-95	%	0,7	0,8
Moisture content	DSTU 8995:2020	%	< 10	< 10
Sulfur content	DSTU 3528-97	%	No	< 0,01
Chlorine content	DSTU CEN/TS 15289:2009	%	< 0,02	< 0,02

The obtained results analysis showed that the content of the main components of biofuels meets the requirements of European standards, and the

content of such harmful substances as sulfur and chlorine, respectively, 0.01 % and 0.02 % less than required by the German standard DIN plus.

It should be noted that the widespread use of additional areas of non-traditional use of hemp products, thanks to scientific developments in the processing industry, will promote the innovative development of hemp production in Ukraine [9, 10]. At the same time, almost the only ways to solve the problems facing enterprises for fibrous materials processing are deep processing of low-grade short fiber in various industries, fuller use of industrial waste and so on. Comprehensive processing of hemp raw materials is a prerequisite for the efficiency of the enterprise.

The most profitable in Europe is the production of biocomposite materials from hemp. The market leaders are France and Canada, where such materials are used in shipbuilding and mechanical engineering, on railways, for the manufacture of furniture, packaging and so on. The modern European car consists of 20 % of biocomposite materials based on hemp. So, it is much lighter and more environmentally friendly than the models currently produced at domestic enterprises. The Ford Motor Company has made a special racing car, which on 80% is made of hemp based materials. Even fuel for it was obtained from hemp. Only glass, mirrors and individual engine parts are made of the usual materials in the car. The fuselage of the Boeing 787 on 80% is made of hemp biocomposites.

Recently, seed, energy (Elifibre LLC), textile (Agro-Hanf LLC), oil and food (FG Kravets OP, Kunchansky) and other areas of technical hemp use have started to develop quite successfully in Ukraine. All members of the Ukrainian Technical Hemp Association believe that that the results achieved by breeders on the creation of non-narcotic and highly productive varieties of hemp have allowed not only to maintain high efficiency of the world hemp industry, but also to ensure the functioning of highly profitable export-oriented enterprises using domestic hemp raw materials [11].

Summarizing the achievements of Ukrainian scientists in the field of modern technologies of deep processing of stems of technical hemp, we can conclude that that these developments are pioneering and are at the initial stage of experimental laboratory research. Their systemic development requires further scientific work. Therefore, one of the main tasks of this work is the development of scientific bases

for deep processing of stems of technical hemp in order to obtain fibers of different functional purposes.

3. Technical hemp deep processing to obtain cellulose-containing products

Due to the limited raw material base of Ukraine, during the production of cellulose for the cellulose-paper industry it is most appropriate to use industrial crops and waste processing [12]. As hemp has some of the strongest plant fibers (breaking length is 3,3-6,0 km, while in cotton it is 2,3-3,6 km), it is used by the world's cellulose-paper industry to produce high-strength paper. So, for example, in Australia from hemp cellulose receive special kinds of paper for banknotes, actions, filters, tea bags, in the United States and Canada, hemp straw is processed into cellulose for the production of office, banknote, cigarette and airmail paper, in British Columbia - for the printing paper production, in Egypt – as part of a composition for the various types of paper manufacture [13].

In Canada and Argentina, where flax and hemp are grown, shives are used to make cellulose for cardboard and wrapping paper. [14].

The domestic cellulose-paper industry does not use hemp as a raw material for the production of cellulose, paper and cardboard.

The Ukrainian market for technical hemp production is small and highly regulated. Only 2,000 to 4,000 hectares of land are sown annually, however, back in Soviet times, Ukraine grew about 120,000 hectares of technical hemp and had 35 processing plants, of which only 3 remained today. Thus, today Ukraine's production capacity has decreased by 30 times.

In the process of primary processing of hemp into fiber, the bast fibrous part (20-28 % by weight of the stem) is separated from the wooden, a long fiber and short fiber are formed (83-85 % of the total yield of fibrous mass) and a shive, the yield of which is about 55 % of straw weight. Short fiber and shives are production wastes, so solving the problem of their processing and rational use is an urgent task today.

Recently in the countries of the European Union long and short fiber of hemp is applied to production of fabrics and clothes – 50 %, furniture upholstery – 13 %, other household products – 20 %, bags and ropes – 17 %. Hemp fiber is now used in the automotive industry by such companies, as AUDI, BMW, Opel, Saab Volkswagen. Its advantage is that the plastic parts of the car interior can not be

utilized, and parts with hemp fibers due to their biological processing are converted into humus [15-18].

Another interesting use of hemp fiber is medicine – for the production of bandages and surgical threads.

Hemp shives are used to produce blocks and plates made from hempcrete for construction and furniture industries, as well as fuel briquettes.

Today, almost all high-quality hemp fiber is exported from Ukraine. Short fiber with a with the hemp shives content of 10-24 % has limited use in the textile industry for the production of low-value products – technical fabrics, ropes, twine. The rest of the fiber is exported at dumped prices, as there are no technologies for its processing. The use of non-narcotic hemp short fiber in the cellulose-paper industry will make it possible to rationally use the waste of hemp processing plants and receive domestic raw materials for the needs of Ukrainian enterprises.

4. Conclusion

Analysis of world and domestic experience in the use of hemp for the manufacture of consumer goods shows that in European countries, China, South Korea, Canada the volume of growing hemp and processing them into various products is steadily increasing. In Ukraine, despite the great potential, hemp production is in crisis, despite the fact that Ukrainian breeders are pioneers in the selection of non-narcotic hemp. This state of the hemp processing industry is due to the use of outdated technologies for hemp raw materials processing and a narrow range of products. – long and short fiber, which is almostly not demanded in domestic and foreign markets.

The hemp industry can avoid the crisis by developing the latest straw and hemp rettig processing technologies, which will allow the fiber receiving with new technological properties, with the requirements of technologies for their further use in the textile, pharmaceutical, pulp and paper and other industries.

As a result of production tests, it is proved that high-quality cellulose is obtained from hemp fibers obtained by retting grinding to a length of 15-20 mm. Although the cellulose received from a bast and hemp fibers is characterized by high values of physical and mechanical indicators: density, breaking length, absolute resistance to puncture and tearing, resistance to breakage and whiteness. In most of these indicators, hemp cellulose is not inferior to the wood-derived

cellulose, and in terms of tear resistance and resistance to breakage, it is superior to it.

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STUDY OF A BIO-BASED FIRE RETARDANT FOR IMPARTING FIRE RESISTANCE TO COTTON TEXTILES

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DOI: 10.31891/monograph/2021-10-67

1. Introduction

The most common phosphorus-containing formulations for processing cellulosic textiles are [1] tetrakis hydroxymethyl phosphonium chloride (THPC) and N-methylol dimethylphosphonopropionamide (MDPA), marketed under the trade names Pyrovatex CP and Pyrovatex CPN. These compounds interfere with the pyrolysis reaction, which prevents the formation of levoglucosan and flammable volatiles, and increase the formation of char. But the main disadvantage in the use of these compounds is the release of formaldehyde during the curing of the finishing compound and the use of the treated textile materials, since formaldehyde is declared as a carcinogen according to the World Health Organization. Given the shortcomings of the used fire retardants, the strict directives of many countries regarding their chemical composition, the need for the introduction of environmentally friendly durable flame retardant substitutes increases [2].

Recently, researchers have shown interest in phosphorus-containing substances based on bioorganic compounds of phytic acid for the development of flame retardants. Phytic acid is also known as inositol-hexakisphosphate acid or phytate, in the form of a salt, and is regarded as a "green" molecule found in abundance in plant tissues such as beans, grains and oilseeds [3, 4]. As a biocompatible, environmentally friendly, non-toxic and easily obtained organic acid, it is widely used in antioxidant, antitumor, biosensor, cation exchange, nanomaterial and other fields due to its special structure of inositol hexaphosphate [5]. In terms of molecular weight, phytic acid contains 28 wt% phosphorus and is promising as one of the possible and effective materials for the development of flame retardants.

Phytic acid is being studied as a fire retardant to reduce the flammability of materials based on cellulose, silk, wool, mixed fibers. One of the pioneering studies on the use of this biologically based molecule as a fire retardant dates back to 2016 and describes its effects on wool fabrics [9]. The fabrics were immersed in

aqueous solutions of phytic acid with a concentration of 10 to 200%, under acidic conditions at pH = 1.2, and then thermally treated at 90°C for 1 hour. As a dopant acid, it was used to significantly improve the characteristics of fire retardant composite paper deposited with polyaniline [6]. The potential fire retardant effect of various metal phytates has been assessed as biosource phosphorus additives for polylactic acid-based composites [8].

Phytic acid is composed of six negatively charged phosphate groups and has a strong tendency to combine or interact with positively charged metal ions or proteins [10, 11]. This means that phytic acid can combine with wool fibers (natural protein fibers) through electrostatic interactions between positively charged amino groups in wool and negative phosphate groups. It also readily chelates with metal ions and provides an acid as well as a carbon source [12]. Phytic acid with chitosan, as well as phytic acid and nitrogen-modified silane hybrids were used by layer-by-layer assembly for the manufacture of thin flame retardant films on cotton fabric [7].

Interesting studies carried out [20] to determine the thermal behavior of phytic acid solutions, which confirm the ongoing processes of carbonization and dehydration of phytic acid as a result of the OH groups decomposition present in the biomolecule between temperatures of 248°C and 447°C. With a further increase in temperatures, the next stage is observed between 447 and 863°C (Dm = 41.5% and DTG T_{peak} = 648°C) and is due to the process of thermal decomposition of phytate groups and the removal of elemental carbon formed in the previous stages. At 870°C, the cumulative weight loss was 97%.

2. Goal of the study

Phosphorus-containing compounds used as fire retardants are thermally decomposed to PO, which blocks the combustion process of textile materials, despite the fact that when matrix combustion is extinguished, H and HO are also formed. However, phosphorus-containing compounds are capable of catalyzing dehydration and carbonization reactions containing OH compounds [13]. Considering this circumstance, studies were aimed at increasing the thermal stability of cotton textile materials using a phosphorus-containing biomolecule.

3. Materials and methods

The change in weight, the rate of change in weight and the magnitude of heat effects under the influence of elevated temperatures on the cellulose-containing textile material were studied by thermogravimetric and differential thermal analysis after examining the samples on a Thermoscan-2 derivatograph. The studies were carried out with treated and untreated fabric samples in a temperature range of up to 700°C using quartz crucibles. During the study, the rate of temperature rise was 10°C. Alumina was used as a reference. The mass of the samples was 0.1 g. The samples were heated in air from 10 to 800°C at a constant heating rate of 10°C/min.

Cotton textile materials were treated with an aqueous solution of phytic acid as the main fire retardant with the addition of tricarboxylic acid, which helps to increase the solubility of phytic acid in water and to increase the carbon residue during the burning of the fabric. To eliminate residual combustion, reduce the length of the charred section, and reduce smoke generation during combustion, inorganic metal compounds are used, therefore, the effectiveness of the addition of aluminum salt was also studied in the work.

4. Results and discussion.

After processing with the finishing composition, the textile materials were dried to constant weight at a temperature of 80°C. The results of the thermal stability of the studied textile materials are compared with untreated textile materials in Table 1.

Table 1. Thermal stability of cotton fabric

Composition	T_{init} (°C)	T_{max1} (°C)	**Residue T_{max1} (%)**	T_{max2} (°C)	**Residue T_{max2} (%)**	Residue at 600°C (%)
Untreated fabric	323	363	**51**	499	**2.82**	< 1
Phytic acid + tricarboxylic acid	230	321	**56**	550	**25.2**	6.8
Phytic acid + tricarboxylic acid + aluminum salt	120	230	**64**	544	**24.5**	6

As follows from the results of heat resistance presented in Table 1, a sample of cotton fabric without treatment demonstrates three stages of decomposition, the initial of which occurs at a temperature of 323°C and two temperatures with peaks T_{max1} at 363°C and T_{max2} at 499°C.

The combined treatment of textile material with phytic and tricarboxylic acids reduces the onset of destruction of the cellulose substrate to a temperature of 230°C. The studies carried out correlate with the data published in [14, 15], which showed that cotton decomposes in air in three stages: the first stage of decomposition occurs between 300 and 400°C and includes two competitive pathways that trigger the formation of both aliphatic semi-coke and gaseous particles. The second stage occurs at temperatures from 400 to 800°C, during which the aliphatic semi-coke is partially converted into an aromatic, more stable analogue or is oxidized, forming CO and CO_2. When the temperature rises to 800°C, the charcoal formed in the previous stages continues to oxidize.

Metal ions can also effectively catalyze the formation of a stable crosslinked layer of charcoal, preventing smoke and further pyrolysis of polymers. It was shown in [16] that, in fact, gC_3N_4 and PAZn containing nitrogen, phosphorus and zinc can be an ideal combination to improve the fire resistance of the matrix.

The presence of phytic acid on the fabric, as well as phytic acid and aluminum sulfate, shift the temperature towards lower values, for example, 230, 321°C, and 120 and 230°C, respectively. These shifts, as was estimated and in works [17, 18], are obvious in the presence of phytic acid in the compositions. This behavior is observed for cotton fabrics treated with biomacromolecules, when the flame retardant coating is activated to form a stable char that can act as a thermal barrier, in contrast to the formation of flammable gaseous products that can further stimulate the decomposition of the cellulose substrate [19].

The composition containing $Al_2(SO_4)_3 \cdot 18H_2O$ as a smoke suppressor lowers the decomposition temperature to 230°C, which is explained by the loss of water when the temperature rises in the range from 230°C to 420°C, and at a temperature of 420°C a completely anhydrous form is formed aluminum sulfate. With a further increase in temperature, aluminum sulfate also decomposes above a temperature of 580°C into the γ-modification of aluminum oxide and sulfuric anhydride. The beginning of the thermal decomposition of aluminum sulfate with the release of sulfur oxide helps to limit the residual combustion of the fabric under study.

The maximum temperature at which the final degradation of cellulose occurs, on the contrary, shifts to a higher temperature range, from 499°C for untreated fabric, to 550°C and 544°C for fabrics containing phytic acid. The weight loss in this case varies from 51 to 56% of the residue, and the presence of final residue increases by 6%. The shift in temperature to a higher region confirms the increase in fire resistance of cellulosic textiles treated with compositions containing phytic acid.

For the development of fire-resistant compositions, the creation of intumescent systems has recently been widely studied. When heated, these systems form a bulk foamed carbonized layer that acts as a physical barrier that slows down heat and mass transfer between the gas and condensed phases. Intumescent systems consist of an acid source, a carbon-containing component and a blowing agent. In combination with phosphorus synergists, intumescent agents (nitrogen-containing compounds) increase the stability of coke by forming nitrogen-phosphorus bonds.

Phosphorus-nitrogen synergism is explained by the formation of phosphorus-nitrogen bonds during thermal decomposition. At elevated temperatures, polyphosphoric acid is released, melts, covering the textile fibers with a protective film, protecting it from smoldering. The decomposition of the nitrogen-containing agent is accompanied by the formation of gaseous ammonia, which hinders the access of oxygen and inhibits the oxidation of carbon in the gas phase.

The intumescent effect of the finishing composition after exposure to an open flame from the introduction of thiourea into the composition is shown on the photo in Fig. 1.



a b

Fig. 1. Formation of a carbonized coke layer on the surface of a cotton fabric (a) and a cotton/polyester blend (b)

The formation of a bulk charred area is observed on the surface of cellulose textile materials, as well as a mixture of cotton with polyester. The advantages of processing can also be attributed to the absence of splashing and droplets, which in a real fire can cause additional sources of ignition of the blended cotton-polyester fabric.

5. Conclusion

The presence of compositions containing phytic acid on the fiber surface significantly outpaces the degradation of cotton. Despite the apparent contradiction, as a result of the tests carried out, it was proved that it is the carbonization and dehydration of phytic acid that is a necessary condition for increasing the resistance of the textile material to the effects of flame, due to the activation of its decomposition before the decomposition of the main substrate.

An increase in textile residues at T_{max1} indicates the formation of a sufficiently thermally stable product as a result of the first decomposition step. At the same time, the carbonated residue formed at the first stage acts as a barrier that prevents the diffusion of decomposition products into the flame zone and oxidizer, primarily air oxygen. It further decomposes at higher temperatures, which is confirmed by the T_{max2} values, in addition, the final residues at 600°C are slightly higher than that of untreated cotton. The use of thiourea in the finishing composition allows an increase in the bulk foamed carbonated layer, which acts as a physical barrier to protect the surface of textile materials. A significant advantage of such processing is also the absence of splashing of the synthetic component of the mixed fabric, which makes it possible to reduce the threat of additional sources of ignition in the event of a fire.

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OPERATIONS ANALISYS OF REAPER OPERATION FOR SUNFLOWER HARVESTING

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DOI: 10.31891/monograph/2021-10-68

1. Introduction

More than 20 species of crops are used in global production of plant oil. The most significant are soybeans, oilseed rape, and sunflower, after proceeding of which oil and high-protein grist (importantly, of vegetable origin) are received as well as other necessary products that are in demand with the population [1].

Considering the volumes of sunflower production, Ukraine is in the top three together with Argentina and Russian federation [2] (Fig. 1.1). Sunflower cultivation is one of the most profitable area of crop production.

The process of harvesting sunflower seeds is the most responsible and extensive stage in its production that shall be completed at the earliest possible date, as the delay in harvesting may cause significant losses due to shedding. At most farms, the harvesting begins under the condition that the seed moisture is 12-14% [3]. However, if there is a sufficient number of grain cleaning and drying machines, the harvesting shall be organized a week earlier, when the seed moisture is about 20% [3]. With such an organization of work, an additional 1.2-1.5 c/ha of seeds are harvested [3].

Normal and intensive technologies are shown as basic one in the register of crop production technologies of sunflower cultivation [4, 5].

Normal technology is a system of obtaining sunflower seeds with the most efficient use of soil fertility and agro-landscape resources, biological potential of plant properties, which ensures the realization of the genetic potential of sunflower varieties and hybrids for 45%, and productivity is less than 5 man-hours/t , and the yield of sunflower is 1.2 t/ha [5].

Intensive technology is a system of obtaining the high-quality sunflower seeds with the restoration of nutrient losses during the harvest, with a set of measures to protect plants from the great effects of diseases, pests and weedage; a set of measures to combine technological processes that will implement 65% of the genetic potential of varieties and hybrids.

In Ukraine, contradictions are seen between the growth of areas for sunflower cultivation in order to increase oil production and high seed losses, provided that combine harvesters are used during their harvesting.

High requirements for product quality, which is a key factor in ensuring competitiveness, require a solution to the problem of imperfection of technological processes and appropriate technical means for harvesting sunflower. The key task is to reduce seed losses during sunflower harvesting.

In order to form a concept for solving this problem, we analyzed the current research of technologies and technical means for sunflower harvesting. The summary of the obtained results showed the following.

Research aimed at improving the technological processes of harvesting is mainly dedicated to the development of management actions for the rational organization of operation of harvesting complexes, modernization of technical means, development of methods for their effective use. The issue of improving the operational and technological properties of technical means for sunflower harvesting is covered in the works of V.D. Shaforostova [6, 7], V.D. Kukhmazova [8], K.Z. Kapustina [9], S. Karparvarfard, A. Kornacki [10], Skoric and Dragan [11], Z. Zhao [12] and others.

From the analysis of current research, the following is established:

- losses of sunflower seeds due to shedding of head and incomplete harvesting of the plant from the field make up a significant share of the harvest and are equal to more than 7%.

- current designs of reapers do not provide optimal harvesting of sunflower from the field. There are two variants of harvesting: a) harvesting of fallen and low sunflowers, however, this will lead to excessive hammering of the combine; b) the highest cutting of sunflower heads that will reduce clogging of the moving parts of the combine harvester and thresher, but will lead to significant economic losses due to incomplete harvesting.

- threshing and separating equipment of the combine according to the constructive parameters is not adapted for work with sunflower seeds. This leads to the increase of foreign material in the combine hopper.

Taking into account the stated purpose of our research it was necessary to carry out the operations analysis of technical systems of a reaper for sunflower

harvesting to reveal the lacks of operation and the reasons of losses of the crop having made a holistic picture of technological process.

2. Statement of basic materials

The research analyzed by the authors may be defined as aimed at analyzing the impact of independent units of the technical system, i.e. is the reaper, on the losses formation of sunflower seeds during harvesting. However, the properties of the system should be considered as a whole, i.e. as those that depend not only on the physical action of its separate structural components and also taking into account their own characteristics (Fig. 1).

This article outlines the main technological stages of movement of sunflower seeds within the technological process from the moment of capture of stalks by operating elements of the reaper to its transportation to the combine hopper.

The article also considers the process of technical system designed for harvesting that contains two structural elements: a sunflower reaper and a combine harvester. It is worthy of note that all the processes from stalks cutting to the direct transportation of seeds and the peculiarities of the technical components of this system shall be considered for a operations analysis of the technical system. These processes are characterized by a certain list of parameters. This list includes the following: physical and mechanical properties of stalks, heads and sunflower seeds; operational and technological performance of the combine with the mounted reaper. This article gives the analysis of some elements of the structural model of seed loss (Fig. 1).

The reaper is a component of the technical system designed to capture and cutting of stalks by the cutting device and their transfer into the inclined chamber. The flow of heads is formed in the chamber, which according to the bibliography [15] is estimated by the specific weight – the number of heads with segments of stalks, transferred per second into the inclined chamber. The value of this indicator depends on the following parameters: speed V_r, reaper working width B_w, the amount of losses B_{loss}.

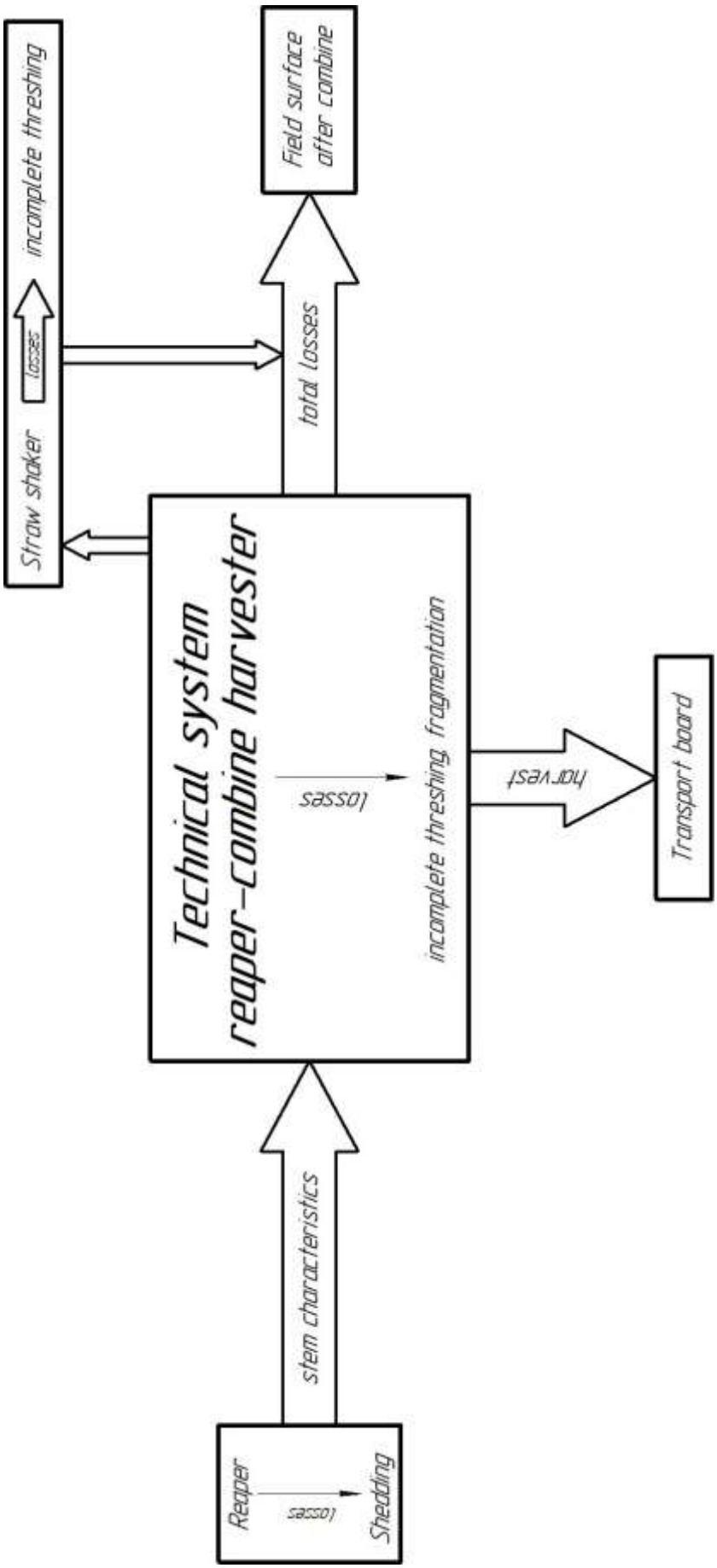


Fig. 1. Structural model of seed losses

Given the importance of energy conservation, the calculation of the specific value of the cut mass (in relation to power) will be carried out as follows:

$$\frac{g}{N_r} = \frac{V_r \cdot B_w}{N_r} \cdot B_{sun} - \frac{B_{loss}}{N_r} \quad (1)$$

where N_r – reaper power;

Then the specific losses of heads with stalk segments will be determined as follows:

$$\frac{B_{loss}}{N_r} = \frac{V_r \cdot B_w}{N_r} \cdot B_{sun} - \frac{g}{N_r} \quad (2)$$

The next structural component where losses are formed is threshing equipment. The seeds can be damaged due to the influence of rasps; there is underthreshing as well. These are components of the total losses, the amount of which is determined similarly to (2)

$$\frac{B_{loss}}{N_{com}} = \frac{V_r \cdot B_w}{N_{com}} \cdot B_{bas} - \frac{g_{bas}}{N_{com}} \quad (3)$$

or

$$\frac{g_{th} + g_{dam}}{N_{com}} = \frac{V_r \cdot B_w}{N_{com}} \cdot B_{bas} - \frac{g_{bas}}{N_{com}} \quad (4)$$

where g_{th}, g_{dam} – the volume of losses due to underthreshing and seed damage accordingly;

N_{com} – capacity of combine engine;

B_{bas} – sunflower heads yield;

g_{bas} – mass of heads with seeds, which have been threshed for a fixed period of time excluding damage and underthreshing.

The mass of seeds coming out of the threshing unit arrives on the transport board – g_{seed} The mass of seeds coming out of the threshing unit – g_{seed}^{ss} is added to above

mass at a given time. It should also be noted that the seeds, which have undergone additional purification g_{seed}^{ac}, are added to the flow.

Then the volume of the flow that is given will be determined as follows:

$$g_{tr} = g_{seed} + g_{seed}^{ss} + g_{seed}^{ac} \quad (5)$$

The loss of seeds during purification – B_p^{cl} with the help of sieves and losses on blowing during repurification – B_p^{clr}. shall be taken into account.

Considering the losses, the mass of seeds that have been purified is as follows:

$$g_{\text{int}} = \left(g_{seed} + g_{seed}^{ss} + g_{seed}^{ac}\right) - (B_{siev} + B_{re}) \quad (6)$$

where B_{siev} – loss of seeds on sieves;

B_{re} – loss of seeds during repurification.

The specific amount of losses shall be determined accordingly:

$$\frac{(B_{siev} + B_{re})}{N_{com}} = \frac{\left(g_{seed} + g_{seed}^{ss} + g_{seed}^{ac}\right)}{N_{com}} - \frac{g_{\text{int}}}{N_{com}} \quad (7)$$

The given mathematical expressions describe losses of seeds in the course of sunflower harvesting using the reaper, threshing equipment, and after repurification.

From the mentioned above it is seen that the final value of raw material losses is formed as the sum of losses that occur in the individual structural components of the technical system. Summing up all the specific losses (formulas 2, 4,7) we get their total value, $\frac{kg\ /\ force}{kW}$.

3. Conclusions

After analyzing the process of losses formation during sunflower harvesting, it was found that the main structural elements of the technical system “reaper - combine harvester” operation of which affects the amount of losses are the reaper, combine thresher unit, and cleaning sieve system.

Obtained mathematical equations, which describe the formation of specific losses during cutting of heads together with stems, heads and seeds threshing and its transportation with possible repurification, by the summation, allow to systematically describe the formation of total losses.

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MODERN TECHNOLOGIES OF MOTOR VEHICLE BODYWORK AND PAINT REPAIRS

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DOI: 10.31891/monograph/2021-10-69

1. Introduction

The increasingly stringent environmental protection requirements set for the automotive industry led manufacturers of motor vehicles to abandon the production of motor vehicles with conventional engine units (i.e., gasoline, diesel engines).

In the last decade, the growth of hybrid and electric vehicles on Polish and European roads can be clearly seen. In addition, some car manufacturers, such as Audi - have already announced the end of the production of vehicles with an internal combustion engine in 2026 (this also applies to hybrids), which means that from 2033 the above-mentioned manufacturer will probably only offer electric vehicles in its offer. Ecology in production is not only about drives and drive units, but also the application of a varnish coat. In this regard, all manufacturers have convinced themselves to apply water-based car paint [9].

Therefore, another important branch of the automotive industry, including the production of cars, is their service and repairing process, in which body and paint repairs can be distinguished. Also in this matter, repair shops should be convinced to use the most modern technology of car paint materials.

Nowadays, many times in refinishing, conventional paints are still used, in which about 84% is solvent. Car painters motivate the usage of this type of material, believing that water-solvent-based paints do not meet the requirements to which the paint surface coating is exposed (atmospheric, chemical, mechanical), which is not true.

Improving the condition of the environment and meeting quality standards is not only the use of water-based paints, but also the plant's infrastructure is necessary, which will ensure the conditions for the entire body and paint repair process in the required quality, with an emphasis on sterility in the scope of coating application [7].

Adequate infrastructure is also the possibility of ensuring greater efficiency of the spray booth with varnishes based on "water". The main aim of the article is to present the differences in the applied painting materials used in the refinishing painting process of motor vehicles and their importance in the range of their environmental impact.

2. Analysis of paint ingredients

Comparison of chemical components of selected recipe pigments based on water-soluble and conventional lines in relation to VOC, on the example of LC9Z varnish, RM mixer were introduced in Table 1 [8].

Table 1. Composition of paint pigments based on the use of materials based on a water-dilutable line and a conventional (solvent-based) line

VW – AUDI LC9Z BLACK MAGIC PERL	
Water-dilutable 200g	Conventional 200g
HB002 – 145,7	BC020 - 18,9
HB140 – 0,5	-
HB46l – 0,8	BC118 - 2,9
HB130 – 0,8	BC170 - 6,8
HB464 – 9,2	BC471 - 22,3
HB250 – 43,1	BC201 - 95,1
Dilution Hydromix	Dilution BC020

Among the proposed color lines of the RM system, two can be distinguished: ONYX suitable for water-soluble pigments and DIAMONT for solvent-based pigments.

Pigment HB002 – mixtures

Charakterystyka chemiczna

Woda, poliuretan

Składniki niebezpieczne (GHS)
zgodnie z Rozporządzeniem (UE) nr. 1272/2008

2-metyloizotiazolinon

Zawartość (W/W): > 0 % - < 0,1 %	Acute Tox. 2 (Wdychanie - pył)
Numer CAS: 2682-20-4	Acute Tox. 2 (Inhalacyjne- para)
Numer WE: 220-239-6	Acute Tox. 3 (doustne)
	Acute Tox. 3 (dermalne)
	Eye Dam./Irrit. 1
	Aquatic Acute 1
	Aquatic Chronic 1
	Skin Corr./Irrit. 1B
	Skin Sens. 1A
	Faktor M - ostry: 10
	H314, H311, H330, H301, H317, H410
	EUH071

Specyficzne stężenie graniczne:
Skin Sens. 1A: >= 0,001500 %

Fig. 1. Hazardous ingredients HB002 [1]

Due to the fact that the chemical characteristics are mainly water and polyurethane, only 2-methylisothiazolinone in a low concentration is present among the components hazardous to the environment, which means that the content of Volatile Organic Compounds is 0.1%.

Pigment BC020 – mixtures

Charakterystyka chemiczna

rozpuszczalnik organiczny

Składniki niebezpieczne
zgodnie z rozporządzeniem (WE) nr 1272/2008

Nr. CAS Nr. WE Nr. Rejestracji Nr. INDEX
Ciężar %
Klasa, Kategoria, Zwroty wskazujące rodzaj zagrożenia

octan butylu
123-86-4 204-658-1 01-2119485493-29-XXXX 607-025-00-1
50,0 - < 75,0
Flam. Liq. 3, H226
STOT SE 3, H336

dimetylobenzen - mieszanina izomerów [4]
1330-20-7 215-535-7 01-2119488216-32-XXXX 601-022-00-9
7,0 - < 10,0
Flam. Liq. 3, H226
Acute Tox. 4, H312
Acute Tox. 4, H332
Skin Corr./Irrit. 2, H315
Eye Dam./Irrit. 2, H319
STOT SE 3, H335
STOT RE 2, H373
Asp. Tox. 1, H304
Aquatic Chronic 3, H412

propionian etyloetoksylowy
763-69-9 212-112-9 01-2119463267-34-XXXX
5,0 - < 7,0
Flam. Liq. 3, H226

4-metylopentan-2-on
108-10-1 203-550-1 01-2119473980-30-XXXX 606-004-00-4
5,0 - < 7,0

solwent nafta (ropa naftowa), węglowodory lekkie aromatyczne
64742-95-6 265-199-0 01-2119455851-35-XXXX 649-356-00-4
5,0 - < 7,0
Flam. Liq. 3, H226
STOT SE 3, H336
STOT SE 3, H335
Asp. Tox. 1, H304
Aquatic Chronic 2, H411

1,2,4-trimetylobenzen
95-63-6 202-436-9 601-043-00-3
3,0 - < 5,0

etylobenzen
100-41-4 202-849-4 01-2119489370-35-XXXX 601-023-00-4
1,0 - < 2,0

mezytylen
108-67-8 203-604-4 601-025-00-5
1,0 - < 2,0

n-propylbenzene
103-65-1 203-132-9 601-024-00-X
0,3 - < 0,5

Fig. 2. Hazardous ingredients BC020 [2]

With regard to HB002, a significant greater amount of ingredients classified as hazardous are found in the BC020 pigment, and this pigment structure results in a Volatile Organic Compounds content of 100%. The illustrated VOC difference shows an environmental benefit when using the ONYX line (water-borne).

Other important pigments in the presented LC9Z formulation are black pigments - HB 250 and BC201, respectively. The chemical compositions of the hazardous substances in mixtures are given below. When analyzing the structures again, one can see a greater amount of hazardous components in the pigment based on the thinner line, although there is no such extreme difference in the value of Volatile Organic Compounds - i.e. 59% in HB 250 and 73% in BC201 - as in the case of the first statement .

Pigment HB250 - mixtures

Charakterystyka chemiczna

poliuretan, rozpuszczalnik organiczny, pigment

Składniki niebezpieczne
zgodnie z rozporządzeniem (WE) nr 1272/2008

Nr. CAS Nr. WE Nr. Rejestracji Nr. INDEX
Ciężar %
Klasa, Kategoria, Zwroty wskazujące rodzaj zagrożenia

2-butoksyetanol
111-76-2 203-905-0 01-2119475108-36-XXXX 603-014-00-0
30,0 - < 50,0
Acute Tox. 4, H312
Acute Tox. 4, H332
Acute Tox. 4, H302
Skin Corr./Irrit. 2, H315
Eye Dam./Irrit. 2, H319

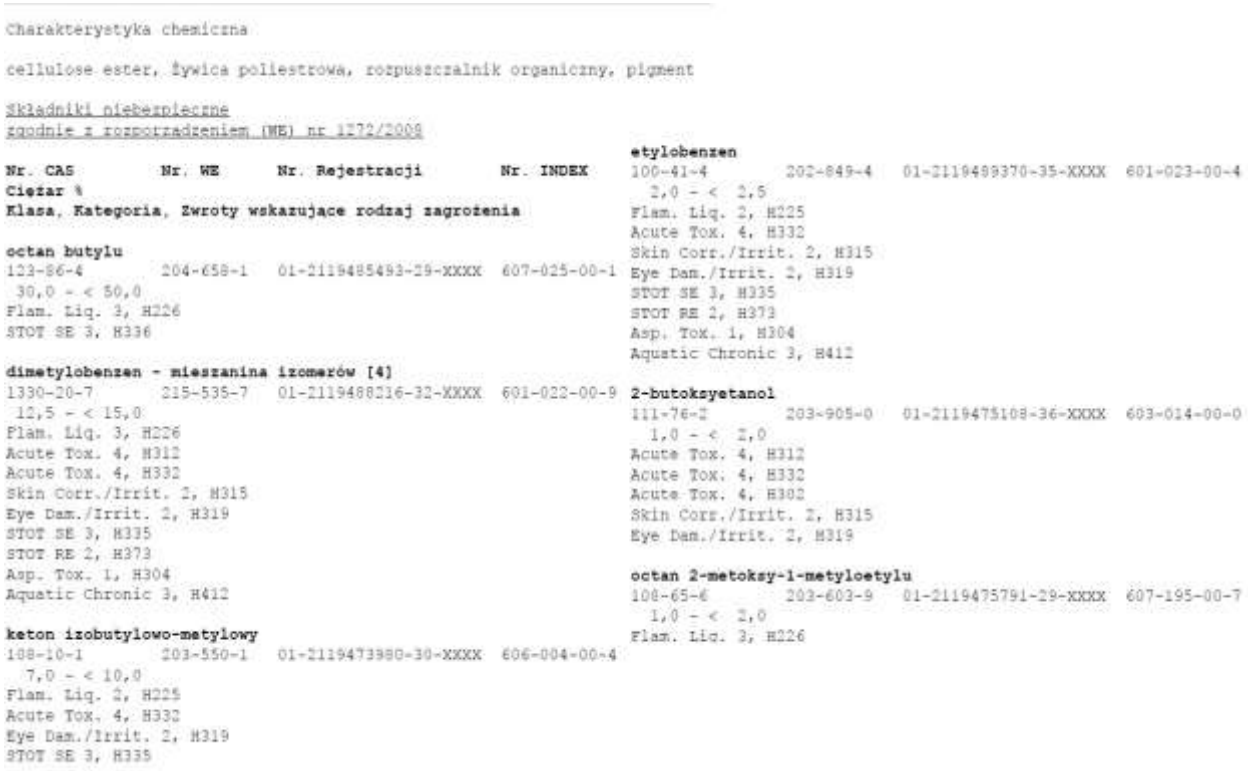
2-butanol
78-92-2 201-158-5 01-2119475146-36-XXXX 603-127-00-5
12,5 - < 15,0
Flam. Liq. 3, H226
Eye Dam./Irrit. 2, H319
STOT SE 3, H336
STOT SE 3, H335

2,4,7,9-tetrametylo-5-decyno-4,7-diol
126-86-3 204-809-1
3,0 - < 5,0
Eye Dam./Irrit. 1, H318
Skin Sens. 1B, H317
Aquatic Chronic 3, H412

2-(dimetyloamino)etanol
108-01-0 203-542-8 01-2119492298-24-XXXX 603-047-00-0
1,0 - < 2,0
Flam. Liq. 3, H226
Acute Tox. 3, H331
Acute Tox. 4, H312
Acute Tox. 4, H302
Skin Corr./Irrit. 1B, H314
Eye Dam./Irrit. 1, H318
STOT SE 3, H335

Fig. 3. Hazardous ingredients HB250 [3]

Pigment BC201 - mixtures



Charakterystyka chemiczna

cellulose ester, żywica poliestrowa, rozpuszczalnik organiczny, pigment

Składniki niebezpieczne
zgodnie z rozporządzeniem (WE) nr 1272/2008

Nr. CAS	Nr. WE	Nr. Rejestracji	Nr. INDEX	Ciężar %	Klasa, Kategoria, Zwroty wskazujące rodzaj zagrożenia
octan butylu					
123-86-4	204-658-1	01-2119485493-29-XXXX	607-025-00-1	30,0 - < 50,0	Flam. Liq. 3, H226 STOT SE 3, H336
dimetylobenzen - mieszanina izomerów [4]					
1330-20-7	215-535-7	01-2119488216-32-XXXX	601-022-00-9	12,5 - < 15,0	Flam. Liq. 3, H226 Acute Tox. 4, H312 Acute Tox. 4, H332 Skin Corr./Irrit. 2, H315 Eye Dam./Irrit. 2, H319 STOT SE 3, H335 STOT RE 2, H373 Asp. Tox. 1, H304 Aquatic Chronic 3, H412
keton izobutylowo-metylowy					
108-10-1	203-550-1	01-2119473980-30-XXXX	606-004-00-4	7,0 - < 10,0	Flam. Liq. 2, H225 Acute Tox. 4, H332 Eye Dam./Irrit. 2, H319 STOT SE 3, H335
etylobenzen					
100-41-4	202-849-4	01-2119489370-35-XXXX	601-023-00-4	2,0 - < 2,5	Flam. Liq. 2, H225 Acute Tox. 4, H332 Skin Corr./Irrit. 2, H315 Eye Dam./Irrit. 2, H319 STOT SE 3, H335 STOT RE 2, H373 Asp. Tox. 1, H304 Aquatic Chronic 3, H412
2-butoksyetanol					
111-76-2	203-905-0	01-2119475108-36-XXXX	603-014-00-0	1,0 - < 2,0	Acute Tox. 4, H312 Acute Tox. 4, H332 Acute Tox. 4, H302 Skin Corr./Irrit. 2, H315 Eye Dam./Irrit. 2, H319
octan 2-metoksy-1-metyloetylu					
108-65-6	203-603-9	01-2119475791-29-XXXX	607-195-00-7	1,0 - < 2,0	Flam. Liq. 3, H226

Fig. 4. Hazardous ingredients BC201 [4]

3. Technical examples of the application of ONYX and DIAMOND paints

Among other aspects important for environmental protection, but also for improving the efficiency of the paint shop in the repair shop, are the possibility of applying individual paint lines. As in the case of chemical composition, technicians have much greater benefits in water-based paints[10].

Of course, the biggest differences can be found in services based on the latest equipment of the spray booth, because in a simple way, such as increasing the flow of dry air, you can accelerate the drying process of the paint coating without adversely affecting the final effect. Waterborne paints also have the option of drying with an IR lamp, which in turn can "slow down" the spray booth, which can be used for the next task. Such important matters are reflected in the efficiency of the entire plant, and assuming that the profitability of this type of company is estimated between 15-25%, it is of great importance, especially with regard to energy costs and order processing.

ONYX HD bazy **HYDROMIX**	100 (obj.) 60 (obj.)	zależnie od koloru 60 g
Lepkość natryskubei 20°C: Kubek ISO 4: Kubek DIN 4:	 42 do 68 sekund 18 do 25 sekund	
Czas życia: ONYX HD kolor: 6 m-cy w oryginalnym opakowaniu. ONYX HD RFU: 1 tydzień w zamkniętym pojemniku..		
HVLP ze zbiornikiem górnym	1,4 – 1,5 mm	0,7 bar na wyjściu
 Liczba warstw: Grubość powłoki: Czas schnięcia między warstwami – do zmatowienia.	**Kolory gładkie** 2 – 3 20 – 25 µm	**Kolory metalizowane / perłowe** 1 lub 2 + 1 lekka 12 – 15 µm
Schnięcie w 20°C Schnięcie w 45°C	ok. 15 min. (Możliwość przyspieszenia poprzez zwiększenie przepływu powietrza) ok. 10 min. + chłodzenie	
Schnięcie z IR	1 warstwa: 2 warstwa:	Odparowanie do zmatowienia. W 40-50°C (max 60°C) do zmatowienia + chłodzenie (Warstwa dodatkowa:Warstwa lekka, odparowanie w temperaturze otoczenia do pełnego zmatowienia).

Fig. 5. Technological sheet of the pigment from the ONYX line - selected parts [5]

The next aspect necessary to show the difference between the two color lines is the price of the products itself. In this regard, conventional paints are cheaper as a unit price (on average by 15%) and this factor often determines repair shops to choose thinner paints. Unfortunately, the unit price of products misleads the users of materials, because pigments based on a water-soluble base are more effective in covering and efficient, which in terms of global costs favor this type of materials.

The last and usually the most important argument for the use of water-soluble varnishes is their much lower negative impact on the health of paint shop workers - e.g. washing tools is much simpler and does not require special chemicals.

	DIAMONT **BC 020** (15°C – 25°C) **BC 030** (>25°C)	100 (obj.) 60 (obj.)	zależnie od koloru 53 g
	Lepkość natrysku w 20°C: Kubek ISO 4: Kubek DIN 4:	 22 do 25 sekund 14 do 15 sekund	
	Czas życia: 24 godz. w 20°C		
	HVLP ze zbiornikiem górnym **Konwencjonalny ze zb. górnym**	1,3 – 1,5 mm 1,3 – 1,4 mm	0,7 bar na wyjściu 2,0 bar
		Kolory gładkie	**Kolory metalizowane / perłowe**
	Liczba warstw: Grubość warstwy:	2 15 – 20 µm	2 + 1 lekka 15 µm
	Schnięcie w 20°C	5 min.	

Fig. 6. Technological sheet of the pigment from the DIAMONT (BC020) line - selected parts [6]

4. Application and exploitation defects in paint repairs

The most important in paint repairs process are identify materials and optimize the process in terms of efficiency. The most common application and exploitation defects of decorative coatings in the paint process include:

Application defects

- hologram effect after polishing
- gassing
- punctures
- shade incompatibility
- settling of the spray mist
- subsidence of coatings
- blistering
- swelling and floating of the coating
- water stains
- discoloration
- fish eyes
- sanding scratches

- orange peel
- poor coverage
- cracking of the coating
- cloud formation
- loss of adhesion to plastics
- loss of adhesion between the varnish and the base
- streaks
- pollution
- marking of the coastal zone

Application and exploitation defects:

- Corrosion – reasons:
    - mechanical damage to the paint coating,,
    - improper preparation of the substrate,
    - no anti-corrosion protection for metal sheets and closed profiles.

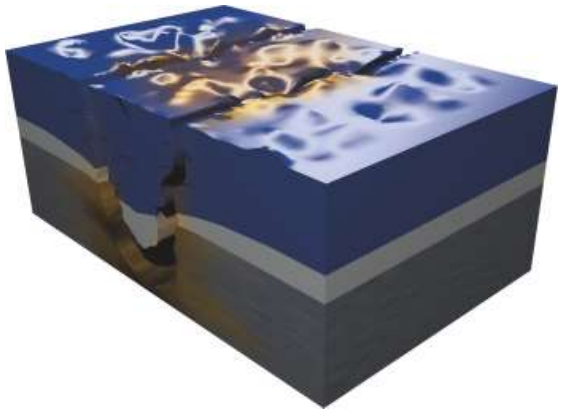


Fig. 7. Corrosion of paint coating [11]

- Loss of gloss - Reasons:
    - insufficiently hardened varnish exposed to moisture from the air,
    - too thick layers of varnish,
    - too high air humidity during painting,
    - sensitivity of the substrate to solvents,
    - incorrect amount of hardener,
    - expired or damp hardener,
    - interrupting the drying process or its lack,
    - using drying and curing accelerators,

- insufficient air circulation during drying

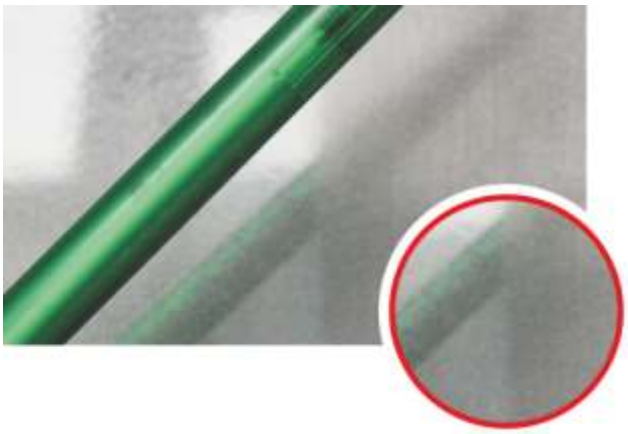


Fig. 8. Loss of paint coating gloss [11]

5. Conclusions

Summarizing the above comparisons in the light of the challenges in terms of global greenhouse gas emissions, many benefits and opportunities are provided by paints based on a water-soluble basis. The technical advantages of this color line allow repair shops to reduce the emission of Volatile Organic Compounds, but also to improve the plant's efficiency and, most importantly, to reduce the exposure of paint shop workers to hazardous substances that have a negative impact on their health, while maintaining the expected result of repair quality.

Undoubtedly, one of the most important advantages, apart from being environmentally friendly, is the possibility of being copied to some extent by factory painting workshops, because all new cars are painted on the basis of water-soluble paints.

It is also necessary to mention the issues related to the settlement of vehicle repairs in the settlement of motor damage, and the materials used during their repair. Insurers' estimates show that over 50% of claims are still settled in the cost-estimate variant, which is a derivative of the fact that vehicle repairs are carried out in non-professional workshops, without maintaining the appropriate technology and consuming mainly conventional paints.

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YARN CLASSIFICATION BY APPEARANCE CRITERIA

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DOI: 10.31891/monograph/2021-10-70

1. Introduction

The internal and external structures of yarn play a key role in the formation of the properties of textile products; during production, the structure is mechanically affected by weaving or knitting equipment, technological finishing production modes, etc. Together, this affects the appearance of the finished textile product [1]. For textile science, the external structure of the yarn is a manifestation of surface properties and is associated primarily with the hairiness [2]. The number and orientation of yarn hairs is taken into account at the stage of textile design, as these indicators depend on the speed of equipment, dye consumption, viscosity of the printing solution, the type of surface finish of the fabric, etc. [3-5]. In the textile industry, yarn hairiness is one of the key parameters [6], so for its quantitative evaluation numerical methods [2, 7] and a nomenclature of indicators are developed [8], the main of which is the hairiness index H, which represents the number of hairs per unit length of yarn. [9]. At the same time, in addition to the quantitative characteristics of pile, its production requires a qualitative assessment, as for textile manufactures and optimal selection of finishing parameters it is also necessary to know how tangled these villi are, how the villi are oriented relative to the yarn core and other features of pile appearance [10]. For this purpose it was proposed to determine its differentiation by length classes from 1 to 12 mm [11] and the pile severity index [12] in addition to the amount of pile. This expansion of the range of pile indicators in some way improved the problem with the qualitative assessment of the yarn appearance, but in the conditions of weaving and knitting production visual appraisal of hairs appearance remains the main information source for product design. Therefore, the need to develop a classification of yarn on the basis of hairiness is an urgent task for the textile industry. One of the first steps in this direction is the identification of hairiness parameters and the development of a categorical apparatus, which is the basis for assessing the yarn appearance.

2. Materials and methods

In order to determine the parameters of the appearance of the yarn hair, the methods of optical examination were used, namely:

- determination of the number of hairiness by computer algorithm of the program Poil [13];
- visual assessment of the appearance parameters of hairiness in the micrographs.

The yarn sample is laid out on a contrasting matte substrate in a straightened but not stretched state in front of the microscope so as not to disturb the orientation of the hairiness. The size of the elementary yarn sample is 10 mm. The modes adjust the scale and illumination of the sample in order to obtain the clearest possible image of all villi, after which the image is taken. The resulting images are transferred to the Poil program for further processing and analysis. The number of yarn images that provides the required accuracy with 95% confidence, accepted for the textile industry [14], is 37 micrographs per 10 m for each type of yarn under study. The total length of the yarn to determine the hairiness is 100 m. Thus, 3700 micrographs of the yarn are analysed.

More than 200 samples of yarn of different types, raw material composition, and linear density, manufacturing method, diameter and twist were used for the experimental study.

An example of photomicrographs of yarn samples is presented in Fig. 1.



Fig.1. Photomicrographs of the yarn samples

In order to make faster the visual analysis, a complete division into three zones of hairiness was adopted: the zone of dense, random and informational pile [15]. This is an additional characteristic of hairiness to clarify the classification features (Fig. 2).

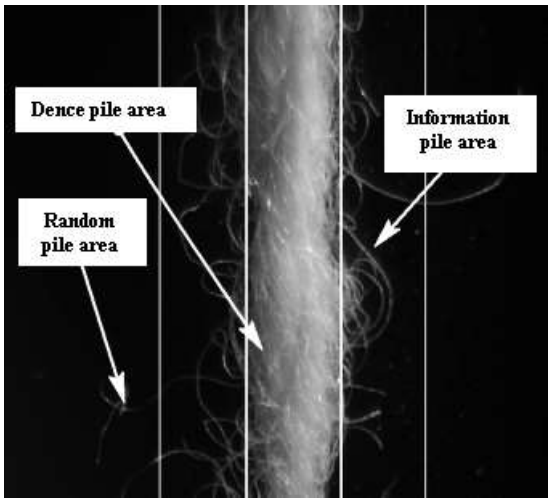


Fig.2. Yarn pile areas

The area of random pile is at a fairly large distance from the yarn core, the hairs appear quite rarely and in most cases are the tips of the fibres. Such hairs negatively affect the course of technological processes, and are also the cause of deterioration of the finished products appearance. In the area of informative pile is the largest number of villi, they are clearly visible and determining of their appearance could be make easily. The nature of the villi of this zone is mainly determined by the yarn hairiness. The area of dense pile, in which the villi are tightly adjacent and intertwined with each other, is excluded from the calculations, as determining the type of villi in this area is impossible and impractical.

A list of appearance criteria has been developed in previous studies [16]. These criteria are: pile density; the shape of the villi; the presence of intersections with other villi; the presence of sections with the yarn core; presence of own sections; number of sections. The ranking range of visual information for the operator is as follows:

- the density of the pile and the distance from the yarn core dense, informative and random pile are distinguish;

- according to the shape of the villi distinguish tips and loops;

- in the presence or absence of intersections with other villi distinguish between single and average villi;

- in the presence of their own sections - free and closed villi;

- the number of sections distinguishes between paired, multiple and complex (tangled) groups of villi.

3. Results

According to the experiment results, an array of data was obtained, which was systematized by the similarity of the characteristics of the hairiness. In the table 1 shows the results of the hairiness evaluation of the most characteristic yarn samples.

Table 1. Characteristics of the yarn samples appearance

Raw material	Yarn liner density	Hairiness indices					Number of hairs
		Uniformity of pile	Pile density	Pile entanglement	The presence of loops	The presence of long hairs	
Cotton	150	uneven	average	great	present	present	7
Cotton	25	uneven	small	is present	missing	present	11
Viscose	64	uneven	average	is present	missing	present	21
100% PA	274	even	great	very large	present	missing	0,1
Flax 60%, PE40%	195	even	great	very large	present	missing	0,1
Wool, mylar	327	even	great	very large	present	missing	0,1
Cotton	33	uneven	average	is present	present	present	17
Nitron	292	uneven	great	very large	present	present	13
Acrylic	66	uneven	great	very large	present	present	11
100% acrylic	310	uneven	great	very large	present	present	12
Acrylic	200	uneven	great	very large	present	present	14
Wool	324	uneven	great	very large	present	present	12
Wool	542	uneven	great	very large	present	present	8
Cotton kapron	347	uneven	average	average	present	present	12
Lawson	18	-	-	-	missing	missing	–
Yarn of chemical fibers	203	-	-	-	missing	missing	–
Flax, myrrh	100	uneven	average	average	missing	present	24
Linen	95	uneven	small	average	missing	present	8
Nitron	267	uneven	great	very large	missing	present	7
Tech. linen	259	uneven	average	very large	missing	present	11

System analysis, as well as gradation of photomicrographs of yarn samples allow us to conclude that some yarn samples, different in raw material composition

and linear density; have similar or almost identical indicators of the external hairiness manifestation. Given that in textile science, as in other scientific fields, the processes of studying objects and phenomena are more effective if these objects and phenomena are classified according to certain characteristics, a classification of yarn based on the appearance of pile was developed [17], which is presented in table 2.

Table 2. Yarn classification by hairiness signs

№ groups	Graphic image of yarn	Number of hairiness zones	Possible raw material composition, system and method of spinning, yarn structure, linear density
1	2	3	4
I	The fibres in the yarn body are close to each other, part of the fibres forms an infrequent long pile, which is at a fairly large distance from the yarn, the presence of intersections with other hairs, with the yarn and its own sections, the number of multiple intersections		
		1, 3 zones	Blended yarn (cotton, bast fibers of the ring spinning method)
II	The fibres in the yarn body do not fit tightly together, form a relatively uniform in density and length of tangled pile with loops, the presence of intersections with other hairs and their own intersections, the number of intersections is complex		
		1 zone	100% polyamide, twistless spinning system, twisted, 274 tex
III	The fibers in the yarn body do not fit tightly together, have a twist, form a long uneven tangled pile with loops, the presence of intersections with other villi, with the yarn trunk and its own intersections, the number of intersections is complex (tangled)		
		1, 2, 3 zones	Wool yarn, wool with nitrone
1	2	3	4
IV	Smooth yarn with a small volume, small pile, the characteristic presence of loops, the presence of intersections with other hairs and their own sections, the number of intersections complex (tangled)		

		1, 2, 3 zones	Cotton, pneumomechanical method of spinning
V	The yarn is smooth, almost lint-free, like a monofilament		
		1 zone	Yarn of chemical fibres
VI	The yarn is uneven, the fibres form an uneven tangled pile of different lengths, characterized by the presence of very long protruding ends, the presence of intersections with other hairs, with the yarn core and its own intersections, the number of intersections is complex (tangled)		
		1, 2, 3 zones	Yarn of bast fibres and of a mixture of bast fibres with cotton and chemical
VII	The yarn is smooth, the random pile is at a fairly large distance from the yarn, here the hairs appear quite rarely and in most cases are the tips of the fibres, the presence of intersections with other hairs, the number of intersections is even		
		1, 3 zones	Yarn of chemical fibers

4. Discussion

The classification of yarn by hairiness signs presented in Table 2 can help optimize the processes of studying surface properties [2] and increase the accuracy of estimating the yarn pile effect on the fabrics pile, so it is advisable to characterize each classification group.

Group I is most characterized by cotton and viscose yarn of the cardiac spinning system of low linear density (Fig. 3). Cotton fibres are soft, thin and have a low stiffness, so the fibres in the yarn body fit snugly together.



Fig.3. Yarn samples appearance of group I

The voluminous tangled pile with loops, which is typical for group II yarns, is due to the use of yarn of the hardware spinning system. Loops are formed by adding woollen elastic or bast hard fibres (Fig. 4).



Fig.4. Yarn samples appearance of group II

Class III classification contains the largest number of samples (Fig. 5). This indicates that the long uneven tangled pile is the most common characteristic among the threads of different raw material composition and method of manufacture. This group is most characterized by cotton yarn of the cardiac spinning system of high linear density, wool, acrylic and mixed yarn of the hardware spinning system.



Fig. 5. Yarn samples appearance of group III

Group IV is characterized by the presence of loops, which are due to the addition of long flax fibres. Flax fibre is much stronger than cotton, due to the greater wall thickness of flax fibre, so hard flax fibres try to "get out" of the body of the yarn, creating loops that wrap around the yarn body (Fig. 6).

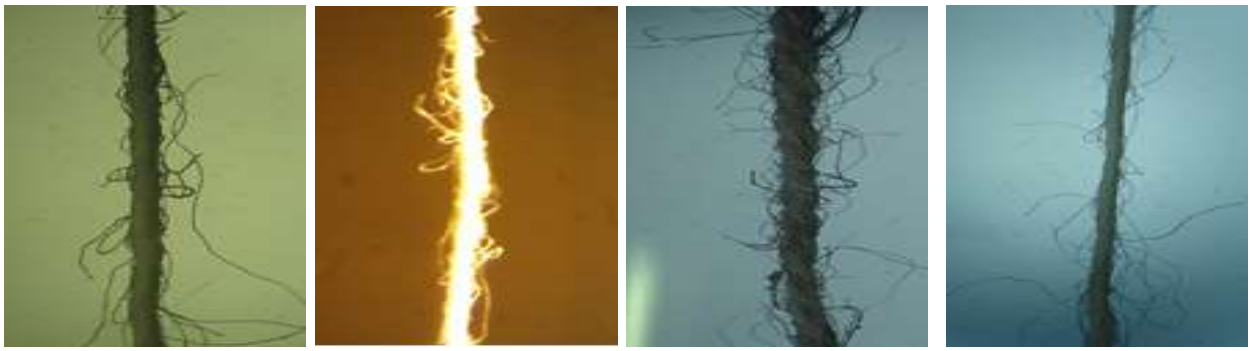


Fig. 6. Yarn samples appearance of group IV

Group V most vividly confirms that the yarn made of chemical fibers has a flat, smooth surface, similar to a monofilament, which has almost no pile (Fig. 7). This is due to the nature, method of production and structural organization and geometric properties of chemical fibres.



Fig. 7. Yarn samples appearance of group V

Group VI is characterized by the presence of very long protruding ends due to the mixing of different types of fibres with bast of low degree of cottonization and mixing of different types of fibres with coarse wool (Fig. 8). This is due to the fact that bast fibres have a rigid structure, much thicker than other fibres, have a longer length than cotton. Therefore, in the formation of yarn, such fibres try to "come out" of the yarn body, creating increased hairiness. This yarn is in most cases used for the manufacture of technical fabrics.



Fig. 8. Yarn samples appearance of group VI

Group VII is characterized by yarn made of twisted chemical fibres, which is characterized only by a random pile, which is located at a fairly large distance from the yarn (Fig. 9).



Fig. 9. Yarn samples appearance of group VII

5. Conclusion

1. Experimental studies of yarns of different types, raw material composition, linear density, manufacturing method, diameter and twist were carried out according to the criteria of hairiness appearance.

2. For the first time on the basis of the system approach at the analysis of yarn hairiness appearance and indicators a regularities of the form, length and mutual placing of piles were defined therefore yarn classification on signs of hairiness appearance is developed.

3. The proposed classification allows to increase the efficiency of scientific research in the field of textile materials science and to develop practical recommendations for predicting the textile products properties.

6. Referrals for further research

The goal of the further research is to determine the effect of yarn hairiness on the surface properties of textile materials.

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FEATURES OF TECHNOLOGICAL PROCESS OF SCREEN PRINTING ON TEXTILE MATERIALS

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DOI: 10.31891/monograph/2021-10-71

1. Introduction

Today, despite the difficult economic situation in the country, Ukraine's light industry is developing rapidly. In a market economy, to ensure the competitiveness of products, Ukrainian companies need to constantly create a range of models of clothing, footwear, leather goods. Every clothing company tries to compete with other industries in different ways. Manufacturers use different methods of finishing products that differ in the use of various technologies and materials. One of the ways to decorate light industry products is to print on textile materials.

In the second half of the last century, the application of images on paper and various solid surfaces by stencil method began to be widely used in printing and advertising services. At the beginning of the new millennium, this imaging method began to be used in the light industry for clothing and footwear. However, the influence of the printing process on the image quality on textile and knitted materials has several new issues [1]. This is primarily due to the physical and mechanical properties of textiles and knitted fabrics, artificial and natural leather, and other light industry materials.

It is established that the main differences of the screen printing process on light industry materials are the resistance of materials to high temperatures, their hygroscopicity, adhesive properties of the material surface, significant linear deformation, temperature shrinkage, the performance of clothing and footwear [2-5]. In addition, canvases of light industry materials contain dyes [2], which can interact with the solvent in the composition of the applied paint, causing the migration of fabric dye into the paint, thereby changing the color of the print. It should also be borne in mind that each batch of fabric requires an individual choice of ink and adjustment of technological modes of printing and drying of the applied image.

The aim of the research is to identify differences in the process of screen printing on textile materials, natural and artificial leather in contrast to printing on

paper and other dense sheet, roll materials. The equipment used during screen printing on light industry materials, as well as the technological process itself, require the formulation of a number of tasks of analytical and experimental research, which will establish optimal technological regimes, reduce energy consumption, reduce metal consumption of structures and ensure high-performance sewing and shoe products.

2. Screen printing on textile materials

The essence of the screen printing method is to push a unique tool (squeegee) ink through the open holes of a flexible mesh shape on the printing surface [6, 7]. Printing can be done on paper, tin, glass, fabric, polyethylene, plastic, leather, and other sheet or roll materials or articles.

Inks that differ in chemical composition, adhesive properties, and temperature regimes are used for screen printing on light industry materials. The most commonly used paints include plastisol, water, solvent, and "etching" [8, 9].

To set the analytical and experimental research tasks, we will consider in more detail the stages of applying images of screen printing on materials of the light industry and equipment used for this purpose.

The technological process of applying the image by screen printing on light industry materials is presented in Fig. 1.

Information on the technological process of screen printing on light industry materials was obtained from empirical research conducted by the authors of the article.

The operations of this technological process can be divided into two groups. The first group includes preparatory procedures: making a printing plate, applying a photo emulsion to the surface of the grid, making a photo template, and exposure. To the second - the primary operations that directly affect the processing object: drawing on the printing surface, intermediate and final drying of the ink layer.

Consider in detail each technological operation.

Production of a framework of a printing form. Frames are made of different types. According to the method of production, there are wooden and metal materials, solid and collapsible ones, and grids with and without fasteners according to the process of fixing the grid.

The main requirement for the quality of the frames is to ensure the tolerance

of parallelism and flatness of the working surface of the structure (mesh fixing surface).

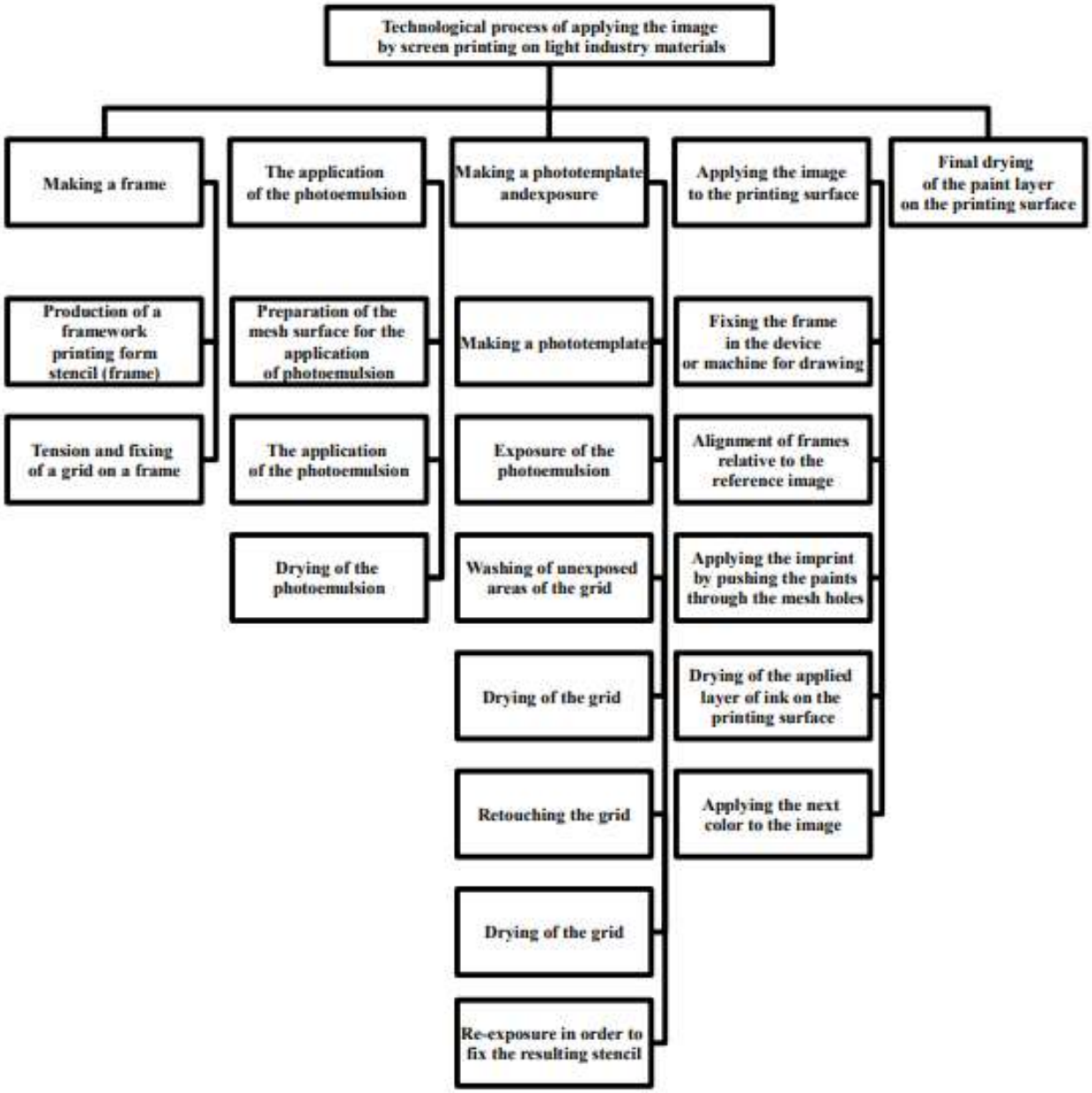


Fig. 1. Technological process of applying the image by screen printing on light industry materials

Solid frames of wood are made by the adhesive method of aluminum - by welding. In collapsible construction, threaded connections with or without intermediate elements are used.

Tension and fixing of a grid on a frame. To stretch the mesh on the frame, special equipment and devices are used, which must ensure uniform stretching of the mesh in all directions with a given force. After stretching, the grid is fixed on

the surface of the frame.

In the case of using frames with clamps, the grid is stretched and fixed mechanically. In the case of structures without clamps, the surface of the frame should be pre-prepared to improve adhesion, after which the grid is fixed with glue.

The quality of the image depends on: the raster line (the number of grid lines per 1 cm in length, ranging from 12 to 120 lin/cm); mesh fiber material; workpiece material; the thickness of the layer of applied paint; dispersion of paint components or special effects; accuracy and resolution of the obtained print [1].

Preparation of the mesh surface for the application of photoemulsion. This technological stage includes several operations during which the grid is treated with special chemicals.

The first operation is to increase the surface roughness - the distortion of the grid. It involves applying reagents to the surface of the grid, holding, and cleaning. The next step is to decrease the surface in order to improve the adhesion between the mesh and the emulsion.

The application of the photo emulsion is performed from the working (squeegee) side or from the contact side of the grid with the material. Depending on the type of ink and the desired printing effect, the emulsion is applied on both sides in one, two or more layers. Since the photo emulsion is sensitive to UV radiation [11], neutral light or yellow and red light filters should be used during application [12].

Drying of the photo emulsion. They are carried out in order to remove moisture from the photo emulsion until it is completely cured.

Making a photo template. This technological stage involves the conversion of a monochrome raster image into a binary one. In the case of color image processing, first carry out the division into a color scheme RGB, CMYK, or pontoon division of the existing color gamut with the subsequent translation of the resulting layers into binary images [10].

Exposure of the photo emulsion occurs under the action of ultraviolet radiation [11]. Thus, when a UV lamp is heated, the flux penetrates through the glass and the transparent film onto the surface of the grid. Thus, areas not protected by photoemission are exposed, and protected areas are left unexposed [12].

Washing of unexposed areas of the grid is carried out in order to remove the

emulsion from the unexposed areas and clean the stencil mesh. For water-soluble emulsions, high-pressure water washing is performed using special equipment or high-pressure nozzles.

Drying of the grid is carried out in order to remove excess moisture from the surface of the grid. At the end of the operation, a visual inspection of the surface of the exposed areas of the photo emulsion is performed, and, if necessary, retouching is performed.

Retouching the grid. After detecting defects in the exposed areas of the grid, which appear as a result of uneven application of photo emulsion, or as a result of invisible dark pixels on the photo template, it is necessary to retouch the surface of the grid, which consists of spot (zonal) application of photo emulsion or special mixture sensitive to UV rays in places of defects.

Re-exposure in order to fix the resulting stencil. This operation is performed in the case of retouching areas of large size or after multilayer application of the photo emulsion, for guaranteed exposure of the inner (first) layers of the emulsion.

Upon completion of the stencil preparation, proceed to the actual procedure of applying ink to the printing surface.

Fixing the frame in the device or machine for drawing. The location of the printing surface is marked on a rigid base. Water-soluble adhesive mixtures, polyvinyl acetate-based mixtures (PVA), and special aerosol adhesive mixtures are used to fix the printing surface on the plane. After placing the workpiece, the frame is fixed in the holder, and a test transfer of paint to the workpiece is performed. If necessary, the frames are shifted relative to the workpiece or vice versa, depending on the design features of the equipment and the location of the drawing on the printing plate.

Alignment of frames relative to the reference image in the case of full-color printing. In the case of drawing in several colors or in full-color printing, or printing with additional effects, use the combination of all stencils relative to the reference print. As a reference, you can use a white print, which is the basis for printing on dark blanks or black materials. As a standard, in our opinion, it is better to use the photo template itself, which is fixed on a hard surface - a tabletop, taking into account the location of the workpiece.

Applying the imprint by pushing the ink through the mesh holes. The image application procedure includes the following steps: lowering the stencil frame to

the printing plane, filling the empty cells of the template with paint, transferring the ink to the workpiece, and returning the frame to its original position.

Paintfilling of empty cells is realized by the uniform distribution of ink by a squeegee cloth in a printing zone. Then the squeegee web is pressed against the grid with a force that provides a choice of the technological gap between the grid and the workpiece, and the transfer of a layer of paint on the surface of the workpiece is carried out by the rapid movement of the squeegee web along with the stencil.

Drying of the applied ink layer on the printing surface (preliminary or intermediate) is carried out to prevent bonding of the workpiece when moving to the next position, or to dry the first ink layer during full-color printing, to prevent mixing of freshly applied color with the next

Applying the next color to the image is applied in full-color printing. The procedure for applying a layer of paint or additional effects is similar to the operation of applying the first color of the print.

As a result of empirical experience, it is established that there are two technologies for full-color printing: "wet on wet" or "dry". Wet-on-wet printing allows for a wider range of color image shades by mixing RGB or CMYK base colors [10]. However, the disadvantage of such printing is the effect of "dirt", which appears as a result of transferring each pre-applied color to the grid of the next printing plate. This requires constant cleaning of the printing plate from the workpiece. Dry printing produces a much clearer image; however, the color gamut suffers from insufficient mixing of the base colors.

Final drying or polymerization of the paint layer on the printing surface. This operation is performed in order to fix polymerize the applied pattern. This operation is performed using different types of equipment depending on the paint used. The main purpose of this operation is to fix a layer of paint on the workpiece in order to increase resistance to abrasion and natural wear.

3. Equipment for screen printing on light industry materials

Special tools, devices, and equipment are used for each of the described stages of screen printing.

In view of the above information, it is possible to divide the equipment for screen printing on light industry materials into three main groups. The first group includes all auxiliary and preparatory equipment and devices. These are equipment

for the manufacture of frames, devices for tensioning and fixing the mesh on the surface of the frame, devices for applying photo emulsion, drying cabinets for frames, high-pressure washing equipment, as well as cameras for exposing the photo emulsion. Tools and fixtures include ditches, stencil baths and heat fans.

The second group - equipment for direct application of the image to the printing surface by stencil. These can be devices for drawing drawings in one color, devices for drawing in several colors or drawing a full-color image, automated manual complexes for drawing a full-color image with additional effects.

The third group includes equipment for fixing the applied layer of ink on the printing surface. Since, when applying a full-color image, it is necessary to apply intermediate drying of the applied layers of paint, the equipment is divided into dryers of intermediate and final action. Intermediate dryers, or so-called Flash dryers, are designed to dry the surface film of the applied layer of paint in order to prevent the adhesion of the applied layer with the subsequent layer of paint. The equipment for final drying of paint includes tunnel-type dryers, press equipment of through and rotary type, as well as with manual or mechanized drive.

4. Conclusion

The sequence of operations of drawing images by the method of screen printing on materials of light industry is considered, and also a grouping of the equipment on purpose for the realization of the specified process is executed.

As a result of consideration and structuring of information about the operations of the technological process of screen printing on the materials of light industry, obtained as a result of theoretical and empirical research, the tasks of further analytical and experimental research are formulated:

– to inspect and analyze the equipment for screen printing on light industry materials;

– as a result of the conducted analysis to develop a classification of the equipment for screen printing on materials of the light industry;

– to develop engineering methods of calculation of technological modes of the process of drawing and drying of paint, and also technical parameters of the technological equipment;

– develop recommendations for the design of equipment for screen printing on light industry materials.

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RESEARCH ON THE EFFECT OF COMPOSITIONS OF BIOSURFACTANTS ON THE STRUCTURAL-MORPHOLOGICAL AND MECHANICAL PROPERTIES OF TEXTILES

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DOI: 10.31891/monograph/2021-10-72

1. Introduction

Creation of innovative formulae of washing compositions allows combining the high efficiency of the washing process with the treatment of textiles with special types of finishing. Studies aimed at the development of effective compositions with polyfunctional action based on biosurfactants (surface-active biodegradable substances) are urgent and promising. They also contribute to the development of the market of chemical products, reduce the material consumption of technology and the cost of production and increase the ecological safety of the process.

The complex study of the influence of compositions of biosurfactants on the structural-morphological and mechanical properties of textiles is presented. The results of the study will contribute to reducing the ecological burden on the environment and human health. In addition, this ensures the preservation of the consumer properties of textiles during operation.

2. Formulation of the problem

Washing, wet cleaning and finishing means should meet the following requirements [1, 2]: they should not cause irritating and allergenic reactions to the human body while respecting the mode of their use; they should not have teratogenic, carcinogenic, embryotoxic, mutagenic and other negative effects on the human body; the formulation of the equipment for finishing should include ingredients manufactured according to the normative documentation agreed with the respective controlling bodies of Ukraine; they should not contain chemicals of I and II classes of hazard; the aggregate states of the compositions should prevent the passage into the respiratory tract, the digestive tract, and the mucous membranes of a human when used; synthetic compositions should not change the

physical and chemical properties of the treated materials and worsen their hygienic properties; when developing new formulas of compositions it is necessary to use high-biodegradation surfactants (biosurfactants).

Bio-surfactants, unlike synthetic ones, are biodegradable and ecologically safe [3, 4]. The practical application of biosurfactants is subject to their ability to significantly reduce the surface and interphase tension of aqueous solutions, emulsify hydrophobic substances, regulate the wetting of surfaces and the rheology of solutions. In this regard, bioparticles are promising as independent reagents, as well as for the preparation of complex solutions.

According to the European Biocidal Products Directive 98/8/EC [5] the means used in the textile industry are of type 9: "Biocides for fibrous materials, leather, rubber and polymer materials". The Annex to this Directive contains a list of all active substances authorized for use in the EU countries.

It was shown [6] that the open areas of the human skin have a non-permanent microflora, and the closed ones are dependent on the textiles and the conditions of their use. The issue of the safe influence of modern compositions on the consumer properties of textiles and human health remains urgent.

The authors' use of the systematic approach to the analysis of chemical and technological processes of treatment of textiles, for the processes of laundry, wet cleaning allow expanding the possibilities of their use in the treatment of textiles from the standpoint of functionality and finishing effect.

Thus, it can be stated that a comprehensive study of the effects of compositions of biosurfactants on the structural-morphological and mechanical properties of textiles is appropriate and represents scientific and practical interest.

3. Results of the research and discussion

The study of the influence of compositions of biosurfactants on the structural-morphological and mechanical properties of textiles was carried out on samples of cotton, polyester and mixed fabrics. Characteristics of the fabrics are given in Table 1.

The fabrics used in the studies were in the prepared form – boiled and bleached. To assess the structural-morphological and mechanical properties of the studied samples of textiles, the indicators of tensile strength (Ts, H), elongation at

the time of rupture (l,%), wear resistance (the number of cycles), diameter of the yarn (mm) and electrical resistance (Ω, ohm) were determined.

Table 1. Characteristics of the investigated fabrics

Name of fabric	Width, cm	Binding	Surface density, g/m^2
Fabric made of cotton	150	linen	180
Fabric containing 80 % cotton and 20 % polyester	150	linen	220
Fabric containing 65 % cotton and 35 % polyester	150	linen	220
Fabric made of polyester	150	linen	220

Wet cleaning and finishing of the samples were carried out in aqueous solutions of a composition of biosurfactants (at a concentration of 2,5 g/l) [7]. The characteristics of wet cleaning for each type of textile sample are given in Table 2.

Table 2. Parameters of treatment of cotton, polyester and mixed fabrics with solutions of the composition

Operation name	Temperature, °C	Movement/pause, s	Speed of rotation, r/min	Treatment time, min
Cleaning	30	5/10	20	3
Draining	-	5/10	30	0,5
Rinsing	30	5/10	30	3
Draining	-	13/4	40	0,5
Wringing	-	-	400	2

Strength fiber is the ability to resist external damage, which largely determines the durability of the textile goods. Textiles in the processing and use, should be subjected to external forces, and generates corresponding deformation. When the external force is removed, a portion of the fibers of a recoverable deformation, while another portion is deformed are not restored.

It is closely related to its resistance to abrasion fastness fiber textile products. The wear resistance is an important indicator of the merits of clothing fabric wearability.

The mechanical properties of the cotton, polyester and mixed fabrics after treatment with the compositions, were determined by the indicators of tensile strength (Ts, H) and elongation at the time of rupture (l, %). The results of the study are presented in Table 3.

Table 3. The mechanical properties of the cotton, polyester and mixed fabrics, after treatment with the compositions

Treatment	Fabric made of 100 % cotton		Fabric containing 80 % cotton and 20 % polyester		Fabric containing 65 % cotton and 35 % polyester		Fabric made of 100 % polyester	
	Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft
	Tensile strength (Ts, H)							
Original sample	655	245	870	630	1235	1140	1800	1700
Aqua solution	400	305	790	520	1150	1000	1790	1700
Composition of biosurfactants	620	380	860	600	1210	1100	1800	1690
Treatment	Elongation (l, %)							
Original sample	14	28,5	25	41	33	46,5	45	47,5
Aqua solution	14	21	23	40	32	45	42	46
Composition of biosurfactants	14	21,5	24,5	40,5	33	46	43,5	48

Textiles size with good elastic fibers stability, the process of taking difficult to wrinkle, and more wear-resistant. Such as: polyester with excellent elasticity, which made clothing with a stiff, wear-resistant properties.

Textiles in the processing and actual use, due to the constantly subjected to friction caused by wear and tear. The wear resistance of the fiber refers to fiber withstand external wear performance.

The wear resistance (the number of cycles) of the cotton, polyester and mixed fabrics after thirtyfold (30 tr.) of the compositions of biosurfactants have been determined. The relative changes of these properties in comparison with untreated fabric (original sample) are presented in Figure 1.

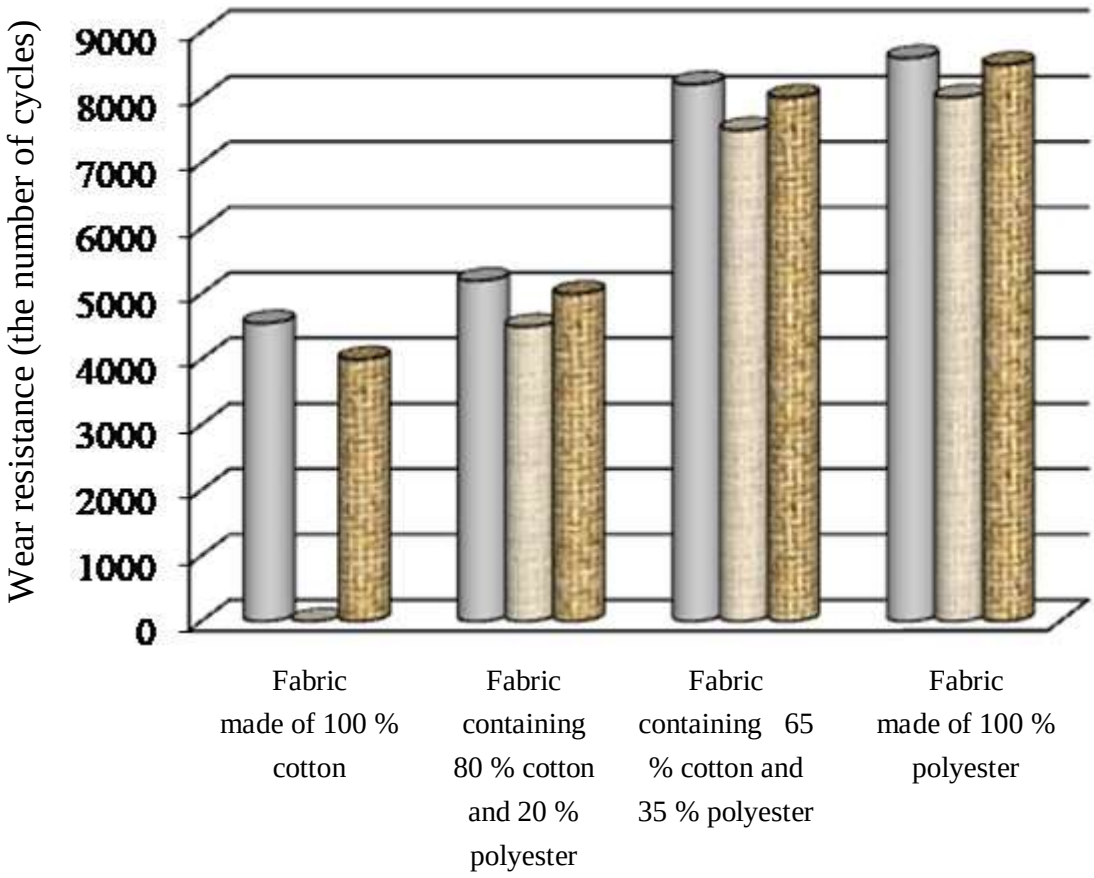


Fig. 1. The wear resistance (the number of cycles) of the cotton, polyester and mixed fabrics after thirtyfold (30 tr.): □ – original sample; □ – wet cleaning without composition; □ – wet cleaning with composition of biosurfactants.

Macromolecular structure of the fiber to fiber abrasion, supramolecular structure, elongation at break, elasticity and other factors. The study of structural and morphological changes of textiles was performed using a digital microscope Hirox® KH-8700. The relief image of the surface of cotton, polyester and mixed fabrics without treatment with compositions (1) and after treatment in solutions of compositions (2) are shown at Figure 2.

Analysis of digital images of the surface of textile products shows that the surface of the samples treated with the compositions acquires smoothness, softness of the fingerboard, gloss and surface density.

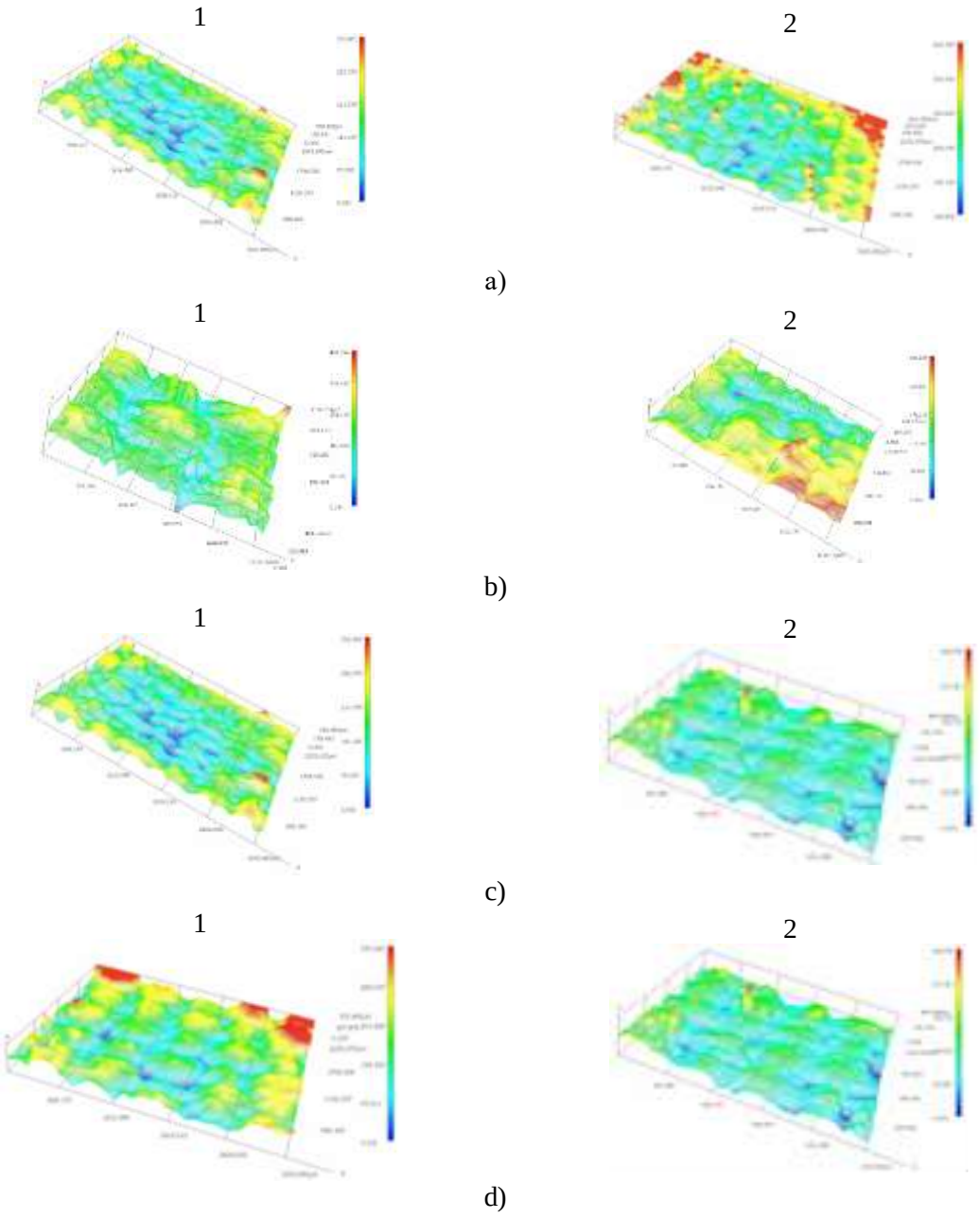


Fig. 2. The relief image of the surface of cotton, polyester and mixed fabrics: a) fabric made of 100 % cotton; b) fabric containing 80 % cotton and 20 % polyester; c) fabric containing 65 % cotton and 35 % polyester; d) fabric made of 100 % polyester.

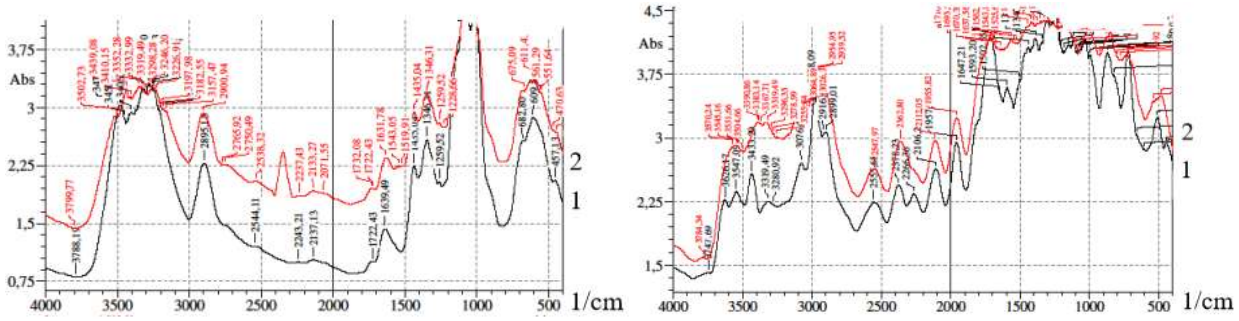
Studies have shown that in the process of wet cleaning of materials with compositions of biosurfactants, there is a change in the diameter of the yarn (Table 4) from 0,884 mm to 1,236 mm for cotton fabrics, from 1,096 mm to 1,688 mm for mixed fabrics, from 1,092 mm to 1,424 mm for polyester fabrics.

Table 4. Change of geometrical parameters of yarn after wet cleaning of compositions of biosurfactants

Name of fabric	d_{dirty}, mm	d_{wet}, mm	$d_{composition}$, mm
Fabric made of 100 % cotton	0,884	1,494	1,236
Fabric containing 80 % cotton and 20 % polyester	0,936	1,523	1,395
Fabric containing 65 % cotton and 35 % polyester	1,096	1,697	1,688
Fabric made of 100 % polyester	1,092	1,599	1,424

The increase in the diameter of the yarn after treatment of compositions of biosurfactants is due to the removal of contaminants from the material that contributes to the loosening of the threads, the elasticity of the neck of the fabric surface.

The spectral analysis of samples of textiles after wet cleaning in compositions of biosurfactants was performed to explain in detail the mechanism of interaction of biosurfactants with the surface of the fibers. The influence of the developed compositions on the structure of textile products (Figure 3) was investigated using IR spectroscopy methods [4, 9] on a spectrometer IRAffinity-1 (Shimadzu®, Japan). The results of spectroscopic analysis are shown in Figure 3.



a **b**

Fig.3. The spectral analysis of samples of textiles after wet cleaning in compositions of biosurfactants: a – fabric made of 100 % cotton; b – fabric made of 100 % polyester; 1 – original sample; 2 – wet cleaning with composition of biosurfactants.

Infrared spectroscopic studies have shown that the bands of bound absorbed water are shifted to the low frequency range, and their intensity decreases due to the extraction of OH-groups.

Spectral analysis are showed that the cellulose and polyester samples contain primary and secondary -OH groups, which have maxima of approximately equal

intensity: 3317 cm^{-1} - primary -OH and 3286 cm^{-1} - secondary -OH (Figure 3a); 3319 cm^{-1} - primary -OH and 3280 cm^{-1} - secondary -OH (Figure 3b), which are able to form a hydrogen bond of different strength.

Primary groups form such a bond faster, but it is weaker in strength, and secondary groups are slower, but the bond is stronger. Hydrogen bonds ensure the ability of compositions of biosurfactants to be well absorbed and retained on the surface and inside the fiber molecules.

It is difficult to directly detect the presence of adsorbed compositions on the fibers by IR spectroscopy, because the main characteristic bands of the groups of atoms of the components of the mixture overlap with the characteristic bands of the groups of fibers. Analysis of the obtained IR spectra is showed that treatment with compositions of biosurfactants does not change the chemical structure of fibers of different types.

Textiles are able to absorb moisture from the environment, resulting in a mono or polymolecular layer of moisture on their surface. In addition, the surface of the products is contaminated with various salts that play the role of electrolytes. The presence of moisture and electrolytes creates conditions for a sharp increase in electrical conductivity of materials, increasing the rate of charge accumulation, which is a negative phenomenon – causes discomfort and discomfort in humans, adhesion to the body, promotes rapid contamination by concentrating dust particles, causes biological effects on the body.

For this reason it is important to develop ways to reduce the specific surface electrical resistance (Ω, ohm) of textiles. Treatment of products with antistatic surfactants is a safe and effective method that is widely used [8, 10]. Therefore, the effectiveness of the antistatic action of the compositions of biosurfactants in the process of wet cleaning textiles was determined (according to DSTU GOST 21790: 2008). In the process of adsorption of biosurfactants form a layer on the surface of the material, which causes the scattering of electric charges and thereby reducing the electrical conductivity of textile products [4, 10]. The results of determining the electrical resistance of textile products of different types at different humidity after treatment of the compositions of biosurfactants are given in Table 5.

Table 5. The electrical resistance (Ω, ohm) of samples of textiles after wet cleaning of the compositions of biosurfactants

Treatment	Air humidity				Z*, %
	φ=5%		φ=85%		
	Ω, ohm	Ω_s, ohm	Ω, ohm	Ω_s, ohm	
Fabric made of 100 % polyester					
Original sample	$5,5 \cdot 10^{11}$	$5,71 \cdot 10^{11}$	$2,8 \cdot 10^{11}$	$2,76 \cdot 10^{11}$	12,14
Composition of biosurfactants	$3,2 \cdot 10^{9}$	$3,4 \cdot 10^{11}$	$8,9 \cdot 10^{8}$	$9,44 \cdot 10^{10}$	19,28
Fabric containing 80 % cotton and 20 % polyester					
Original sample	$5,2 \cdot 10^{12}$	$4,6 \cdot 10^{11}$	$4,2 \cdot 10^{11}$	$3,44 \cdot 10^{11}$	16,40
Composition of biosurfactants	$6,1 \cdot 10^{11}$	$5,6 \cdot 10^{11}$	$4,2 \cdot 10^{11}$	$3,32 \cdot 10^{11}$	18,52
Fabric containing 65 % cotton and 35 % polyester					
Original sample	$6,7 \cdot 10^{10}$	$6,84 \cdot 10^{10}$	$7,2 \cdot 10^{10}$	$7,25 \cdot 10^{10}$	16,87
Composition of biosurfactants	$5,6 \cdot 10^{10}$	$5,65 \cdot 10^{10}$	$7,2 \cdot 10^{10}$	$7,25 \cdot 10^{10}$	10,53
Fabric made of 100 % cotton					
Original sample	$8,7 \cdot 10^{11}$	$8,22 \cdot 10^{11}$	$2,23 \cdot 10^{10}$	$2,22 \cdot 10^{11}$	2,20
Composition of biosurfactants	$1,7 \cdot 10^{10}$	$1,60 \cdot 10^{11}$	$1,56 \cdot 10^{10}$	$1,35 \cdot 10^{11}$	1,94

Note: Z – residual contamination of products, after wet cleaning of the compositions of biosurfactants

Thus, when cleaning products of different range of the compositions of biosurfactants there is a decrease in the surface resistance of the products. For polyester samples of textile materials, the surface resistance is reduced by an order of magnitude and ranges from 10^9 to 10^{10} ohms. After treatment with the compositions of biosurfactants, hydrophilic cotton materials are much lower electrified compared to hydrophobic polyester, due to the different nature of the fibers.

4. Conclusions

The quantitative indicators of tensile strength (Ts, H), elongation at the time of rupture (l,%), wear resistance (the number of cycles), diameter of the yarn (mm)

and electrical resistance (Ω, ohm) of efficient treatment of textiles for preservation of consumer properties of textiles were determined.

The research results show that the compositions of biosurfactants are effective during wet cleaning and finishing of textiles, which promotes the care of products, removes static charge, improves the quality of removal of contaminants from fabric surfaces and reduces product contamination during operation.

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TECHNOLOGY OF FORMATION OF ANTIBACTERIAL PROPERTIES OF LINING LEATHERS

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DOI: 10.31891/monograph/2021-10-73

1. Introduction

Problems of improving the quality, reliability and the biological stability of the finished product is inextricably linked to the quality of the materials used to produce it. The widespread use of substandard materials for manufacturing of footwear crucially influences comfort of shoes, contributing to the creation in inner part of the shoe the environment that accelerates development of harmful microorganisms. In addition to direct action associated with damage to the structure of the skin, bacteria reduce hygiene and physiological properties of the footwear. This contributes to premature wear of joints and, consequently, self-development of pathogens inside the shoe [1], which negatively affect the human body.

The relevance of this study is due to demand in developing biocidal agents for leather materials and products that do not pollute the environment, withstand microorganisms of different taxonomic groups (bacteria, fungi, etc.), have a long term protective actions, are available and cheap.

Protection of shoes and, accordingly, the user's feet from the ravages of pathogens is closely associated with increased bio-stability of interior materials of shoes – materials of first category that are in direct contact with the skin of the foot and are standardized by QEKO TEX Standart 100. Finding ways to increase the biological stability of lining and insole materials using biocide drugs that are able to resist micro-organisms of different taxonomic groups (bacteria, fungi, etc.), have a long-term protective action, do not pollute the environment and at the same time are available and cheap, this area of research is urgent and promising.

The task of increasing the biological stability of materials has two solutions:

- application of biocidal disinfectant on the surface of the material or the finished product;
- formation of microbiological resistance of the material together with the other functional and application properties in the production process.

Solution of materials microbial resistance problems is related to the study of the nature and extent of changes in chemical and physical structure of the material and the preservation of its inherent complex of operational and technological

2. Problem

1. Creating multifunctional polymeric biocide formulations using natural minerals zeolite, montmorillonite and polymeric guanidine derivatives for antibacterial and antifungal leather treatment.

2. Introduction of polymeric biocides into leather texture as a filler at post tanning leather manufacturing processes.

3. Getting bio-resistant leather materials, especially lining and insole leather, using environmentally friendly, non-toxic, cheap and available materials, which significantly improve the physiological and hygienic properties of footwear and other leather products.

3. Objects and methods of research

Minerals of various crystal-chemical structure zeolite and montmorillonite, polymeric guanidine derivatives (PGMG-GC), semi-finished leather for lining and insole, as well as model collagen preparation (gelatine) will be used for the study. To modify the minerals alkaline peptizing agents will be used that are capable of dispersing the mineral particles in suspensions, align their electrical inhomogeneity and create anionic structured and aggregate stability system. Chrome semi-finished product from cattle raw material (thickness 1,2-1,4 mm), outgrowth (thickness 1,1-1,3 mm) and pig skin lining (thickness 0,6 – 0,8 mm) has been used for testing as objects of research for shoe uppers. At the stage of filling and retanning of semi-finished leather, instead of expensive mineral filler Tanicor FTG of company "Clarian" (Poland) modified dispersion of natural minerals were injected into the structure of the dermis - the most common types of aluminosilicate extracted in Ukraine: zeolite (fraction 0,02-0,08 mm), which has a solid frame tetrahedral skeleton with a system of cavities and channels (Figure 1) and montmorillonite, which by the nature of the crystal lattice refers to a clay layered hydrated silicate of alumina of lamellar structure. Deprived of water zeolite is a microporous crystalline "sponge", in which the pore volume is up to 50% of the zeolite framework (Figure 1, b).

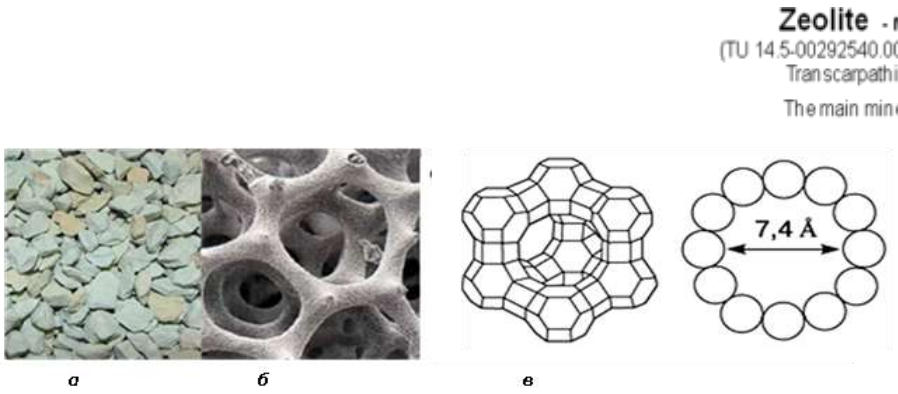


Fig.1. The appearance of natural zeolite (а), its image of microporous (б) and crystal (в) structure with large and small pores, formed by sodalite units (zeolite Y)

This "sponge", with a diameter of ports from 0,3 to 1,0 nm is high adsorbent. Features of adsorption on zeolites are due to the fact that tracery of crystal structure creates a large adsorption volume (0.54 cm^3 to / g), and its geometry determines molecular sieve properties

To modify the selected minerals alkaline rubber peptizing agent hexametaphosphate of sodium $(NaPO_3)_6 \times 6H_2O$ of 10% of the dry weight of the mineral, which is able to disperse mineral particles in suspension, align electrical inhomogeneity and create anionic structured and stable aggregation systems.

To assess the effectiveness of formation of leather structure and definition of its functional properties resulting from the modification with modified dispersion of montmorillonite (MDM), zeolite (MDZ) and their mixtures (MDZ:MDM) a set of traditional chemical, physical, chemical, physical, mechanical and several modern research methods including spectroscopy, chromatography, differential thermal analysis DTA, TGA thermogravimetric analysis and derivative of thermogravimetry DTG, methods of mathematical analysis and planning of the experiment have been used.

For technological investigation, semi chrome finished item of light steers from butt was used (Fig.2). The raw material treatment was performed according to traditional technology of chrome leather for the upper of shoes production used by Public Joint Stock Company ″Chinbar″.

It is well known that organic compounds containing in their structure the guanidine moiety, possess antibacterial properties and are used as therapeutic drugs and fungicides. They are not inactivated with proteins and at the same time

biodegradable and therefore are widely used as a physiologically active substances, drugs, antiseptics, pesticides [1,2].

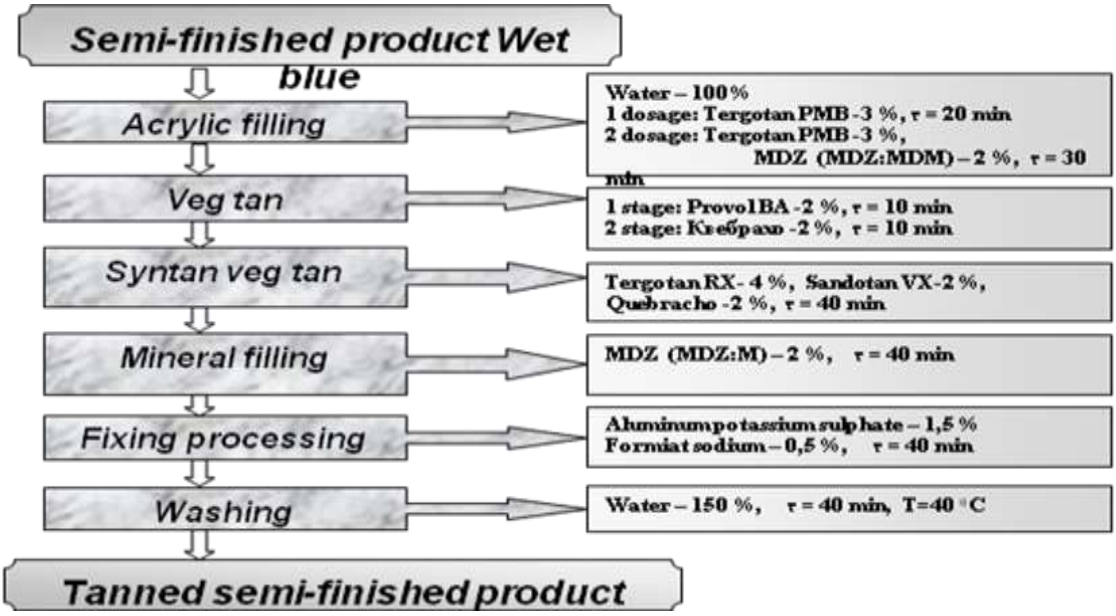


Fig. 2. Technological scheme of filling-tanning process of leather semi-finished product modified with zeolite dispe*rsion*

Hexamethylenediamine is an antibacterial, antiseptic, sterilizing and preventing coming into existence „ugly" of smells element in polymer. Guanidine groups are giving it cationic character. It is a well known and willingly applied biocide, eliminating both Gramm positive and Gramm negative bacteria, some viruses, yeast, mushrooms, unicellular algae. On the world market it is available in the form of the salt of inorganic acids, most often hydrochloride - CAS 57028-96-3 and phosphate CAS 89697-78-9. Additionally PHMG is high thermal resistant, non-inflammable and stable chemically in very wide range of pH (1-10) [3,4].

Destructive PHMG (Fig.3) action against microorganisms is being explained by the fact, that positively charged polymer is being pulled to contrary charged cell walls of the micro-organism, what is making it impossible to expel ions of potassium from cells by and causes the diffusion of nucleotides. Simultaneously it is non-toxic for people, isn't causing irritation to the skin, eyes and mucous membranes. The index of the toxicity for micro-organisms is 3000 times bigger than for people and terrestrial animals (for the rat orally LD_{50}=610 mg/kg, for the skin contact LD_{50}>2000mg/kg). Moreover it is compatible with the majority of

remaining elements of disinfectants and doesn't influence their form - perhaps to be applied in compositions for forms of liquid, cream, gel, aerosol, emulsion, pastes, etc. It is possible to apply it with other available germicides so as the copper sulphate, zinc sulphate, quaternary ammonium salts, hydrogen peroxide and peracetic acid in the concentration much smaller than in case of other disinfectants. It shouldn't been linked with anionic surface-active agents so as soaps or alkyl- and aryl- sulphonates, because it can cause their throwing solution off [4-6].

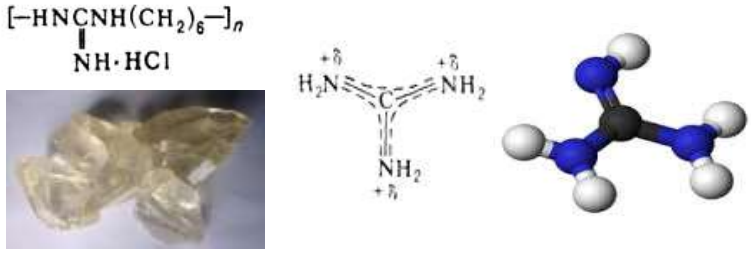


Fig. 3. Polyhexamethylene guanidine hydrochloride

Due to the high incidence of guanidine its bactericidal activity has been well studied.

The apparent advantage of guanidine is a low human toxicity and virtually no corrosion activity in respect to most materials [7]. Moreover, guanidine is capable of forming a film on the treated surfaces, allowing suggesting the prolonged activity of the surface treatment of agents without subsequent rinsing.

4. Results and discussions

The research results of chemical and physical changes that occur under the influence of heat between macromolecules of collagen and particles of mineral, changes in the degree of structure crystallinity of the dermis and the internal heat capacity of the system support the hypothesis of a thermal stabilization of the structure of collagen involving acrylic-mineral composition and its partial transition from amorphous to crystalline state. Thermal impact facilitates phase transformation in the structure of the dermis and the transition to a more sustainable modification that determines rate increase of thermal stability of investigated skins [8,9].

Analysis of differential thermal curves (Fig. 4) allows asserting effective regulation of the dermis structure at different levels of its organization by sealing micro and mesostructure.

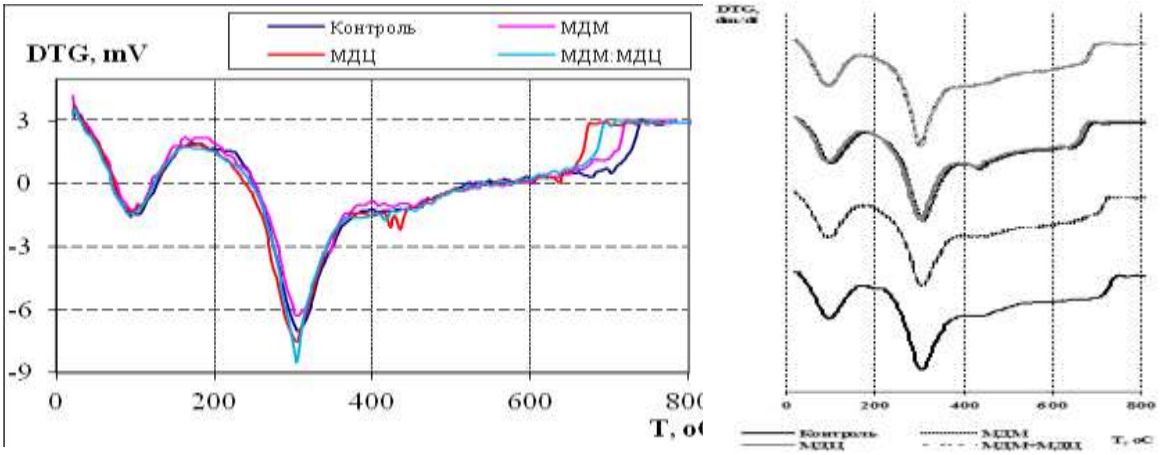


Fig.4 Differential thermogravimetric curves of the samples of filled skin

The results of thermal studies show that the thermooxidative destruction of filled dermis collagen is a multistage process that takes place in at least two stages.

The first stage takes place in the temperature range 25 ... 125 ° C and is characterized by almost the same amount of weight loss of all samples (~ 10%) and low speed 1.61 ... 2.0 mg / min. At this stage of thermal destruction modified mineral fillers help to reduce speed destruction of skin samples compared to the control sample. It also confirms the value of activation energy, which is 18 ... 24% more (90.3 ... 92.5 kJ / mol to 76.4 kJ / mol) than in the control sample. The growth of activation energy of skins filled with mineral compositions may indicate the formation at the structure of the dermis additional physical and physical-chemical bonds type hydrogen and Van der Waltz, which will strengthen the structure of the treated leather and a certain increase in thermal resistance [10, 11].

This process is likely also associated with dehydration of mechanically bound water in the process of heating of samples as well as the formation of new hydrogen bonds between the structural elements of the skin by removing water and seal of structure.

5. Conclusion

To sum up, there are grounds for the assumption of the possibility of obtaining biostable lining and insole leather through the development of highly active biocide compositions based on natural minerals and polymer derivatives of

guanidine and then applying them as a filler to the semi-finished leather at post tanning leather production processes.

Rationality of the results of the project will be the creation of an innovative technology for obtaining bio stable leather materials through the creation of low-cost multifunctional biocidal products to ensure a high biological activity, the widest range of action, safety for humans and the environment, and at the same time available and cheap.

Physiological and useful properties of the shoe will be improved, as the risk of possible negative influence of the material on the skin of the foot will be reduced. The project also includes the development of methods for studying the mechanisms of processes of adhesion, sorption, diffusion and fixation of biocidal products with leather collagen.

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RATIONALE FOR IMPLEMENTING EUROPEAN MODULAR SYSTEMS IN EUROPE

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DOI: 10.31891/monograph/2021-10-74

Abstract: The aim of the article is to show the rationale for the implementation of European Modular Systems in Europe, in particular in the Three Seas Region: the Black Sea, the Baltic Sea and the Adriatic Sea. The article describes the characteristics of modular systems and analyses the legal and infrastructural aspects of their operation in Europe. It also identifies the European countries in which the solution is used. The conclusion of the study is the indication of the infrastructural conditions related to the implementation of the European Modular Systems, with particular emphasis on the factors influencing the development of the cooperation of the Three Seas Initiative with other countries, in particular Ukraine and Moldova. The study also refers to a comparative analysis of the selected loading means in the Three Seas region using the Bellinger method, showing the rationale for the implementation of the EMS.

1.Introduction

The current situation on the market, the increase in demand for transport services, poses new challenges and forces entrepreneurs to look for new ways to make savings. The costs connected with transporting goods from point A to point B constitute a large part of the costs of completing the entire order.

For many years, the world has been searching for and implementing new solutions aimed at reducing fuel consumption, increasing transport safety and protecting the environment.

From the 1930s, road trains began to be used around the world. Australia was the forerunner, followed by the United States, Canada and some European countries. Over the last 20 years, the solutions have been increasingly used in various European countries. In some of them it is carried out on the basis of a permit, in others it is a common thing. Most transport is carried out on high-speed roads, such as motorways. The implementation of larger vehicles in the form of road trains has the effect of increasing the capacity of road transport, while at the same time reducing transport costs. A very important element here is the modernization and expansion of infrastructure and increasing the load capacity of roads, which will contribute to making road transport more efficient and at the same time safer.

2. Characteristics of European Modular Systems

The European Modular System, or EMS for short, is a solution that makes it possible to combine existing loading units, so-called modules, into longer and also heavier vehicle combinations. The combinations are used on certain sections of the road network, which improves the efficiency of road freight transport and also reduces its negative impact on the environment [13].

European Modular Systems are also referred to as the "modular concept", which is defined in Directive 96/53 EC of 25 July 1996 on the maximum dimensions of individual road vehicles in national and cross-border traffic within the Community and the maximum weights in cross-border traffic. Article 4 of the abovementioned directive indicates that "Member States may permit vehicles or combinations (sets) of vehicles intended for the carriage of goods in the course of a particular national traffic activity which do not significantly impede international competition in the transport sector to circulate even if they have dimensions differing from those set out in Annex I to the directive" [5]. The prescriptive dimensions specified in the Directive in Annex I concern [2, 3, 10]:

a. maximum allowable length of vehicles:
    - engine vehicle or semi-trailer - 12 m,
    - articulated vehicle - 16.5 m,
    - road train - 18,75 m.
b. maximum allowable widths of vehicles:
    - 2,55 m – all vehicles,
    - 2,6 m in the case of freezer trucks.
c. maximum allowable height of 4 m.
d. maximum allowable weight of vehicles:
    - road trains or articulated vehicles - 40 tonnes,
    - articulated vehicles carrying 40 feet long containers - 44 tonnes.

On the basis of the analysis of the above data, taking into account the formulated definition of the "modular concept", it follows that the state may allow on its territory the vehicles in which the maximum permissible parameters deviate from the standards contained in the act, while maintaining the principles of competition in the transport sector. According to this concept, a non-normative vehicle or vehicle combination can be replaced by a non-normative road train [2, 3, 10].

The European Modular System uses vehicles currently in use on the European market for transporting goods. EMS can be found under different names such as: road trains, EuroKombi, Megaliner, Gigaliner, (LHV) Longer and Heavier Vehicles, Megatruck [2, 8, 10]..

The road trains consist of standard and non-standard modules. The sets that are configured from them are 25.25 m long. Their advantage is that they can be freely formed and deformed, creating both normative and non-normative vehicles. The modules from which the sets are configured are listed below [2, 3, 8]:

a) a truck tractor or truck (standard),
b) a 13.7 m long articulated trailer (standard),
c) a 7.82 m long trailer (standard),
d) a 2-axle truck (called bogie) (non-standard),
e) a special 7.82 m long 3-axle articulated trailer with a removable container/body at the front equipped with a fifth wheel to attach another articulated trailer (non-standard).

Using the modules listed below, 5 different sets of vehicles can be configured.

Configurations of modular systems are illustrated in Figure 1 [2, 3, 8]:

a) configuration A - 2/3-axle truck tractor unit coupled with a 13.6 m 3-axle articulated trailer hooked with a maximum 7.82 m long central axle trailer,
b) configuration B - 2/3-axle tractor connected with a special articulated trailer to be hooked to a standard 13.6 m long articulated trailer,
c) configuration C - a 4 axle 8x2/8x4 chassis hooked to a 3 axle trailer,
d) configuration D - 3-axle chassis 6x2/6x4 hooked to a forklift and a 13.6 m long 3-axle articulated trailer,
e) configuration E - 2-axle chassis hooked to two tandem trailers with a 7.82 m long central axle..



Fig.1 Modular system configurations [2, 3, 8]

Thanks to the possibility of any configuration, it is possible to carry loads that were transported by three standard vehicles using two vehicle combinations. A comparison between the standard set and the EMS concept is illustrated in Figure 2.

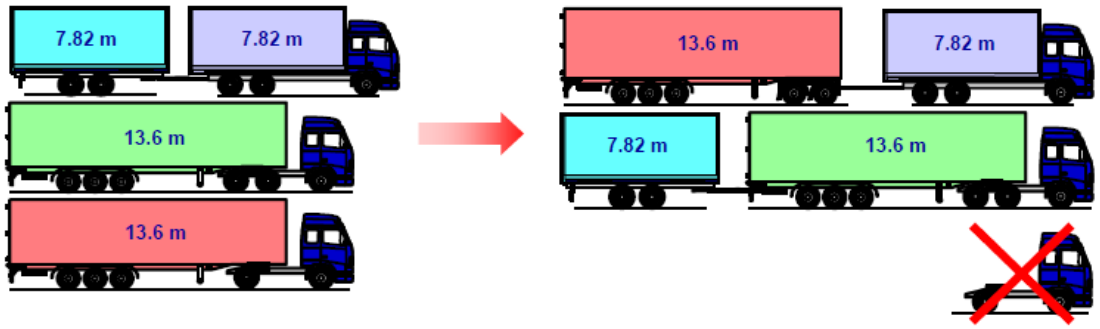


Fig.2: Comparison of the standard set with the EMS system concept [4, 6, 11]

3. Functioning of European Modular Systems in Europe

The use of European Modular Systems (EMS) in the world dates back to the 1930s, so the date can be considered as the beginning of functioning of this type of vehicles. One of the first countries to start using EMS was Australia. In this country, road trains, as they are also called, were used to transport goods between cities over longer distances. Such vehicles are also used in Canada, the United States, Mexico and Argentina [2, 4, 10].

The use of European Modular Systems is becoming increasingly popular in Europe. European countries make use of derogations from the Directive and allow the operation of non-normative vehicles. The last 20 years show that this is becoming quite popular and the number of countries introducing the derogations is constantly increasing. The leaders are the Scandinavian countries, which pioneered with EMS in Europe [2].

Sweden is one of the countries where longer vehicles have started to be widely used. Currently, 25.25 m long vehicles weighing 64 tonnes can be driven on Swedish roads without a permit [2, 10, 12]. Since 2009, vehicles with the length of 30 m and weighing 90 tonnes have also been permitted in the north of the country for transporting timber [2, 8]. The authorization to use such vehicles has been under constant review, the road infrastructure is being modernized and the load-bearing capacity of roads is being increased. Research is also conducted on the impact of ESM on infrastructure, environment or safety. Studies indicate that transport costs for both businesses and the economy have decreased. The operation of road trains in Sweden has not contributed to an increase in accidents involving this type of vehicles, nor it has had a negative impact on the environment or the operation of other transport branches [2, 7, 10].

Another European country where road trains with the length of 25.25 m are operated while increasing the total weight of the vehicle was the Netherlands. Tests were carried out in the Netherlands for years. The use of this type of vehicles was divided into several phases, with a number of companies participating in the tests. Eventually, after testing, it was found that the use of EMS contributed to [2, 9]:

- CO2 emissions dropping from 63 to 56 g per tonne-kilometre, representing about 11% CO2 reduction,
- NOx emissions dropping from 0.4 to 0.37 g per tonne of NOx, representing a 14% reduction in NOx.

Road trains in the Netherlands are used on routes between ports and distribution centers, while their arrival and final distribution is done by standard vehicle combinations. Such actions have contributed to increased transport efficiency in the Netherlands [3, 4].

Finland is another country where vehicles are permitted to be driven in excess of the values laid down in the directive. Since 1997, vehicles with the length of 25.25 meters and a total weight of 60 tonnes have been authorized. The effects of road trains being permitted to drive are still being studied in Finland and these studies show that the operation of road trains has a positive effect on reducing CO2 as well as fuel consumption [1, 2].

In addition to the countries mentioned above, there is Denmark, which, because of its location, is a very interesting country for Swedish transport companies. It has been trying to allow EMS vehicles on its roads for many years.

Currently the maximum permissible weight is 48 tonnes [3, 13]. In Denmark, work is also underway to modernize the infrastructure and expand car parks to accommodate 25-metre-long trucks [2, 14]. Germany is another country that is gradually implementing EMS on its territory. Since January 2011, trucks with the weight of 40 tonnes and length of 25.25 m may be driven on the roads in Germany; according to preliminary calculations, the country is trying to increase the total weight to 44 tonnes, which is very much supported by German companies [2, 15, 16].

In addition to the countries mentioned above, there are some countries that are experimenting by allowing long vehicles on their transport territory. As an example we may mention Spain, where the gradual introduction of vehicles exceeding the permissible standards takes place on the basis of special permits [2, 17]. Such solutions have also been introduced in Portugal [2, 18], Czech Republic [2, 19] and Belgium [2, 20].

In conclusion, it is clear that an increasing number of European countries are choosing to derogate from the Directive, in some cases on the basis of permits, in others this is a generally accepted solution.

Table 1 lists the countries that allow the use of road trains on their territory.

Table 1. Countries allowing the use of road trains [2]

EU country	Length of set	Allowable total weight of the vehicle
Sweden	25,25 m	64 t
The Netherlands	25,25 m	60 t
Denmark	25,25 m (tests untill 2030 r.)	48 t
Finland	34,5 m.	76 t
Norway	24 m (25,25 m based on a permit)	60 t
Germany	25,25 m (some roads and some lands)	40 t
Spain	18,75 (25,25 m based on a permit)	44 t (60 t based on a permit)
Portugal	18,75 (25,25 m based on a permit)	40 t (60 t based on a permit)
Belgium	18,75 (25,25 m based on a permit)	44 t (50 t in Walonia)
The Czech Republic	18,75 (25,25 m based on a permit)	48 t

4. Infrastructural prerequisites for the implementation of EMS

The implementation of European Modular Systems on roads depends on many factors. One of the very important ones is infrastructure. Based on the analysis of European countries operating this type of vehicles, it can be said that the EMS in most cases can be applied especially on motorways or expressways that connect logistic centers and ports [4, 11]. As is also evident from tests carried out in other countries, the implementation of modular systems does not have negative effects on the environment, nor it affects road safety. The key factor is the development of transport infrastructure, increasing the load capacity of roads, which with the current demand for transport services is justified in itself. The implementation of such systems may have a positive impact on the development of the Three Seas region, which comprises 12 states located between the three seas: the Baltic Sea, the Black Sea and the Adriatic Sea. The countries are: Austria, Bulgaria, Croatia, Czech Republic, Estonia, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia and Hungary. Their main objective is cooperation primarily in the fields of energy, logistics and transport as well as IT and telecommunications. The priority for the Three Seas Initiative is to build a coherent and well-integrated infrastructure in Central Europe [4, 21]. Recently, there have been many different discussions about the development of the Three Seas Initiative, as it is beginning to attract countries from outside the European Union that have expressed their interest in cooperation. On 12 January 2021 in Kiev, the Moldovan President Maia Sandu made an official statement together with the President Vlodymyr Zelencki, in which both presidents expressed their wish to strengthen cooperation with partner countries in South-Eastern Europe and confirmed their interest in joining the Three Seas Initiative [22]. Figure 3 illustrates the Three Seas Countries together with Ukraine and Moldova.



Fig. 3. Three Seas Countries with Ukraine and Moldova [22]

Bearing in mind the above considerations, it can be assumed that the application of EMS in the above-mentioned area can positively influence the development of transport, increase the competitiveness of goods transport between countries, increase the trade exchange of countries in this area, which will translate into shorter transport execution time, and thus reduce fuel consumption, which in turn will translate into lower unit transport costs [4].

5. Analysis of the use of EMS in the Three Seas region

The relevance of implementing European Modular Systems in the Rhree Seas region was previously referred to by other authors, who carried out a comparative analysis of selected means of transport using the Bellinger method. The study, which included economic and efficiency criteria for the transport of a cargo unit, i.e.: length of a set, number of pallets, loading capacity, fuel consumption, cost of transporting one pallet clearly shows that when comparing three means of transport on a 1,699 km route from the Port of Stockholm in Sweden to the Port of Rijeka in Croatia, located between the ports of the Baltic Sea and the Adriatic Sea, it was the EMS that scored the highest number of points. A summary of the results of the study by means of transport can be found in Table 2 [3].

Table 2: Results of the comparison of selected cargo means in the Three Seas region using the Bellinger method [3]

CARGO MEANS	RESULT
STANDARD SET	0,0679
SET CONSISTING OF A MOTOR VEHICLE AND A TRAILER	0,0715
EMS	**0,0873**

The conducted analysis allows to conclude that in connection with the ongoing work over implementing the infrastructure projects of the Three Seas Fund, it is reasonable to utilize the European Modular Systems in the area.

6. Conclusions.

The development of European Modular Systems in Europe is very important both for entrepreneurs and for the economy as a whole. The ever-increasing demand for performing transport services has a negative impact on the environment, exhaust emissions and the safety of road users. The concept of

developing modular systems is a solution which will make it possible to mitigate the negative effects. Using fewer vehicles to transport the same amount of goods will contribute to:

- reduced CO2 and NOx emissions,
- reduction in fuel consumption,
- reduction in transport unit costs,
- increased safety for road users.

Taking into account the above-mentioned aspects, it can also be concluded that the implementation of the European Modular Systems in road traffic in the Three Seas Region, including Ukraine and Moldova, is a solution that will positively influence the development of the area, provide an opportunity to increase the transport capacity between the countries and improve trade and relations between the countries.

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CHARACTERIZATION OF NANOCRYSTALLINE ZINC OXIDE SYNTHESIZED BY DIRECT PRECIPITATION METHOD

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DOI: 10.31891/monograph/2021-10-75

1. Introduction

Cotton is one of the most abundant natural fibers in the world. Due to its unique properties such as strong absorption capability and flexibility, high mechanical stability and biodegradability, this natural fiber has become widespread for applications in textiles for various purposes.

In the last few years, the innovation of textile smart materials has increased substantially. These materials, that are capable to respond and to adapt to external stimuli, can be applied in different areas such as healthcare, sports, military et al.

The augmented requirement for fibrous materials possessing multifunctionality implies powerful emerging multidisciplinary approaches as well as the connection with the traditional scientific disciplines. Finishing processes through nanoparticles were among the first commercial application in textiles domain. The surface area-to-volume ratio and high surface energy of nanoparticles improve their affinity for fabrics, leading to an increase in effect durability.

With advent of nanotechnology, a semiconductor nanoparticle has attracted much attention due to their novel optical, electrical and mechanical properties. Among various semiconductor nanoparticles, nanosized zinc oxide (ZnO) particles are the most frequently studied because of their interest in fundamental study and also their applied aspects such as in solar energy conversion, varistors, luminescence, photo-catalysis, electrostatic dissipative coating, transparent UV protection films and chemical sensors [1].

ZnO nanoparticles are semiconductor materials, which have been widespreadly used due to their unique physical and chemical properties, such as surface effect, quantum size effect and macroscopic quantum effect [2].

The application of ZnO nanoparticles to textile has attracted extensive attentions due to the advantages of ZnO nanoparticles, such as UV-shielding, antibacterial activity, biocompatible, biodegradable and biosafety for environmental applications.

Emerging studies on functionalized cotton fibers modified with ZnO nanoparticles expanded the use of cotton fabrics for various applications, such as conductive [3], magnetic [4], photocatalytic [5], antimicrobial [6, 7], super hydrophobic [8] and fire retardant [9, 10] textiles.

ZnO has a certain blocking effect on the rays of different wavelengths (ultraviolet and infrared), due to its high free electron density and strong infrared reflection ability. In addition, the size of nanoscale ZnO particles is similar as the wavelength of ultraviolet light, which endows zinc oxide nanoparticles with excellent ability to scatter ultraviolet light. Ultraviolet rays that radiate onto the ZnO nanoparticles scatter in all directions, thus further reducing the intensity of transmitted beam.

Moreover, antimicrobial activity of ZnO nanoparticles is light-independent, while in other cases, like TiO_2 nanoparticles, light irradiation is required for achieving good antibacterial activity. Due to their antimicrobial properties, ZnO nanoparticles, have been extensively used in fabric finishing's, because they are considered as a viable solution for fighting a broad spectrum of bacteria and fungi [11].

Researchers showed that ZnO nanoparticles coated on cotton fabrics could impart not only functional properties such as better strength properties, air permeability and UV-absorption [12], but also could help to enhance the flame-retardant action [13]. Application of new environmentally friendly flame-retardant systems for cotton is an important textile issue especially for protection of consumers in military and the airline industry [14].

These characteristics make ZnO a very attractive candidate for exploring new applications. However, development of ZnO for new applications requires the ability to control morphological structures within reasonable synthetic conditions, which is one of the biggest challenges. So far, many different ZnO structures such as flowers, needles, wires, rods, spheres, and stars have been reported [15]. In addition to morphological structure, it is important for some applications to be able to control band gap energy for photocatalytic applications, particle size distribution and zero point charge for anionic and cationic adsorption applications.

Several ZnO synthesis routes have been described in the literature with different morphologies and excellent characteristics, including chemical precipitation [16], solvothermal [17], sol–gel processing [18], thermal

decomposition [19], microwave irradiation [20], chemical bath deposition [21], dip coating [22], spin coating [23], electrical deposition [24], and hydrothermal processing [25]. Among these methods, chemical precipitation provides a practical way for low cost and large-scale production, which does not need expensive raw materials and is expected to realize industrialization.

Many factors to affect the properties of the synthesized ZnO such as synthesis temperature, precursor concentration, pH of synthesis mixture, reaction time and heat treatment.

Thus, the goal of this article is to investigate the action of synthesis conditions on the ZnO nanoparticle properties.

2. Materials and methods

In this paper, ZnO nanoparticles were synthesized by direct precipitation method accordingly to the method described in [26] with few modifications. Zinc acetate ($Zn(CH_3COO)_2 \cdot 2H_2O$) and sodium hydroxide (NaOH) were used as precursors. According to stoichiometric ratio, the precursors at a certain quantity were firstly dissolved in distilled water. NaOH solution was added dropwise into zinc acetate solution with vigorous stirring at 70°C for 2 hours to allow complete growth of nanoparticles. The white precursor product was centrifuged and washed with distilled water and ethanol to remove any impurities or possible absorbed ions. The obtained product was dried at different conditions.

The synthesized ZnO nanoparticles were characterized by means of UV-visible absorption spectroscopy by using ULAB 102UV Spectrophotometer. For recording UV-Vis spectra, the sample of ZnO colloidal solution was prepared by dispersing ZnO nanopowder in isopropanol. The prepared solutions were scanned in the wavelength range between 200 and 600 nm at the room temperature in 1 cm path quartz cell.

3. Results and discussion

The size of the nanoparticles plays an important role in changing the entire properties of materials. The influence of the synthesis conditions on the photo-optical properties of the produced ZnO was studied through their capability of absorbing the UV radiation. UV-visible absorption spectroscopy is widely being used technique to examine the optical properties of certain nanoscale particles. The absorption spectra of synthesized ZnO nanoparticles are depicted in Fig. 1 – 3.

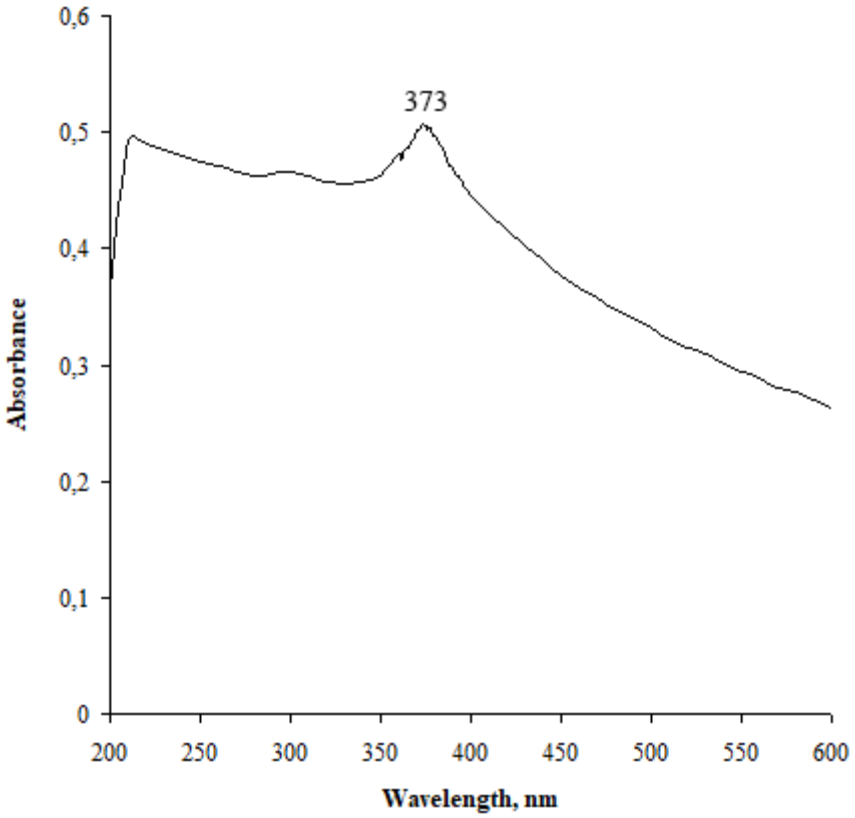


Fig. 1. Absorption spectrum of the ZnO nanoparticles dried at room temperature

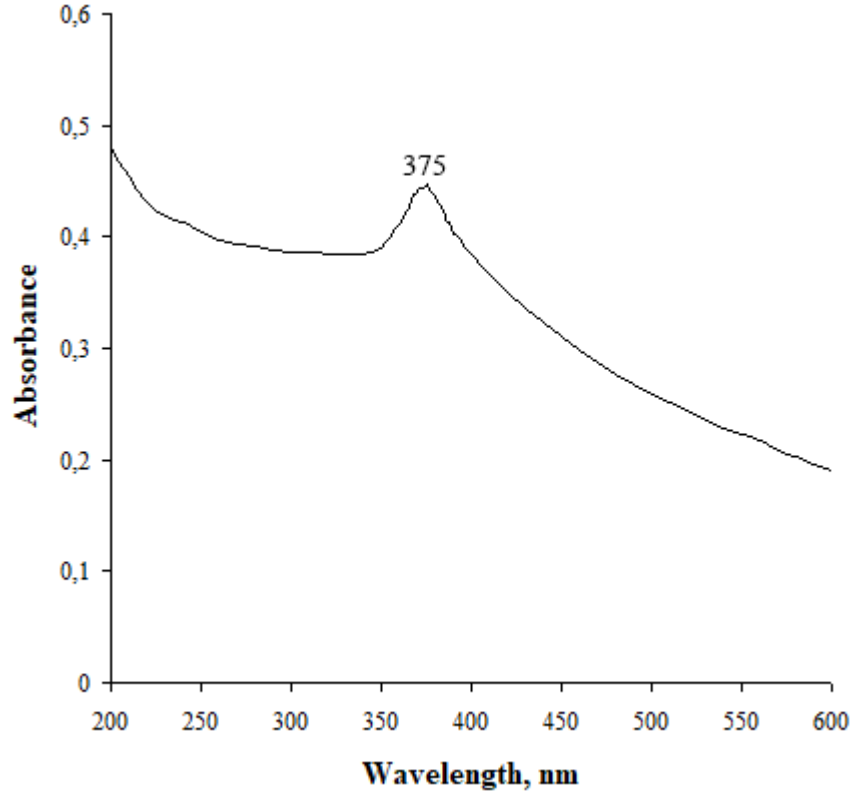


Fig. 2. Absorption spectrum of the ZnO nanoparticles dried at 60℃

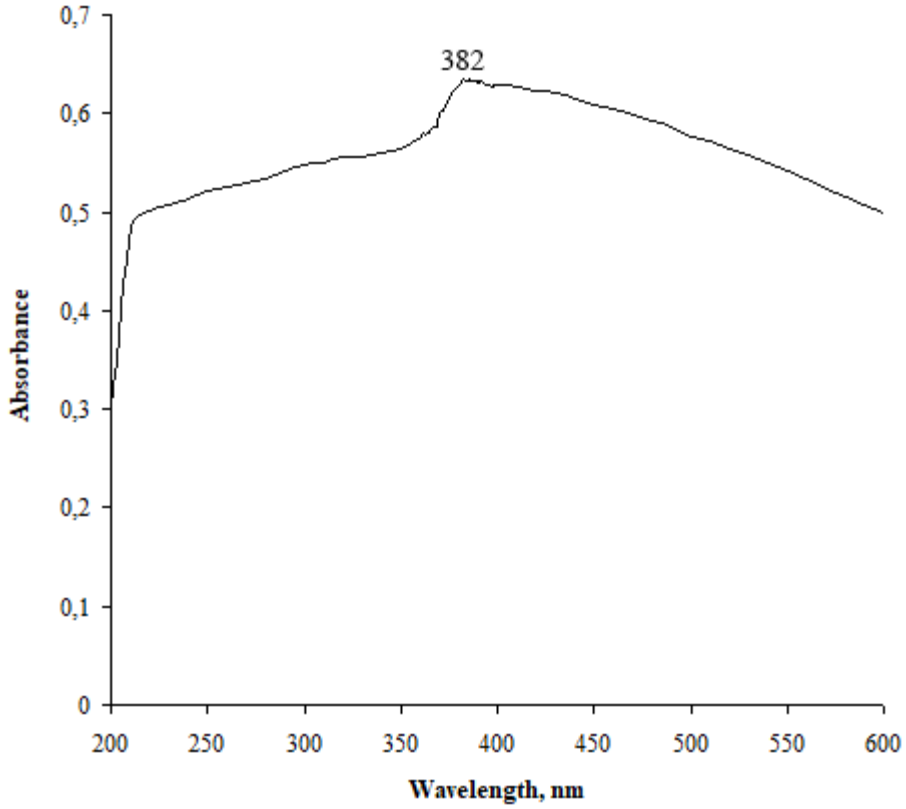


Fig. 3. Absorption spectrum of the ZnO nanoparticles dried at 60℃ and heat treated at 300℃

The spectrum in Fig. 1 reveals the characteristic absorption peak at 373 nm for ZnO nanoparticles dried at room temperature, which can be assigned to the intrinsic band-gap absorption of ZnO due to the electron transitions from the valence band to the conduction band ($O_{2p} \rightarrow Zn_{3d}$).

The absorption peak in Fig. 2 correspond to ZnO sample dried at 60℃ and shows the strong absorption in the wavelength of 375 nm. In addition, these sharp peaks (Fig. 1, 2) indicates the monodisperse nature of the nanoparticle distribution and the most of the particles are in nanoscale.

The absorption peak for ZnO nanoparticles dried at 60℃ and heat treated at 300℃ (Fig. 3) takes the value around 382 nm. It can be seen that with an increase in the calcination temperature, the optical density in the ultraviolet region increases, which indicates an increase in the content of the crystalline phase of zinc oxide in the sample. A broad peak in the 282 – 285 nm range may indicate aggregation of nanoparticles.

No other peaks were observed in the spectra, which confirms that the synthesized product is only the wurtzite hexagonal phase of ZnO.

4. Conclusion

As a result of this experiment, ZnO nanoparticles were successfully obtained by direct precipitation method in an aqueous medium using zinc acetate and sodium hydroxide as precursors. Based on the results of UV-Vis spectroscopy it has been proved that obtained ZnO is nanoscale with good crystallinity. It is shown, that increase in the heat treatment temperature leads to particle aggregation.

Thus, the synthesis of nanoparticles by the described method is simple, fast, and environmentally friendly. Further research will be aimed at studying the chemical structure of the obtained ZnO samples and developing technologies for their application for processing textile materials.

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INTERNATIONAL JOURNAL OF ROTATING MACHINERY
IMPROVING THE EFFICIENCY OF THE DARRIEUS ROTOR

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DOI: 10.31891/monograph/2021-10-76

Abstract

The aim of this paper is to solve the self-starting problem of the Darrieus rotor without equipping it with an additional Savonius rotor. In the proposed design of the wind turbine (WT) the blades are installed to be able to rotate around vertical axes.

During start-up period, the wind turbine operates as a blade wind turbine, and when the required rotational speed is reached, it switches to Darrieus rotor mode. To determine the coefficient of blade resistance of NACA 0015 profile, a calculation of the velocity field of a turbulent air field was conducted and included the numerical solution of the Reynolds equations for the incompressible gas flow. To ensure the efficiency of the proposed design and the adequacy of the obtained analytical dependences, an experimental setup was made. Studies have shown that the proposed design with movable blades can increase the utilization of wind energy by 25… 33% while reducing the material consumption of wind turbines by 18… 23%.

Introduction

At present, wind energy generation occurs with the use of horizontal or vertical axis wind turbines (WT). Horizontal axis wind turbines have a complex blade geometry, which requires a specified level of accuracy and increases its cost, respectively. In addition, the rotor axis must be directed to the flow of the wind using special mechanisms.

Vertical axis wind turbines are mainly equipped with a Darrieus rotor, the main disadvantage of which is the low starting torque, resulting in the problem of starting up these equipment. Therefore, in order to spin the rotor to the required rotational speed, the generator is brought into the mode of the engine, which requires energy from the outside and usually complicates the control system of the wind turbine, or it is additionally equipped with Savonius rotors. Savonius rotors have a significant starting torque to accelerate the rotor to the required speed; on

the other hand, with increasing speed, the Savonius blades create a braking torque that negatively affects the overall energy efficiency of wind turbines [1, 2].

Solving this problem will help to reduce the cost of both the wind turbine itself and the cost of operating the machine.

Analysis of the aerodynamics of the Darrieus rotor [3] shows that increasing the angle of attack of the blade from 0 to 4 degrees leads to an increase in the power factor by 1.5 times, from 0.4 to 0.61. Optimization of the geometric parameters of such wind turbines can lead to an increase of the power to 0.72, which is much larger than the maximum theoretical value for horizontal axis wind turbines.

In the paper [4], the aerodynamics of wind turbines, which are equipped with Darrieus and Savonius rotors, was studied. It is proved that the placement of the Savonius rotor in the central part of the installation leads to a significant reduction in torque.

Determination of the influence of the dimensionless radius RL (the radius ratio of the Savonius rotor to the Darrieus rotor, when they are the same height) on the capacity and torque of wind turbines is given in the paper [5]. The larger the value of RL, the lower the capacity factor and the higher the torque factor of the wind turbine.

In the paper [6], the results of experimental studies of a combined wind turbine based on Darrieus and Savonius rotors are presented, and Savonius rotors are installed at the bottom and top of the Darrieus rotor. Equipping wind turbines with Savonius rotors leads to an increase in starting torque, but the capacity is reduced by 20-25%.

The results of experimental studies of a hybrid turbine, in which the Savonius rotor is placed in the middle of Darrieus rotor, are given in the paper [7]. The ratio of the Savonius rotor height to the Darrieus rotor δ varied from 1.5 to 0.5. It is found that at δ=1,4 the capacity of the turbine is Cp=0,2 and a torque factor is CT=0,129. In such a hybrid turbine, compared to Darrieus rotor, the capacity is increased by 48% and the torque by 29%.

Research of combined wind turbine operation with Darrieus and Savonius rotors [8] has shown that placing the Savonius rotor in the middle of the Darrieus rotor makes it possible to increase the efficiency of the turbine up to 20%.

The results of theoretical studies of the Darrieus and Savonius rotors are given in the papers [9, 10, 11].

One of the options to increase the starting torque of the Darrieus rotor is proposed in the paper [12].

To solve the problem of self-starting of the Darrieus rotor, without installing an additional rotor and reducing the capacity, the authors proposed the design of wind turbines with movable blades shown in Figures 1… 5. [13].

The rotor 1 of the wind turbine that is installed in the sleeve 2 contains parallel traverses 3, in the pins of which blades 4 of aerodynamic profile are hinged. On the traverses 3 there are rods 5 and 6, which restrict the movement of the blades.

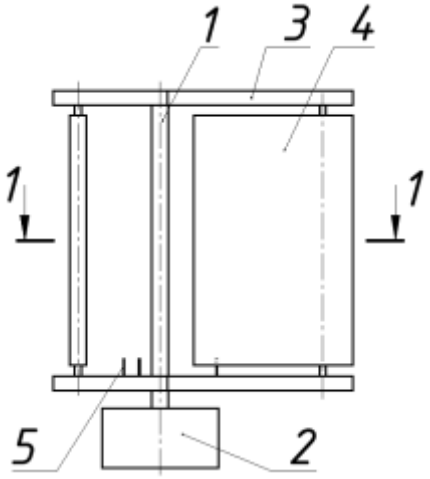


Fig. 1. Scheme of wind turbines when operating in wind turbine mode

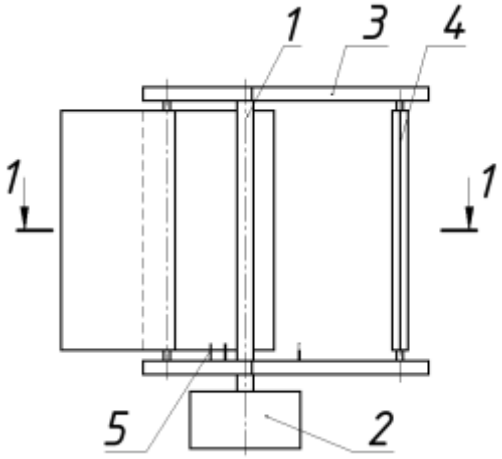


Fig. 3. Scheme of wind turbines when operating in Darrieus rotor mode

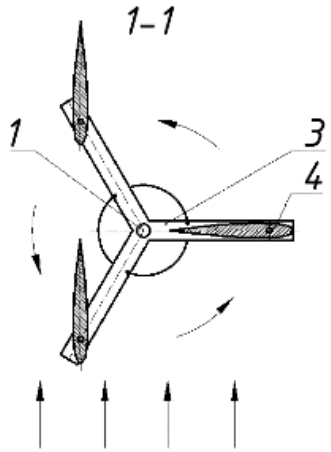


Fig.2. Horizontal section 1-1

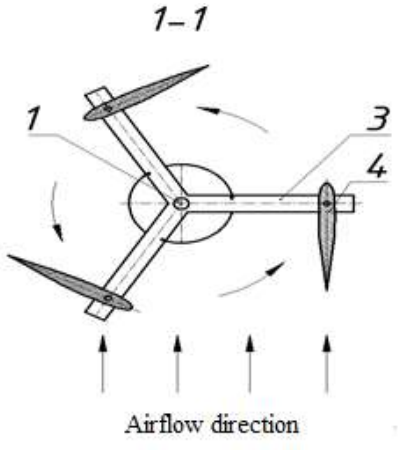


Fig. 4. Horizontal section 1-1



Fig. 5. Scheme of forces acting on the wind turbine blade

At the minimum wind speed, the blades 4, which are on one side of the rotor 1 and rotate around the axes, are based on the rod 5 and receive the wind flow, so that, the rotor begins to rotate. The blades, which are on the other side of the rotor, rotate around their axes, occupy a weather vane position and pass the air flow. As the blades are aerodynamic profile, there is additional positive torque on the rotor due to the lifting force. Consequently, the wind speed increases and hence the rotor speed, and due to the centrifugal force of inertia F the blades, which were parallel to the traverse, rotate around the axes and are based on the rods 6 that are installed so as to provide the optimal angle of attack б. Thus, the wind turbine will operate as a Darrieus rotor, which has much higher efficiency (0.4… 0.5) than a wind turbine with a rotor-type blade. As the wind speed decreases, and hence the rotor speed, the centrifugal force of inertia acting on the blades decreases, too. The blades under the wind flow pressure return to the position when they are parallel to the traverse. Thus, at low wind speeds, the wind turbine operates as a blade wind turbine, and with increasing wind speed and rotor speed, it switches to Darrieus rotor mode.

Theoretical studies of the magnitude of the blade lifting force were performed for simple profiles (thin plate, bracket) at angles of attack α up to 20° [14]. It is found that the coefficient of resistance is proportional to $\sin^2\alpha$..

Theoretical studies

To determine the maximum torque of the wind pressure on the blade at the starting time, we'll consider the rotor position in (Fig. 6). If the blade is not movable, the pressure force will be equal to [15]:

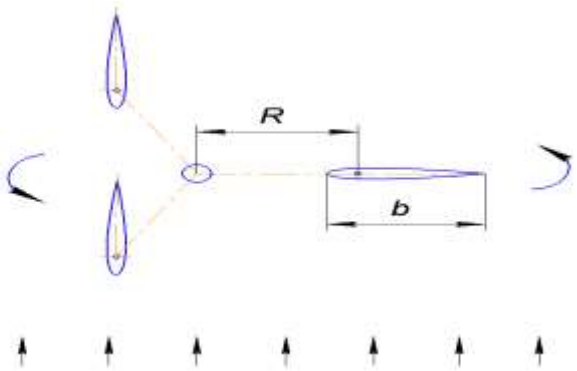


Fig. 6

$$F = C_x \frac{\rho S}{2} V_в^2 \qquad (1)$$

F - air flow pressure (H); ρ – air density 1.29 (kg / m^3);

C_x –coefficient of resistance, which depends on the surface shape and the values of which for some bodies are given in the papers [15, 16].

For the blades of aerodynamic profile of NACA type, such data are not available, so calculations were performed in the field of turbulent flow velocities when flowing around the wind turbine blade. These calculations included a numerical solution of the Reynolds equation for the incompressible gas flow, taking into account the Businesque hypothesis and the equation of the k-ε model of turbulence [17].

The Reynolds-averaged Navier–Stokes equations (or RANS equations) for incompressible gas flow, taking into consideration the Businesque hypothesis is as follows:

$$\frac{\partial u_i}{\partial t} + u_j \cdot \frac{\partial u_i}{\partial x_j} = -\frac{1}{\rho} \cdot \frac{\partial}{\partial x_i}\left(p + \frac{2}{3}\rho k \right) + \frac{\partial}{\partial x_i}\left[(\nu + \nu_t)\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i} \right) \right] + f \text{ , m}^2\text{/sec} \qquad (2)$$

$$\frac{\partial u_i}{\partial x_i} = 0 \text{ , c}^{-1}, \qquad (3)$$

where u_i, u_j – are the averaged components of the velocity vector, m/s; t – is time, s; p – is the average pressure, Pa; ρ – is air density, kg / m^3; k – is the kinetic energy of turbulence, m^2/s^2; ν –is kinematic viscosity, m^2/s; ν_t – is turbulent

kinematic viscosity, m^2/s; f – is a vector of external forces (takes into account gravity, centrifugal force and Coriolis force), m/s^2; and i=1...3, j= 1…3.

Kinematic turbulent viscosity was determined by the formula:

$$\nu_t = C_\nu \frac{k^2}{\varepsilon}, \text{ m}^2/\text{sec}, \tag{4}$$

where k – is the kinetic energy of turbulence, m^2/s^2; ε – is a dissipation of turbulent energy, m^2/s^3; C_ν=0,09.

The values of k and ε were determined based on k-ε turbulence models:

$$\frac{\partial k}{\partial t} + u_j \cdot \frac{\partial k}{\partial x_j} = \frac{\partial}{\partial x_j}\left(\left(\nu + \frac{\nu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right) + \nu_t G + \varepsilon, \text{ m}^2/\text{ sec}^3, \tag{5}$$

$$\frac{\partial \varepsilon}{\partial t} + u_j \cdot \frac{\partial \varepsilon}{\partial x_j} = \frac{\partial}{\partial x_j}\left(\left(\nu + \frac{\nu_t}{\sigma_\varepsilon}\right)\frac{\partial \varepsilon}{\partial x_j}\right) + C_1 \frac{\varepsilon}{k}\nu_t G + C_2 \frac{\varepsilon^2}{k}, \text{ m}^2/\text{ sec}^4, \tag{6}$$

where G – is turbulent energy; σ_k=1, σ_ε=1,3, C_1=1,44, C_2=1,92 – are the model parameters.

Turbulent energy was determined by the formula:

$$G = \left[\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right) - \frac{2}{3}\left(\frac{\partial u_i}{\partial x_j} + \frac{k}{\nu_t}\right)\delta_{ij}\right] \cdot \frac{\partial u_i}{\partial x_j}, \tag{7}$$

where δ_{ij} – is the Kronecker symbol.

Gas motion simulation was performed using Flow Vision 2.5.4 software and COMPASS 3D-V18. When working with this software, the following reference materials were used [17, 18, 19].

Experimental studies

To confirm the efficiency of the proposed design and the adequacy of theoretical research, an experimental setup was made, the general view of which is shown on Fig. 7.



Fig. 7. General view of the experimental setup

The experimental setup consists of a shaft (1), which is fixed in the bearing assembly (2). To reduce the resistance, the traverses are made in the form of two thin disks (3), in which studs (4) with blades (5) are placed. To limit rotation of the blades or to fix them, rods (6) on the disks (3) are placed A rope (7) is attached to the traverse (3) and is passed through the block 8. To the other end of the rope a bowl with loads (9) is fixed.

Results and Discussion

Figure 8, 9 shows the results of calculating the field of wind flow velocities for the NACA profile 0.015 at a value of B = 70 mm.

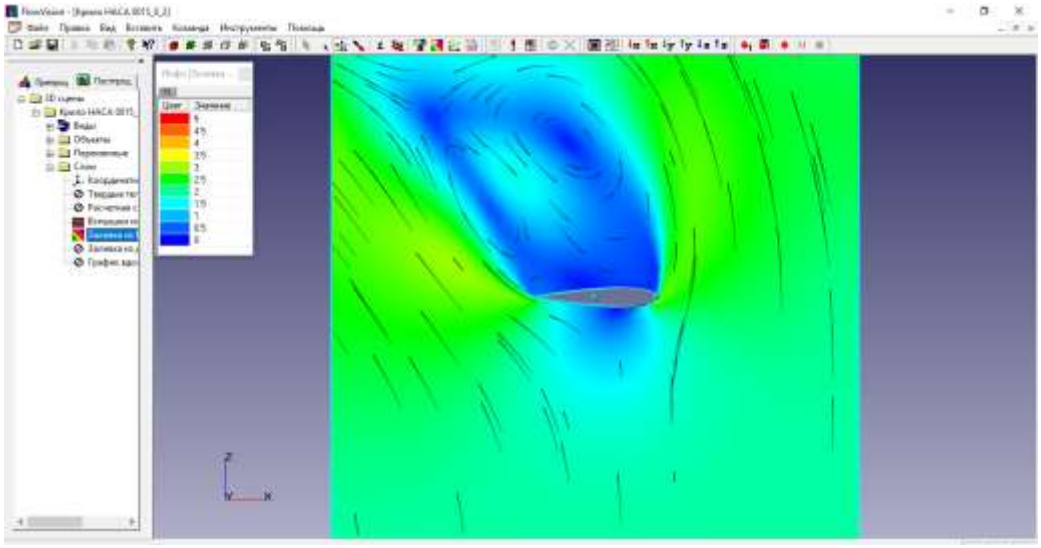


Fig. 8. Field of wind flow velocity at wind speed V=2 m/sec

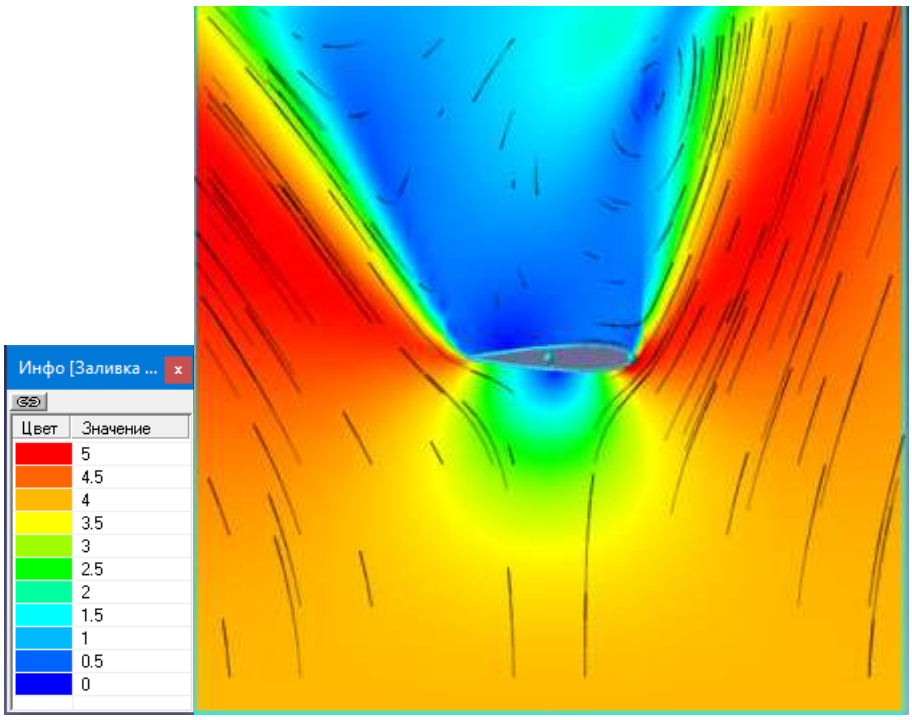


Fig. 9. Field of wind flow velocity at wind speed V=4 m/sec

The dependences of the resistance coefficient on different wind speeds are shown in Figure 10

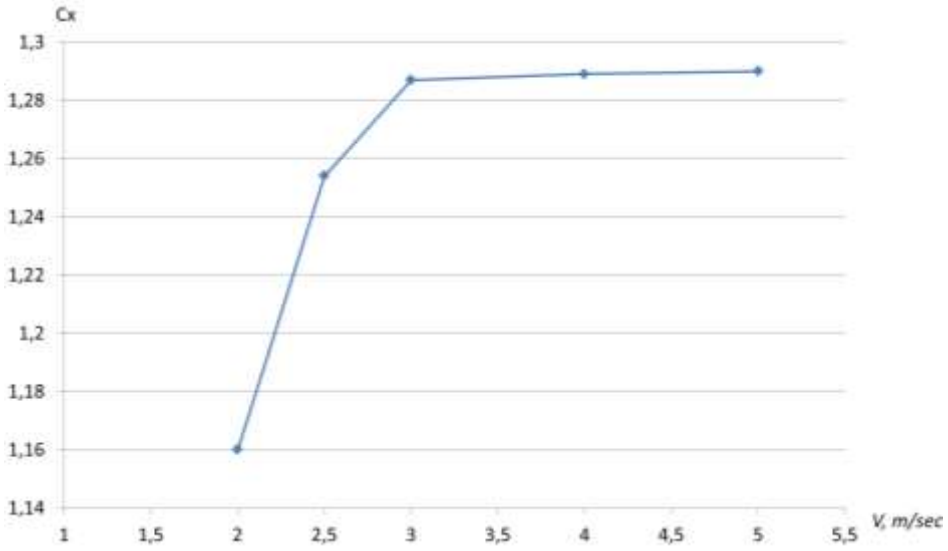


Fig. 10. Ratio of the resistance coefficient of the blade/wind speed

As it can be seen on Fig. 10, the coefficient of resistance depends on the wind speed and becomes a constant value at a speed of 3 m/sec.

In the first stage of experimental studies, the minimum wind flow velocity, at which the rotor begins to rotate, was determined. The wind speed was determined using an anemometer. Two options were considered:

1 - the rotor blades are stationary, i.e. the classical scheme of the Darrieus rotor;
2 - the blades could rotate around their own axes, i.e. when starting up, the rotor began to work in the mode of the blade wind turbine.

In the second stage, the force of pressure on the blades was determined depending on the wind speed. As a result of the experiment, it was found that the required wind speed to start the proposed design of the wind turbine is in the range of 0.9 – 1.2 m/s, while for the start of the classical Darrieus rotor the speed is 3.9 – 4.1 m /s.

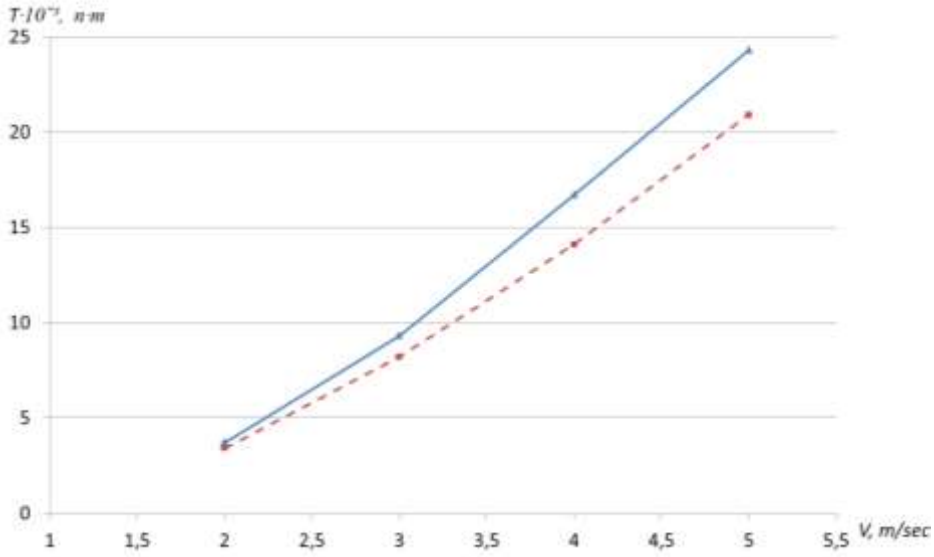


Fig. 11. Ratio of rotor torque on wind speed

———— theoretical values according to formula (1), taking into account Fig. 10.
– – – – – – experimental values.

The torque values that were obtained experimentally are slightly lower than the theoretical ones, because the friction in the bearings was not taken into account.

Conclusions

1. The proposed design of the Darrieus rotor with movable blades allows increasing the amount of starting torque, which solves the problem of wind turbines self-starting, and therefore leads to an increase in energy produced.

2. The start of the Darrieus rotor with movable blades begins at a wind speed of 0.9… 1.2 m/s, and with non-movable blades at 3.9..4.1 m/s.

3. The resistance coefficient of the NACA 0.015 blade profile depends on the wind speed and varies from 1.16 to 1.289, and corresponds to the resistance coefficient of the rectangular plate.

4. The capacity of the proposed design of the wind power plant is 25… 33 more than the capacity of the hybrid power plant, which is equipped with additional Savonius rotors, and the material consumption is less by 18… 23%.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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TRIBOTECHNICAL PROPERTIES OF NANOMODIFIED FLUOROPLASTIC MATERIALS

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DOI: 10.31891/monograph/2021-10-77

1. Introduction

The development of technology for the development and creation of polymeric composite materials based on polytetrafluoroethylene (PTFE) has for a long time been based mainly on empirical research, due to the complexity of interphase interactions in the multicomponent polymeric composite systems. The combination of theoretical research into the structural and phase transformations occurring during the introduction of fillers to the composite's fluoropolymer matrix with experimental studies makes it possible to formulate a scientifically-based approach to forecasting and purposeful regulation of the properties of fluoropolymer materials. The modern industry requires the production of new composite materials with a high level of operational characteristics. This task can be solved by defining the estimation-analytical and experimental-technological principles to design and model fluoropolymer anti-friction materials based on the targeted adjustment of their components.

2. Literature review and problem statement

The process of designing fluoropolymer anti-friction materials can be divided into two stages: estimation-analytical and experimental-technological [1]. The first stage implies analyzing the predefined loading conditions and determining a technique to design a composite with the specified properties. However, the difference in interaction mechanisms hinders the construction of universal estimation dependences based on the studies that model the behavior of anti-friction composite materials exposed to stresses by employing the variational principles of solid mechanics [2, 3]. A characteristic feature of the technology of functional fluoropolymer anti-friction materials is the desire to ensure the optimal level of interaction between the matrix polymer and filler's particles, which determines the structure and characteristics of the boundary layers. This interaction is complicated due to the specific structure of the molecular chain of polytetrafluoroethylene (PTFE), which predetermines a pronounced chemical inertness towards a large number of solid-phase components [4, 5]. In other words,

there are aspects that determine the probability of the course of the physical-chemical processes that form the boundary layers with the optimal parameters of adhesive and durable characteristics. These aspects should be taken into consideration when choosing the composition of a modifier, the particles' dispersion, and the combination of components for composites of different formulations. For a long time, there was a perception that the introduction of various solid fillers in PTFE, without changing the friction coefficient, significantly improves its wear resistance and mechanical characteristics [6–10]. However, the enhanced wear resistance and mechanical characteristics when applying fillers are almost always accompanied by an increase in the friction coefficient and a decrease in the tensile strength. This is due to the fact that modifiers do not have a complex nature of the action in the process of intermolecular interaction and the formation of the molecular structure.

Thus, the construction of the estimation-analytical and experimental principles to design and model fluoropolymer anti-friction materials is necessary for the development of new materials for tribotechnical purposes.

3. The aim and objectives of the study

The aim of this study is to form the basic technological principles for designing and modeling the nanomodified fluoropolymer anti-friction materials for tribotechnical purposes.

To accomplish the aim, the following tasks have been set: to experimentally investigate the tribotechnical and strength properties of antifriction carboplastics based on the Tekarm fabric with an applied fluoropolymer coating; to experimentally study the tribotechnical and strength properties of the nanomodified fluoropolymer composite materials and analyze their resulting structures.

4. The study materials and procedure

In the study, we used the composite materials of tribotechnical purpose based on polytetrafluoroethylene: F-4 PN (GOST 10007-80), an analog to Teflon 7 (TCI, USA) (ASTM D4895, ISO 12086), and fluoropolymer-4MB brand P (Formoplast, Russia) (GOST 30333-2007), an analog to Teflon FEP (TCI, USA), modified with carbon fibers and other components. Carbon fibers made of the fabrics Tekarm (Russia) (TU 48–20–17–77) and Ural T15 (Russia) (GOST 28005-88) were used as a filler; they were obtained on the basis of hydrate-cellulose tissue. For grinding the fibers and mixing the formulation, we used the crusher-grinder MRP-1 (Granat,

Russia) with double knives and a frequency rotation of 7,000 rpm. The average length of fibers after grinding was 50…200 μm.

ZrO_2 zirconium oxide nanopowder was used as a functional additive. The powders were analyzed by X-ray diffraction (XRD) methods at the Dron-3 X-ray diffractometer (IC Bourevestnik, Russia) under Cu-Kα radiation to determine the size of the crystallites and the quantitative phase analysis. Powder particle sizes were estimated using transmission electron microscopy (TEM) (JEM 200, Jeol, Japan). According to XRD and TEM data, the particle sizes were 18±2 nm.

The wear of the materials was determined under a normal load of 100 N and a sliding speed of 0.3 m/s. The temperature was measured at a distance of 0.5…1 mm from the surface of the counter-body. Tests were performed without lubrication on steel 30Kh13 (HB, 4.2 GPa) after working (2 km) on the path of friction of 2…18 km.

5. Results of an experimental study into the properties, structure, and chemical analysis of fluoropolymer materials

The compositions' formulations and comparative data on the wear resistance of the examined fluoropolymer anti-friction materials are given in Table 1. Our analysis has shown that the anti-friction carboplastics based on the "Tekarm" fabric with a fluoropolymer coating applied significantly outperform, in terms of wear resistance, similar carboplastics without a fluoropolymer coating. In addition, such carboplastics demonstrate durability higher than that in the carboplastics coated with the fluoropolymer 4MB, grade P.

Table 1. The wear intensity of antifriction materials based on PTFE containing the carbon fiber made from the "Tekarm" fabric, 10^{-7} mm^3/(Nm)

Coating type	Concentration of carbon fiber from the "Tekarm" fabric, % by weight					
	2	25	30	40	45	50
No fluoropolymer coating	10.2	6.4	7.2	8.5	10.4	39.5
Applied coating from the fluoropolymer 4 MB, grade P	8.1	4.3	5.3	6.3	7.0	18.0
Applied fluoropolymer coating	6.5	3.25	3.15	3.3	3.5	9.4

The results of our studying the tensile strength are given in Table 2.

Table 2. The tensile strength of antifriction materials based on PTFE containing the carbon fiber from the "Tekarm" fabric, MPa

Coating type	Concentration of carbon fiber from the "Tekarm" fabric, % by weight				
	5	15	20	25	45
No fluoropolymer coating	15	16.3	17.0	16.1	14.1
Applied coating from the fluoropolymer 4 MB, grade P	16	17.2	18.0	17.2	16.3
Applied fluoropolymer coating	17	18.4	19.1	18.3	17.5

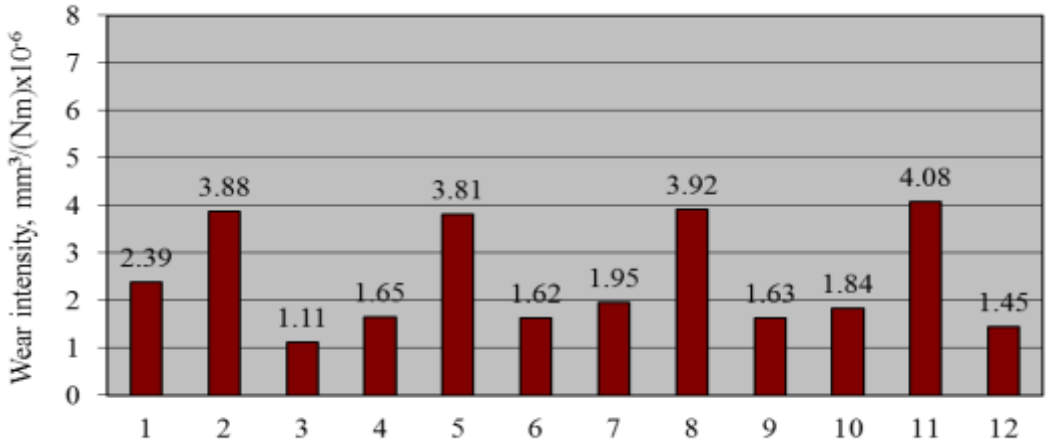
It was obtained that the proposed carboplastics coated with a fluoropolymer coating outperform, in terms of tensile strength, the carboplastics without a coating, and those coated with the fluoropolymer 4MB, grade P.

It was established in [4, 6] that the carboplastics of the flubon type are promising anti-friction materials (F4VV15, F4VV20, materials based on polytetrafluoroethylene and carbon fiber, obtained by special technology, and modified with special additives). To implement this principle, fillers with different dispersion and composition such as coke, carbon fibers, and zirconium oxide nanopowders were introduced to the PTFE formulation. It was established in that one of the best modifiers for fluoropolymer carboplastics is the nanopowder ZrO_2+3 %Y_2O_3, 700 °C. This nanopowder was used to create the fluoropolymer antifriction materials. We tested the developed anti-friction materials for wear resistance. The results of our study are shown in Fig. 1.

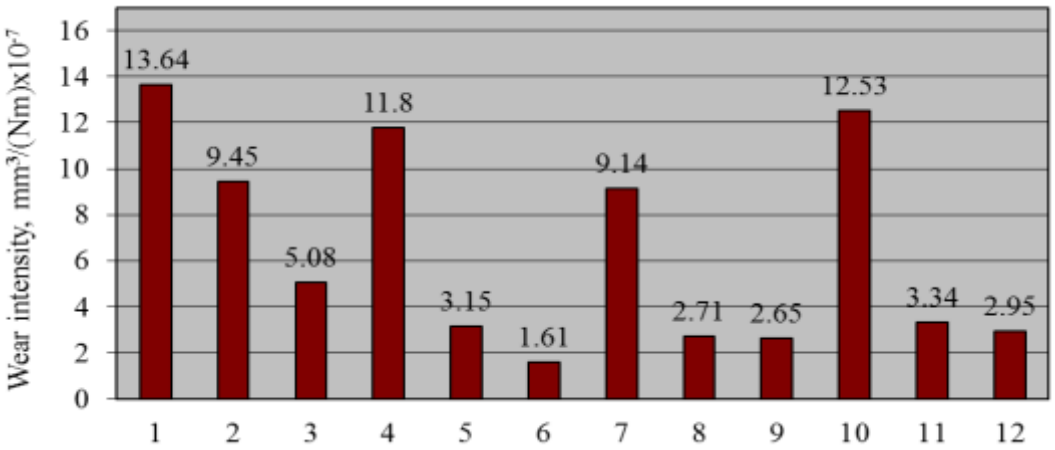
The method of electron microscopy was used to examine the microstructure of the friction surface after the end of testing the PTFE material F4K10VV10, modified with zirconium oxide nanopowder ZrO_2+3 %Y_2O_3, 700 °C (Fig. 2).

The method of energy dispersion analysis was applied to determine the chemical composition of the friction surface of a sample from the material F4K10VV10+2 % by weight of ZrO_2, 700 °C, after testing along the friction path of 23 km under the following friction conditions: the normal load per sample, Ni=100 N; the sliding speed, V=0.3 m/s; the temperature measured at a distance of 0.5–1 mm from the surface of the counter-body, T=(323±2) K (Fig. 3).

Data from the chemical analysis of the sample's friction surface are given in Table 3.



a



B

Fig. 1. The wear intensity histogram of antifriction materials F4K20, F4VV20, and F4K10VV10, modified with zirconium oxide nanopowders: *a* – the first stage of research; *b* – the second stage of research. 1 – F4K20; 2 – F4VV20; 3 – F4K10VV10; 4 – F4K20+1 % by weight (ZrO_2+3 %Y_2O_3, 700 °C); 5 – F4VV20+1 % by weight (ZrO_2+3 %$Y2O_3$,700 °C); 6 – F4K10VV10+1 % by weight (ZrO_2+3 %Y_2O_3, 700 °C); 7 – F4K20+2 % by weight (ZrO_2+3 %Y_2O_3, 700 °C); 8 – F4VV20+2 % by weight (ZrO_2+3 %$Y2O_3$,700 °C); 9 – F4K10VV10+2 % by weight (ZrO_2+3 %Y_2O_3, 700 °C); 10 – F4K20+3.0 % by weight (ZrO_2+3 %Y_2O_3, 700 °C); 11 – F4VV20+3 % by weight (ZrO_2+3 %$Y2O_3$,700 °C); 12 – F4K10VV10+3 % by weight (ZrO_2+3 %Y_2O_3, 700 °C)

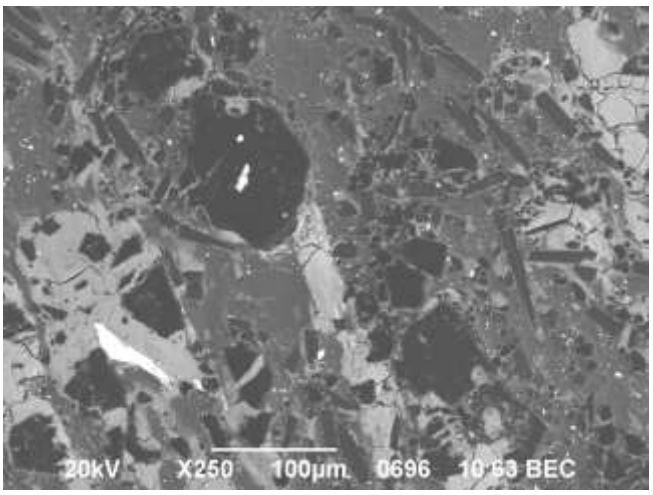


Fig. 2. Microstructure of the PTFE-composite material F4K10VV10+2 % by weight ZrO_2, 700 °C (× 50)

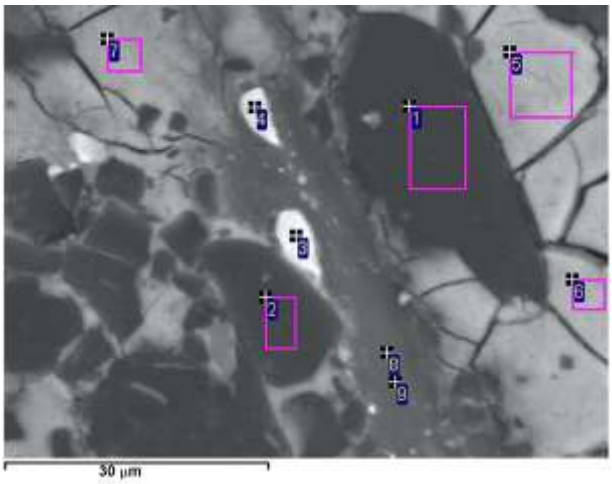


Fig. 3. The friction surface microstructure (a friction path of 23 km) of a sample made from the material F4K10VV10 +2 % by weight of ZrO_2, 700 °C, with the designated zones for determining the chemical composition using an energy dispersion analysis

Table 3 The results of the energy dispersion analysis of the friction surface of a sample made from the material F4K10VV10+2 % by weight of ZrO_2, 700 °C. Spectrum number corresponds to the analysis zones in Fig. 3

Spectrum number	C	O	F	Fe	Zr
1	96.41	3.28	0.01	0.19	0.11
2	94.76	4.51	0.29	0.37	0.07
3	40.1	9.11	10.67	0.48	39.64
4	39.47	13.8	14.07	1.34	31.32
5	23.53	26.97	8.41	37.49	3.6
6	24.84	24.91	8.15	38.34	3.76
7	28.22	22.4	18.85	27.33	3.2
8	47.37	2.23	49.87	0.3	0.23
9	50.45	2.38	43.53	0.41	3.23

Our energy dispersion analysis of the friction surface of a sample made from the material F4K10VV10+2 % by weight of ZrO_2, 700 °C, has revealed the presence of modifying impurities, carbon, and zirconium oxide, in the matrix of the fluoropolymer. The shape of carbon inclusions is rectangular and arbitrary, corresponding to coke particles and carbon fibers, respectively (Fig. 2). Their carbon content is 94–96 % (spectra 1, 2 in Fig. 3). Zirconium oxide particles (spectra 3, 4 in Fig. 3) are arranged in clusters from 0.2 to 10 μm, due to the process of their introduction into the material.

In order to find other effective nano-modifiers from a zirconium oxide group, we have studied the composite material F4K10VV10, modified with the nanopowder of zirconium oxide ZrO_2+3 % Y_2O_3, at 900 °C. Investigating the wear resistance of the composite material F4K10VV10, modified with the nanopowder of zirconium oxide ZrO_2+3 % Y_2O_3, 900 °C, has not shown any positive result from the introduction of the nanomodifier. A tensile strength histogram of the antifriction materials F4K10VV10, modified with zirconium oxide nanopowder ZrO_2+3 % Y_2O_3, 900 °C, is shown in Fig. 4.

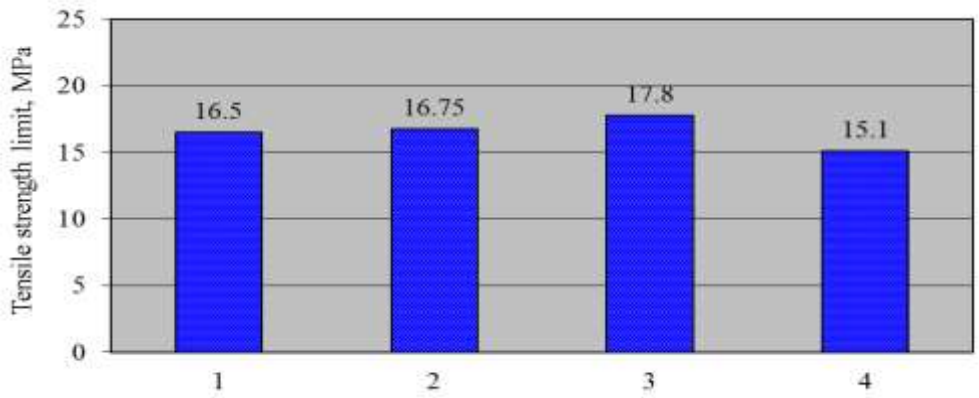


Fig. 4. A tensile strength limit histogram for the following antifriction materials: 1 – F4K10VV10; 2 – F4K10VV10+1 % by weight (ZrO_2+3 %Y_2O_3, 900 °C); 3 – F4K10VV10+2 % by weight (ZrO_2+3 %Y_2O_3, 900 °C); 4 – F4K10VV10 +3 % by weight (ZrO_2+3 %Y_2O_3, 900 °C)

The analysis of our study results has established that the most effective is the introduction to the materials F4K20 and F4VV20 of 2 % by weight of ZrO_2+3 % Y_2O_3, 700 °C, to the material F4K10VV10 – 1 % by weight of ZrO_2+3 % Y_2O_3, 700 °C.

6. Discussion of results experimental studies into the properties and structure of fluoropolymer materials

The heat resistance of the coating increases due to the introduction of optimal amounts of chromium oxide and diphenylsilanediol to its composition. The tensile strength of the examined composites (Table 2) also increases. The disadvantages of the electrostatic application of fluoropolymer coatings include the fact that with a significant increase in the field intensity there is a decrease in the thickness of the polymeric layer. This is caused by the occurrence of the phenomenon of reverse coronation or discharge processes for materials with high electrical conductivity. In addition, the humidity of the ambient air has a significant impact. Thus, an increase in the relative air humidity by 15 % leads to a decrease in the amount of material, which settles, by larger than 2 times.

It was established that the increase in the specific surface of the filler particles leads to an increase in the share of the boundary layer in the system "matrix – filler" and the interface length in the composite materials. When using fibrous modifiers based on thermoplastic matrices, stresses may occur around the fibers under the action of mechanical load that significantly exceed the corresponding indicators in composites with dispersed fillers. Since the fibers are much stronger than the thermoplastic matrix and dispersed fillers, the strength of the created fibrous composites is limited to the possibility of constructing a strong adhesion bond at the interphase boundary.

In the composite, the fibrous modifier will perform the function of a strengthening agent, and the ultra-dispersed one – a wear inhibitor as a result of the participation of the modifier's particles in the process of forming a stable layer on a metal counter-body. Due to this, the wear resistance of the anti-friction composites modified with zirconium oxide nanopowders increases (Fig. 1).

The greatest effect of increasing the wear resistance of a metal-polymeric friction node can be achieved when generating, in the friction zone, those components that have the properties of wear inhibitors. As a result, a lubricant is formed at the surface of friction in the form of low molecular products of the tribodestruction of the polymer with a high adhesion capacity. The introduction of nanomodifiers contributes to the intensive structuring of the matrix, as nanoparticles can create ensembles by cluster type. As a result, a reinforced polymeric system is created, characterized by increased strength and tribotechnical

characteristics.

The nanomodifier particles increase the adhesion interaction between the polymer and filler and enhance the mobility of PTFE structural elements. This facilitates the course of the deformation processes and leads to an increase in the strength characteristics of the composite. These effects can be explained by the fact that zirconium oxide particles are the additional centers of PTFE crystallization, resulting in reduced dimensions of the microstructure elements (Fig. 2).

Spectral analysis of the friction surface of a sample made from the material F4K10VV10+2 % by weight of ZrO_2+3 % Y_2O_3, 700 °C, has shown that due to the fact that the scattering area of reverse scattered electrons accepts a fluoropolymer matrix, the carbon content is 40 %, and fluoride is 10–15 %. Iron, which is part of the counter-body, is oxidized and transferred after friction to the surface of the fluoropolymer (Fig. 3).

It was established that the effect of the oxide modifier on the wear resistance of fluoropolymer carboplastic is most significant at the optimum amount (18...19.5 % by weight) of carbon fiber in the composite. When the concentration of carbon fiber is reduced in the modified fluoropolymer carboplastic, its durability decreases as a result of increasing the degree of deformation of the surface layer and narrowing of areas and the elastic-plastic deformation in interaction with the counter-body. With the increase in the composite of the concentration of carbon fiber, part of the interphase layers in the composite material grows while defects in the polymer structure decrease. The mechanism of the modifying action of fillers on the structure of PTFE is the increase in the density of structural elements as a result of the formation of interphase layers with a certain arrangement of molecules at the interface (Fig. 4).

It was found that the excess carbon fiber content in PTFE leads to a decrease in the cohesion strength of the composition due to the increase in the specific surface of fillers and a decrease in the thickness of the interphase layer in the system.

7. Conclusions

Based on the results of experimental studies, it was established that the developed anti-friction carboplastics outperform, in terms of durability, by 1.97 times, and, in terms of tensile strength, by 13.7 %, carboplastics without a fluoropolymer coating and carboplastics coated with a coating made from the

fluoropolymer 4MB, grade P.

We have determined the optimal concentration of a nanomodifier for the materials F4K20 and F4VV20 – 2 % by weight of ZrO_2+3 % Y_2O_3 (700 °C), for the material F4K10VV10 – 1 % by weight of ZrO_2+3 % Y_2O_3 (700 °C) with a maximum structured effect. The mechanism of the modifying effect of nanomodifiers on the structure of PTFE is the increase in the density of structural elements as a result of the formation of interphase layers with a certain location at the interface polymer–filler.

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RESEARCH OF TRIBOTECHNICAL CHARACTERISTICS OF ORIENTED CARBON PLASTICS

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DOI: 10.31891/monograph/2021-10-78

Introduction

Metal materials are mainly used as structural ones for parts of machine friction units: steel, cast iron, non-ferrous metals and alloys. However, various working conditions of friction units, environments, and conjugate surfaces require the use of new materials with specialized properties. In terms of their properties, carbon plastics are often significantly superior to conventional metals, so their use in mechanical engineering is promising. Carbon plastics demonstrate a low density, high elasticity module, strength, heat resistance, high wear resistance, the low temperature coefficient of linear expansion. Carbon plastics have proven efficient and were extensively scientifically tested as structural elements' materials in the automotive industry, aviation, and other industries. At the same time, special features in the use of carbon plastics for parts of friction and lubrication units in machines require additional research. This is due to the complicated operating conditions of the tribosystems: large contact loads, increased speeds of relative slip, exposure to local and volumetric temperatures, etc. Substantiated recommendations for the choice of the structure and properties of carbon plastics for tribosystems, taking into consideration operational factors, could improve durability, reduce the cost of repair and maintenance of machines.

2. Literature review and problem statement

Composite non-metallic materials for machine friction units require high mechanical, thermal, and anti-friction properties, as well as the stability of dimensions during operation. Modern materials do not fully meet these requirements; at high mechanical properties, they have low thermal properties or insufficient rigidity. For example, antifriction calcined graphite (AO, 2P-1000, K-0), while demonstrating a low density and rather high thermal conductivity, can work reliably only at pressures of 3.0...4.0 MPa. Impregnating these materials with resins or metals can increase their strength by 2 times but, at the same time, their thermal conductivity significantly reduces [2]. The materials that are based on a mixture of artificial graphite with phenol-formaldehyde or polysiloxane resins

withstand specific loads of up to 8 MPa but have insufficient wear resistance [3]. The composite materials that are based on polytetrafluoroethylene have a low friction coefficient but are used only under low pressure since the main disadvantage of materials of this type is low deformation resistance and low thermal conductivity [4]. The properties of textolites also do not fully meet operational needs. Textolite at friction without lubrication works satisfactorily under specific loads of up to 1 MPa. Increasing the load by 1.5 times leads to an increase in the wear intensity by more than 10 times. With lubricants, textolites can work at specific loads of up to 10 MPa but the low thermal conductivity of these materials causes their delamination and a strong warming-up of a friction unit [5].

Given this, recent years have seen the search for the composition and studies into the properties of composites based on thermoreactive resins reinforced with carbon fibers and carbon fabrics. Paper [6] investigated the impact of carbon fiber use on the tribological behavior of various polymeric materials. The authors of work [7], in order to strengthen the interconnection within the polyamide–carbon system, modified the composites by introducing a transition layer of polydopamine (PDA) whose active groups ensure adhesion strength. Epoxy composites reinforced by carbon fiber with different percentages were developed in works [8–10] to study tribological properties. The studies were carried out when rubbing the cylindrical pin and ball only on a circular trajectory [8]. The authors established a decrease in the coefficient of friction and wear, and an increase in the mechanical strength in samples with carbon fibers [9] without taking into consideration their structure. It was found in [10] that epoxy composites are less susceptible to fatigue compared to pure epoxy resins; however, the wear processes were not considered. Paper [11] studied interrelations between the physical-mechanical properties of metal materials mated with carbon-fiber plastic and the wear intensity and a friction coefficient. At the same time, the physicochemical mechanisms of these relations were not considered. Our review of the scientific literature has shown that carbon plastics are promising materials for use in tribosystems with improved anti-friction and anti-wear properties. When studying the properties of reinforced composites, the focus is on the mechanical characteristics of the material compared to tribological properties. In addition, when conducting friction and wear tests, the impact of the structure of carbon plastics on wear resistance is not taken into consideration.

3. The aim and objectives of the study

The aim of this work is to determine the effect of the structure and thermomechanical properties of oriented carbon plastics on their tribotechnical characteristics. To accomplish the aim, the following tasks have been set: to conduct comparative tests for the friction of common anti-friction materials in the absence of lubrication; to investigate the dependences of the anti-friction, anti-wear, and thermomechanical properties of carbon-fiber plastics; to establish the dependences of the tribological characteristics of carbon-fiber plastics on the composition, mechanical, and thermal-physical characteristics.

4. The study materials and methods

To determine the mechanisms of influence of the structure of carbon-fiber plastics on their tribological properties, a set of experimental studies was carried out. The experiments were aimed at establishing the anti-friction, anti-wear, and other mechanical characteristics of materials in the tribosystem "carbon-fiber plastic-metal" for different operating conditions.

The material was studied for the following directions of reinforcement: LLLL – the layers of the tape and fiber in the tape are parallel to the friction surface and a slip velocity vector; RRRR – the layers of the tape and fiber in the tape are perpendicular to the friction surface and a velocity vector; LLLT – the layers of the tape are parallel to the friction surface and a velocity vector; the fibers are parallel to the friction surface and perpendicular to a velocity vector; RLRR – the layers of the tape are perpendicular to the friction surface and parallel to a velocity vector, the fibers are perpendicular to the friction surface and a velocity vector.

The characteristics of wear resistance were investigated using a friction machine (Fig. 1) according to the "cone-plane" scheme. The rotational motion to sample 3 was provided from the spindle of friction machine 1 through four-ball loading pyramid 2. The spindle is connected to a digital speedometer to measure the frequency and number of revolutions during the test. The specimen holder is made with three nests with a diameter of 10 mm. A counter-body was mounted on support bearing 4 and cooled with water. The self-installation of samples was carried out with the help of two-row spherical bearing 5. The dependence of the moment of friction on temperature was determined using two-coordinate potentiometer 7. The counter-body temperature was measured by chromel-copel

thermocouple 6 at a distance of 0.5...1 mm from the surface.

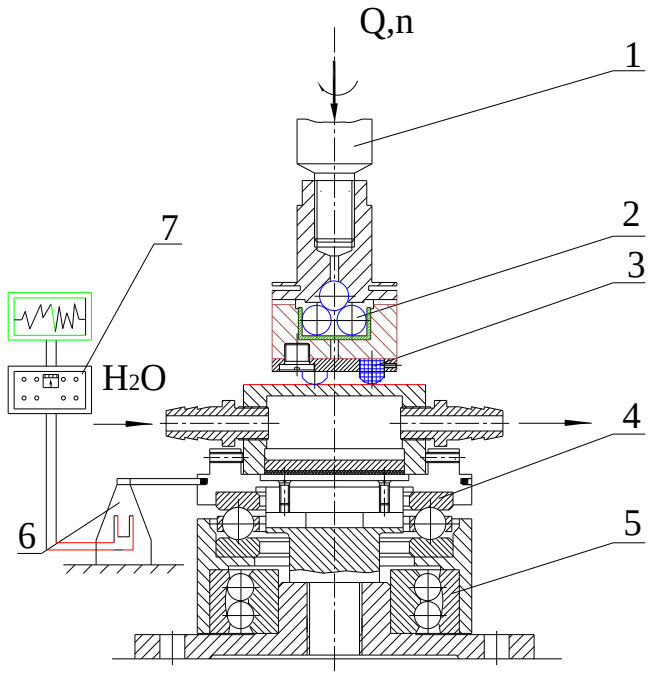


Fig. 1. Friction machine: 1 – spindle; 2 – four-ball pyramid; 3 – examined samples; 4 – support bearing; 5 – spherical self-inserting bearing; 6 – thermocouple; 7 – potentiometer

The reproducibility of the results acquired from the friction machine is within f=±0.011...0.070. The coefficient of variation in the friction coefficient is υ=2.6...18.6 %. We determined the heat capacity of the studied samples at temperatures of 50, 75, 100, 125 °C, for two directions of the filler reinforcement RRRR and LLLL.

5. Results of the experimental study into the tribological properties of oriented carbon plastics

Comparative tests of anti-friction properties of the materials studied were carried out: gray cast iron, bronze, textolite, and carbon plastics at stepped loading under a self-heating mode (Fig. 2).

Test results showed that under small loads, the highest friction coefficient was demonstrated by the cast iron SCh20 and the textolite PTC, within 0.65...0.7. Under these test conditions, a low friction coefficient was demonstrated by the samples of carbon-fiber plastic and carbotextolite.

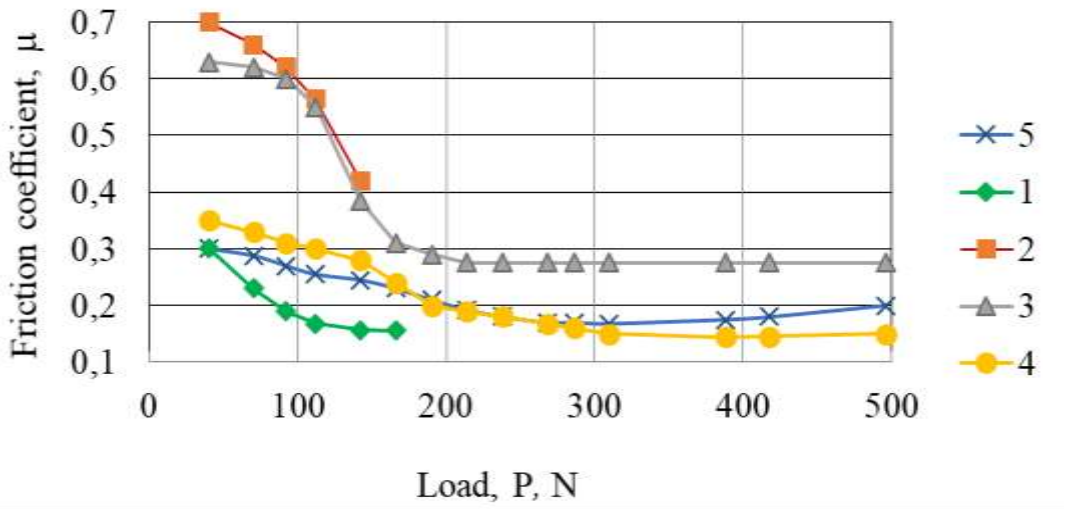


Fig. 2. The dependence of friction coefficient on normal load: 1 – BrOF10-4 bronze; 2 – cast iron SCh 20; 3 – textolite PTC; 4 – carbotextolite; 5 – carbon-fiber plastic

The effect of reinforcement direction on the anti-friction properties of carbon plastics is shown in Fig. 3.

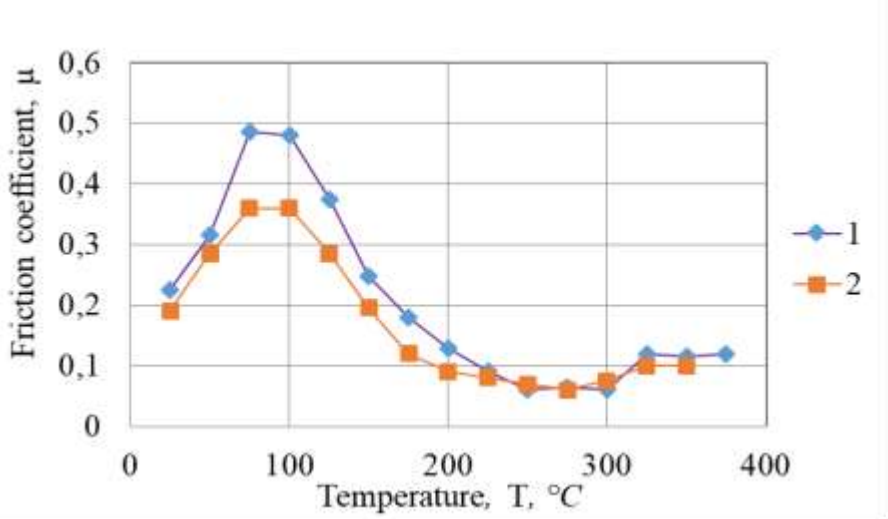


Fig. 3. Dependence of the carbon-fiber plastic friction coefficient on the mated surface temperature and reinforcement direction: 1 – RRRR reinforcement direction, 2 – LLLL reinforcement direction

Our thermal-friction study (Fig. 3) has shown that the carbon-fiber plastics reinforced with fibers demonstrate a decrease in the friction coefficient with an increase in temperature. The maximum values of this indicator are typical of the temperatures of 70...75 °C, and with further increased temperatures, the friction coefficient decreases and practically remains within 0.1...0.09.

Table 1 gives data on the wear intensity of the "composite–steel 45" tribosystem for the corresponding reinforcement directions of the tested samples.

The wear resistance of mated surfaces for different reinforcement directions varies by 5...8 times.

Table 1. Wear intensity of the friction pair "composite–steel 45"

Reinforcement direction	Wear intensity, I, mm^3/Nm	
	Metallic surface, $I \cdot 10^{-11}$	Carbon-fiber plastic $I \cdot 10^{-7}$
RLRR	3.6	5.4
RRRR	5.1	6.5
LLLT	0.5	7.6
LLLL	1.1	8.1

Fig. 4 shows the dependences of the wear of samples on the sample surface temperature and the reinforcement direction.

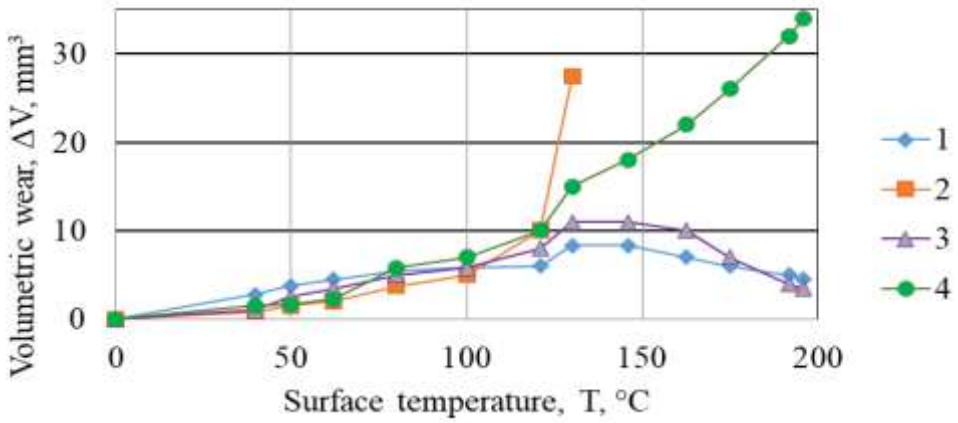


Fig. 4. Dependence of carbon-fiber plastic wear on the mated counter-body temperature (steel 45): 1 – LLLT, 2 – RRRR, 3 – LLLL, 4 – RLRR

The effect of the properties of the mated surface on the anti-wear and anti-friction properties of carbon-fiber plastic are given in Tables 2, 3.

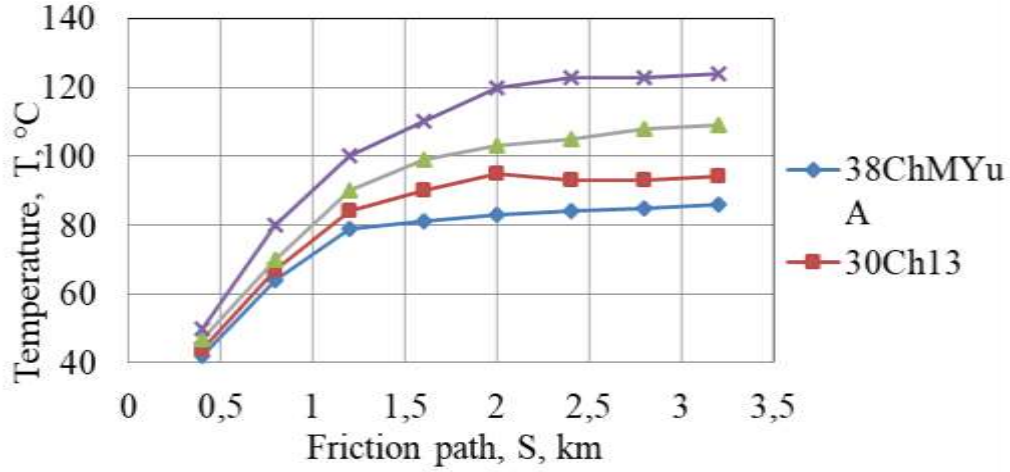
Table 2. Results of testing carbon-fiber plastic at rubbing against mated surfaces of various compositions

Steel grade	HB, MPa	Reinforcement direction			
		LLLL		RRRR	
		Wear intensity, I, mm^3/Nm	T, °C	Wear intensity, I, mm^3/Nm	T, °C
45	1,850	4.36	110	4.57	100
38ChMYuA	1,900	5.25	90	6.2	110
30Ch13	1,750	5.45	100	7.8	135
10Ch18N9T	1,200	6.14	130	10.6	155

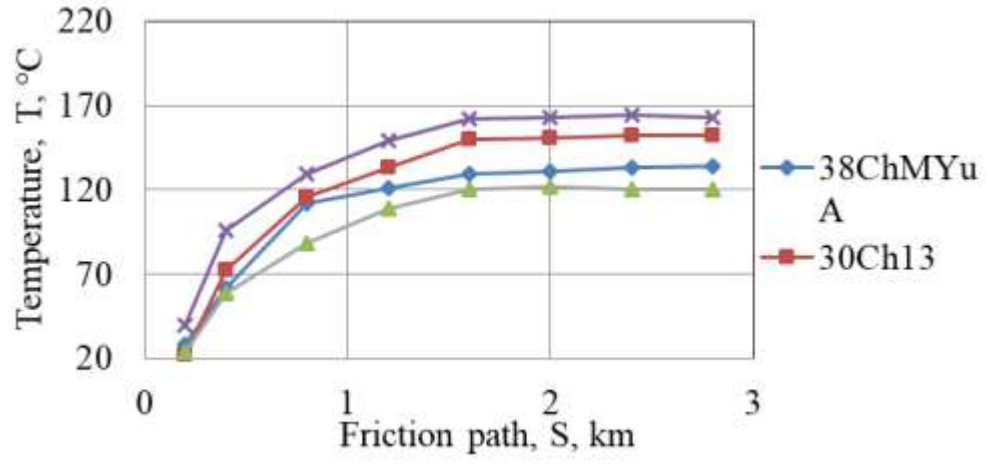
Table 3. Effect of the mated surface on the indicators of the carbon-fiber plastic friction process

Steel grade	HB, MPa	Friction coefficient			
		Reinforcement direction			
		LLLL		RRRR	
		min	max	min	max
45	1,850	0.3	0.38	0.24	0.46
38ChMYuA	1,900	0.27	0.49	0.23	0.53
30Ch13	1,750	0.24	0.38	0.21	0.66
10Ch18N9T	1,200	0.24	0.46	0.38	0.82

The kinetics of temperature changes in the tribosystem "carbon-fiber plastic-steel" is shown in Fig. 5.



a



b

Fig. 5. Temperature dependence in the friction zone on friction path for the pair carbon-fiber plastic-steel: a – direction LLLL; *b* – direction RRRR

6. Discussion of results of the experimental study into the properties of oriented carbon plastics

In the performance of slip tribosystems, the anti-friction characteristics of materials that are responsible for energy losses in the tribounit and have an indirect effect on the durability of operation play an important role. Our comparative tests of dependence of the friction coefficient on loading (Fig. 2) for metallic and polymeric antifriction materials have shown a tangible advantage of the latter. The results of tests without lubrication demonstrate a steady decrease in the friction coefficient for plastics (textolite, carbotextolite, and carbon-fiber plastic).

Thermomechanical influence contributes to the improvement of the structure of carbon fibers: there is a transition from a two-dimensional layered structure to the turbo-stratum one, approaching the graphite three-dimensional ordered structure. In carbon-fiber plastics, the fibrils that form threads are not intertwined, which does not limit the mobility of fibers as in textolite. The layered structure of the composite graphite fibers ensures a decrease in the friction coefficient (Fig. 3) due to the thin layer of the portable film, which is formed at the steel surface. In the temperature region of 50...90 °C, there is a jump-like increase in friction when the friction coefficient reaches μ=0.4...0.5. At the beginning of tribopair operation, this is due to the effect of the roughness of the mated steel surface. Graphitized fibers have a smooth surface, so separating the wear particles from them at low temperatures is difficult due to the increased thermal conductivity of fibers. With a further increase in temperature to 150...200 °C (Fig. 3), the friction zone of carbon fibers experiences thermomechanical destructive processes. Fiber wear particles fill the micro-depressions of the metal counter-body, a protective film is formed at its surface. The carry film significantly affects the anti-friction properties and wear resistance. At temperatures of 200...300 °C, the friction coefficient decreases and almost stabilizes since the film formation is accelerated by the oxidative processes of the fiber and matrix and the transformation of the elementary fiber lattice.

At temperatures of the mated surface of up to 100 °C, the orientation ratio for the wear amount is as follows: RRRR<RLRR<LLLL<LLLT; for the friction coefficient: LLLL<LLLT<RLRR <RRRR. An increase in the temperature of the metal surface from 150 to 250 °C, which leads to destructive processes in the polymeric matrix, the destruction of the carrying film, and the oxidation of the mated metal surface, changes the nature of friction. In this case, the reinforcement

directions that provide for the best wear indicators are LLLL and LLLT; for the friction coefficient, they coincide with the previous ones. When the temperature rises to 200...250 °C, the adhesion between the fiber and matrix deteriorates, the composite monolithicity is disrupted, which causes the stratification of the sample reinforced in the RRRR direction. For samples reinforced in the direction of LLLL and LLLT, stratification of the sample does not occur, which reduces the wear of the composite by almost an order of magnitude (Fig. 4, Table 1). The wear process of the steel surface occurs through layer-by-layer destruction of the surface and the intensive oxidation of wear products.

Our tests for wear have shown that the effect of the mated surface on the wear process is manifested in the same way for both reinforcement directions. For the reinforcement direction of RRRR and LLLL, it was found that the wear intensity is the lowest when rubbing against carbon steel, and, when rubbing against alloy steels, the wear increases with an increase in the content of alloying elements (Table 2). When heating the steel surface up to 100...200 °C, the secondary structures of the first type are predominantly formed. That contributes to the formation of secondary structures of the second type of oxides, nitrides, which are stronger and less plastic, which changes the roughness of the surface, increases the friction coefficient and the wear of the composite (Tables 2, 3). The coefficient of friction and the wear of the composite are significantly influenced by a portable film, which is formed at the steel surface due to the smearing of carbon fiber particles and a polymeric matrix. Our analysis of temperature change in the friction zone has revealed that a significant increase in temperature occurs at the beginning of the friction path (up to 800 m). The temperature rises to almost 110 °C. When the friction path increases to 1.6 km, the temperature rises to 130...160 °C, after which it almost does not change (Fig. 5). For alloyed steels, temperature stabilization in the friction zone is slower depending on their thermal conductivity.

7. Conclusions

Carbon plastics have high anti-friction properties at friction without lubrication. The maximum friction coefficient values do not exceed 0.30...0.32 when operating under normal loads of up to 120 N and reduce to 0.16...0.18 with increased loads of up to 500 N.

Carbon plastics can manifest the effect of reducing the friction coefficient at an elevated temperature of the mated surface. The thermal-physical properties of

carbon plastics significantly affect their wear resistance.

It was established that oriented carbon plastics significantly change the properties of the mated surface; the carbonation and expansion processes occur. A correlation relation between the wear resistance of the pair "composite–metal" and the thermal-physical and mechanical characteristics of metal was found.

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AUTOMATED DESIGNING OF MECHANICAL PROCESSES BY SYNTHESIS METHOD

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DOI: 10.31891/monograph/2021-10-79

1. Introduction

Scientific and technological progress in mechanical engineering largely determines the degree of development of technology as a whole. An outstanding factor for accelerating the technical process is to increase productivity, improve the efficiency of overall production and product quality [1].

Improving technological methods of manufacturing is at the top of this list. Quality, reliability, durability and efficiency in operation depend not only on design improvement, but also on manufacturing technology. The use of advanced high-performance processing methods provides high accuracy and quality of surfaces of machine parts, methods of creating work surfaces that increase the service life of parts and machines in general. The efficient use of modern automated lines, CNC machines, personal computers, the use of advanced forms of organization and economics of technological processes, all this is aimed at solving the main tasks: improving industrial efficiency and product quality, while reducing costs.

Technological and design engineers and industry leaders take an active part in solving such problems. With the use of modern technologies [2] and new methods in the design of technological processes, quality, efficiency and reliability can be raised to a new level, so the use of technology is in the first place in mechanical engineering as a technological process (TP), and the development of drawings or technical documentation. In modern production of paper documentation, production goes to another level - digital information, using a PC, which shows a more efficient use of modern technology for industry as a whole.

2. Main part

The urgency of the problem of automated design of technological processes remains for many decades a common form of presentation of the results of intellectual activity of people and the tool of their information interaction was paper documentation. By its creation millions of engineers, technicians, designers,

serving in industrial enterprises, government agencies, commercial structures were employed (and still are).

With the advent of computers, a variety of tools and systems for automation of paper documentation was being created and widely implemented: computer-aided design (CAD) - for the manufacture of drawings, specifications, technological documentation; automated production management systems (APMS) - to create production plans and reports on its progress; office systems - for preparation of text and tabular documents and so on. However, by the end of the twentieth century, it became clear that all these rather expensive means did not live up to the expectations placed on them: of course, some increase in productivity occurs, but not on the scale that was predicted. The fact is that they do not solve the problems of information exchange between different participants in the product life cycle (customers, developers, manufacturers, operators, etc.). When transferring data from one automated system to another requires a lot of labour and time for re-encoding, which leads to many errors. It turned out that different systems "speak different languages" and misunderstand each other.

Moreover, it turned out that paper documentation and ways of presenting information on it limit the possibilities of using modern IT. Thus, the three-dimensional model of the product created in modern CAD, in general, cannot be properly represented on paper.

As a result, the efficiency of the processes of development, production, operation, maintenance, repair of complex knowledge-intensive products is sharply reduced (Fig. 1).

When designing technological processes, the technologist has the following areas of activity:

- registration of technological documentation (route, operational maps and other documents). This is not creative work and can be fully automated;

- search of information (search of tools, devices, equipment, workpieces, allowances, standards for cutting modes and time norms, and so on). This procedure is automated based on the use of information retrieval system (IRS). When using IRS, the search condition is entered by the technologist in the dialogue mode. Search terms that are stable can be stored in the knowledge base;

- standard calculations (calculation of allowances, operational blanks, cutting modes, etc.). Such calculations can be fully automated;

- making complex logical decisions (choosing the structure of the process and operations, choosing the bases, etc.). The process of making such decisions cannot be fully automated.

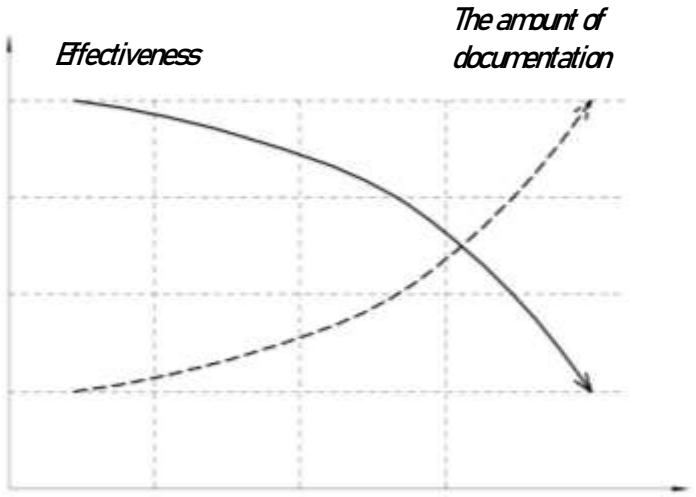


Fig.1. Volumes of documentation and efficiency of engineering activities

The modern concept of computer application in technology design is based on the creation of human-machine systems, in which the communication of the technologist with the computer takes place in a dialogue mode, which can be provided on the basis of synthesis of design and technological information.

The method of synthesis is a universal method designed for the design of technological processes on parts and assembly units for any product.

The method is based on the proposition that the process of designing technological processes is multilevel and iterative. The most common decisions are made at the first level. Next is the evaluation and selection of the obtained options by any or all criteria. The resulting options are involved in decision-making at the second level and so on. When clarifying previously made decisions, it may turn out that these cannot be used, so you need to return to previous levels, ie there is feedback needed to implement iterative processes.

Advantages of synthesis method:

- the method is universal and theoretically allows to design technological processes for any details;
- method focuses on the use of strategy "first in breadth, and in depth", that allows to perform specific search and quickly design the best processes.

Disadvantages of synthesis method:

• the method is complex and therefore the process of TP design takes a long time;

The higher the level of automation, the more difficult it is to adjust the design system to the conditions of the enterprise and the more difficult it is to maintain.

The method of synthesis is based on local standard solutions [3,4]. Algorithms for constructing CAD based on the method of synthesis differ significantly from each other. The reasons for this are as follows:

1. Procedures for the development (synthesis) of technological processes belong to the category of difficult to formalize.

2. A number of CAD, built by the method of synthesis, focused on the design of technological processes for the manufacture of parts of a certain class (for example, "solid of revolution").

3. In order to exclude cycles in the development of technology and provide a linear design strategy, some CAD developers have departed from the classic scheme of design of technological processes "route - operation - transition" and so on.

Implementation of a linear design strategy in CAD technological processes. Simplified scheme of this method.

1. Introduction of the description of the drawing of the part.

2. Synthesis of routes (plans) of processing for all surfaces of a detail.

3. Synthesis of the schematic diagram of the technological process.

4. Synthesis of the route of processing of a detail.

5. Synthesis of the composition and structure of operations of the technological process.

6. Completion of the technological process (calculation of cutting modes, rationing).

7. Registration of documentation.

Introduction of the description of the drawing of a detail and registration of documentation are the general stages for all methods of designing of technological processes in CAD. They are included for completeness of a picture of designing of technological process.

Synthesis of surface treatment routes. The surface treatment route (STR) is a sequence of processing methods (types, transitions of one method) necessary to achieve the required surface detail drawing parameters.

The following parameters are:

• geometric type of surface;

• size accuracy;

• roughness;

• type of heat treatment and so on

There is a relationship described by the function between the processing methods and the surface parameters

$$M_i : P_i \rightarrow P_{i+1}.$$

That is, a surface with lower quality parameters will be transformed into a surface with higher quality parameters using the method.

Any sequence of arcs of the graph leading from the vertex characterizing the workpiece surface to the vertex corresponding to the surface of the part represents a variant of the STR. The number of possible processing methods of STR is very large. At a particular enterprise, it is limited by the capabilities of existing equipment. This reduces the number of alternative STRs, but the problem (task) of choosing a particular STR for a particular surface remains.

Most algorithms for assigning possible STR in CAD processes are based on tables of correspondences. Their structure and principles (algorithms) of work with them will be considered further.

Example. Selection of possible variants of a route of processing of an end surface of a detail like "solid of revolution".

Possible surface treatment routes and a table of correspondences for their selection are shown in table 6.1.

Note: the limits of the ranges (13 ... 11; 11 ... 8; 12.5 ... 6.3) are in the corresponding range.

The left part of the correspondence table, which means rows, is a set of typical solutions (here the set of STR).

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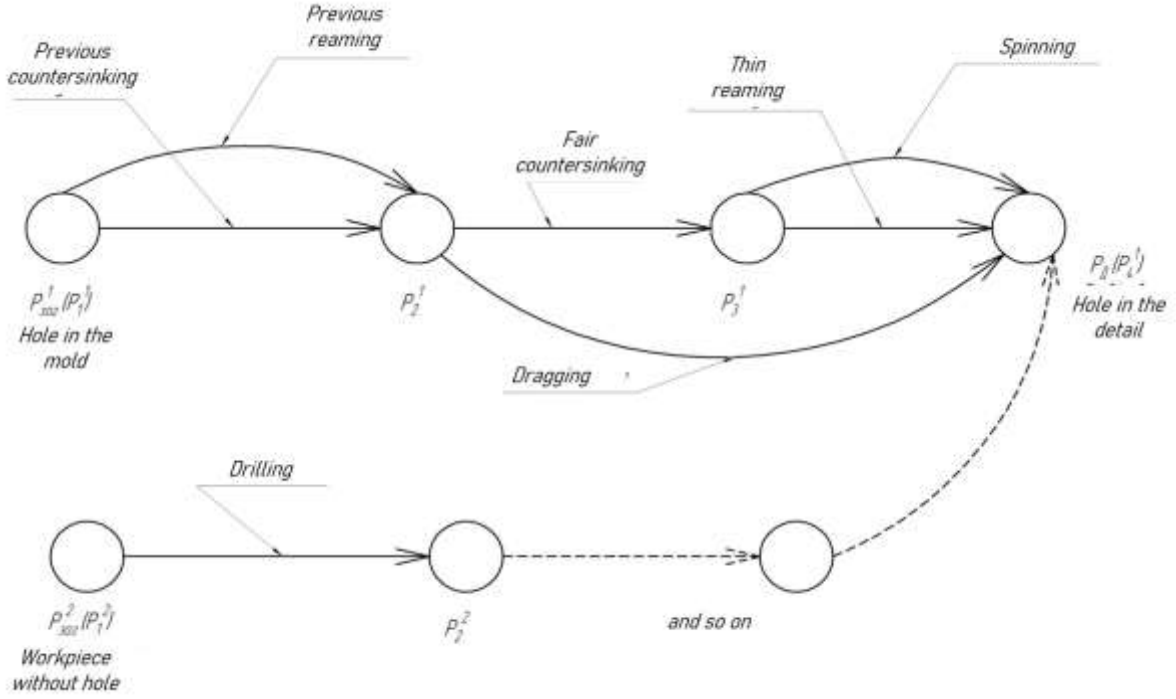


Fig.2. Presentation of options for surface treatment of the part

The upper part of the table of correspondences, which means columns, - the conditions for selection or applicability of standard solutions (here STR) and their numerical values.

The central part of the table of correspondences is the Boolean matrix, which means the connections between the conditions for choosing standard solutions (here the STR) and the most typical solutions (1 - the presence of communication, 0 - no communication).

When designing the technological process by synthesizing constructive and technological information, the method of presenting the knowledge of parametric synthesis was used.

The simplest way to present the knowledge of parametric synthesis is to use productive artificial intelligence systems. In such systems, knowledge is represented in the form of product rules, which are analogous to the conditional sentence of natural language:

IF <condition>, THEN <action>

Table1. Routes of surface treatment of parts such as "solid of revolution" (database fragment) [2]

MOP code	Processing method code	Type of processing	Surfaces parameters after processing	
			Standard tolerance grades	Ra, mkm
12	100	Draft honing	16	25
	101	Semi-fair honing	14	12,5…6,3
13	100	Draft honing	16	25
	101	Semi-fair honing	14	12,5…6,3
	102	Fair honing	13…11	3,2
14	100	Draft honing	16	25
	101	Semi-fair honing	14	12,5…6,3
	102	Fair honing	13…11	3,2
	103	Thin honing	11…8	1,6
15	100	Draft honing	16	25
	101	Semi-fair honing	14	12,5…6,3
	502	Semi-fair grinding	13…11	3,2

Such rules are based on a dictionary of technical language that contains terms and their symbols(identifiers). As actions are used calculations by formulas, selection of data from multilevel tables which can contain both constants, and formulas, a choice of the information from databases, generation of graphic images and so on.

Designing a new TP with its help takes minutes. The technologist shall use a simple interface to describe the part, and then observe the generation of the process, responding to the rare requests of the computer to choose from a valid set of solutions that cannot be formalized. In the end, the automatic generation of technological documentation using the forms of documents adopted at the enterprise is conducted.

3. Conclusions.

The method of technological decision-making in the formation of the list of technological operations of machining surfaces of machine parts in the design process was proposed, which allows the technologist to automatically or manually

select processing methods that provide designer-specified accuracy and surface quality with a significant reduction in design time, as well as technological preparation.

A new method of software implementation of algorithms for forming a complex design and technological model of designed machine parts was proposed, which allows to apply the developed new integrated intelligent methods.

The quality of the designed TP practically does not depend on the qualification of the technologist, but is determined by the content of knowledge bases, so this TP reduces the probability of error of the human factor.

When compiling a TP, if it is not possible to solve the processing method by software, the program will offer several possible technological processes, and the PC operator will decide and accept a more perfect TP for its enterprise.

This method of synthesis is universal and theoretically allows to design technological processes for any details and any complexity providing economic and qualitative indicators of TP thanks to the method of synthesis of technological and design information enclosed in a basis.

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COMPARATIVE ANALYSIS OF FUNCTIONALLY ADEQUATE PRODUCT MOVEMENT MANIPULATORS ON SEWING MACHINES

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DOI: 10.31891/monograph/2021-10-80

1. Introduction

The design of mechatronic modules (MM) requires taking into account the mechanical, energy and information components of the design objects [1].

The main stages in the design of target mechatronic systems (MTS) are functional analysis, structural analysis and parametric synthesis of the object and design subject. At the stage of functional analysis, a comparative analysis of functionally adequate mechanisms (manipulators) is carried out for a reasonable choice of an object according to a set of functional criteria (parameters). At the stage of structural analysis, the selection and joining of the component parts of the MTS facility, selected at the stage of functional design, are made. Calculations are also performed, including kinematic and dynamic analysis of the mechanical and electromechanical components of the MTC. And at the stage of parametric synthesis, the program code (sketch) is written, compiled, the controller (microcontroller) is stitched, the MTS is debugged.

For example, at the stage of functional analysis, schemes of functionally adequate mechanisms (manipulators) are selected. Their functional, economic and other indicators are assessed quantitatively and qualitatively on the basis of the requirements for the design object. At the same time, a comparative analysis of functionally adequate design objects is carried out. For this purpose, it is convenient to use correlation-regression analysis and expert assessments to substantiate rational decision-making. Statistical analysis avoids the stringent requirements of directional vector analysis. The directional vector method is an analogue of a statistical model and has a number of advantages over the well-known method of a priori ranking of factors.

2. Purpose

The purpose of the article is a rational choice of the K-model from a variety of known and potentially possible manipulators for moving products on sewing machines [2] based on the construction mathematical regression models for the

proposed integral indicator (criterion) - a generalized quality indicator K of technical design objects for their intended purpose.

3. Results of functional analysis and their discussion.

For the quantitative substantiation of rational decisions based on the correlation-regression analysis of a certain set of manipulators for moving products on sewing machines, local-integral models were built in the form of a linear regression equation (1):

$$K = b_0 + \sum_{i=1}^{n} b_i . x_i \qquad (1)$$

The analysis of correlations between the selected parameters x_i is carried out on the basis of constructing a square symmetric correlation matrix $\|a_{ij}\|$ of size 10 * 10, the elements of which $a_{ij} \neq 0$ for $i \rangle j = j \rangle i$ and $a_{ij} = 1$ for $i = j$ are the coefficients r_{ij} of pair correlation. The column of the matrix equation consists of the coefficients r_{ij} of the pair correlation between the parameter x_i and the generalized quality indicator K_{0j}, taken as the basic parameter. Another measure of the linear relationship between K_{0j} and the selected (taking into account the significance of the coefficients of the regression equation) set of all remaining insignificant remaining significant parameters x_i after exclusion are the multiple correlation coefficients. Multiple correlation coefficients R_k were calculated by the formula [3]:

$$R_k = R_{1(2\ldots m)} = \sqrt{1 - \frac{|A|}{A_{II}}}, \quad m = (\overline{1,M}), \qquad (2)$$

where $|$ A $|$ - determinant of the correlation matrix $\|a_{ij}\|$;

A_{II} is the algebraic complement of the elements $a_{ij} = 1$.

The coefficients of the regression models (1) were determined by numerically solving a matrix equation of the form:

$$S = \left[[A]^T[A]\right]^{-1}[A]^T B, \qquad (3)$$

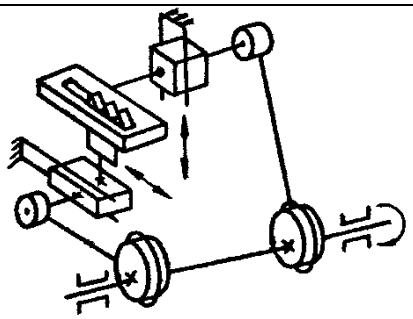
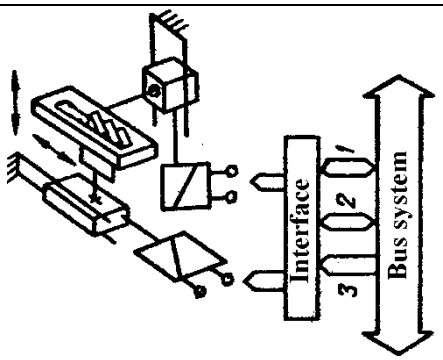
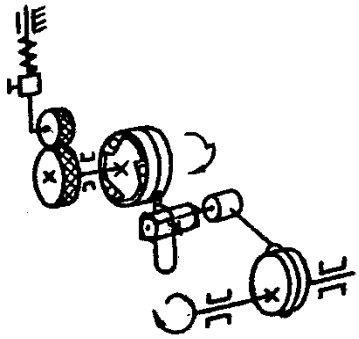
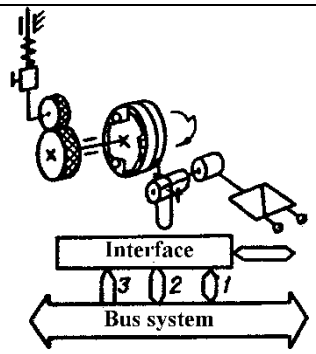
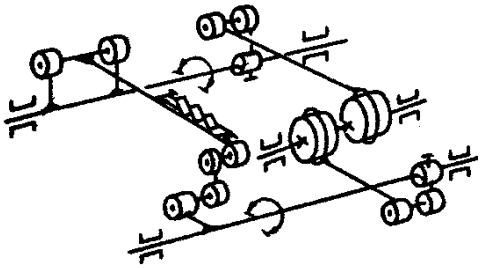
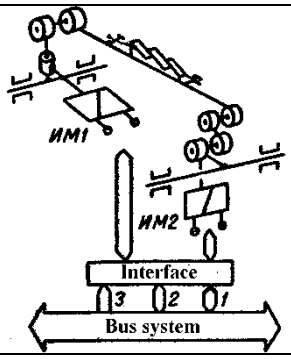
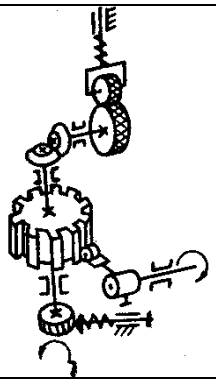
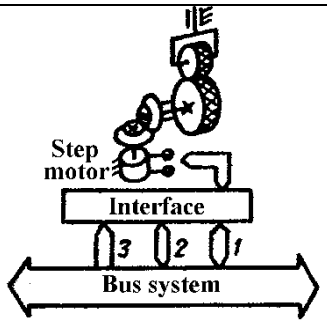
where $[A]^T$ – transposed original correlation matrix 10 * 10;

$\left[[A]^T[A]\right]^{-1}$ – the inverse of the matrix $\left[[A]^T[A]\right]$;

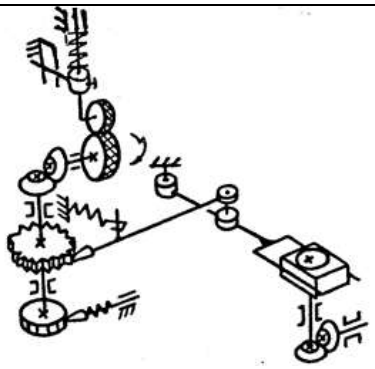
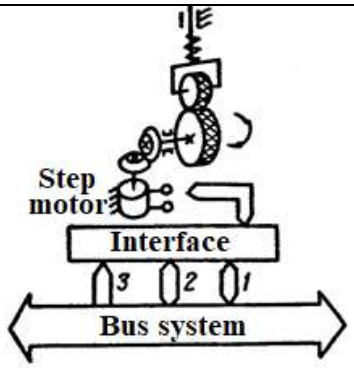
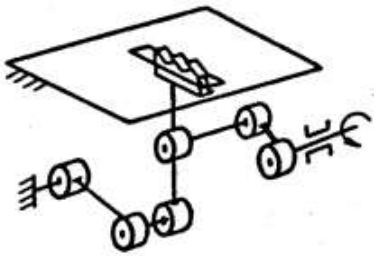
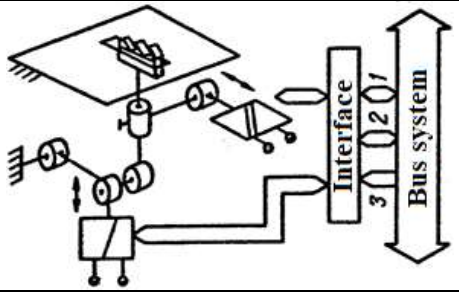
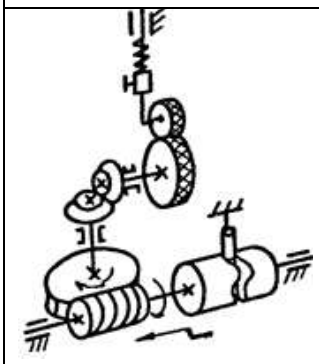
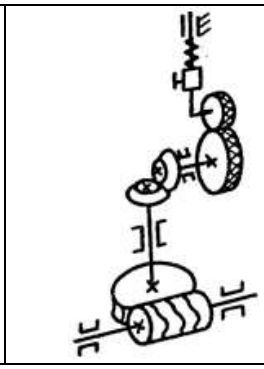
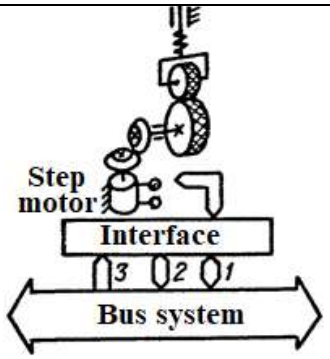
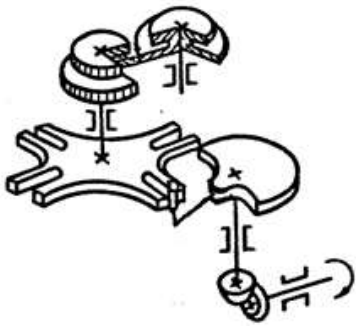
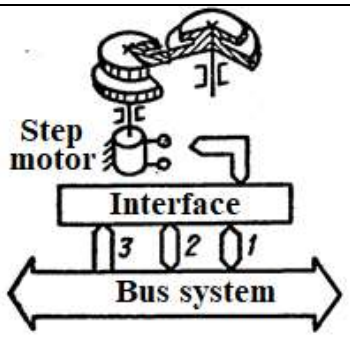
B - initial vector-columnar $r_{i\kappa j}$.

Schematic diagrams of mechanisms and functionally adequate manipulators for moving products on sewing machines are shown in Table 1.

Table 1

Mechanisms	Manipulators
Y1	
	
Y2	
	
Y3	
	
Y4	
	

Continuation of table 1

Mechanisms	Manipulators
Y5	
	
Y6	
	
Y7	**Y8**
 	
Y9	
	

In Table 1, the following designations of the initial data Y_j are adopted:

Y1 - rack and pinion with a movable stitch plate;

Y2 - with freewheel clutch;

Y3 - typical toothed rack;

Y4 - cam;

Y5 - ratchet;

Y6 - clamshell;

Y7 - worm gear with a worm that moves along the axis of rotation;

Y8 - worm gear with variable gear ratio;

Y9 is Maltese.

A comparative analysis of mechanisms and manipulators Y1 ... Y9 was carried out using a generalized quality indicator K. Such an indicator is an integral assessment based on a set of particular indicators (criteria) X_i, quality that have a quantitative and / or qualitative assessment and satisfy the following requirements [3]:

measurability and unambiguous (numerical) description of parameters (properties, characteristics);

completeness of accounting for technical, functional, technological and economic indicators in a reasonable set of possible combinations of them with each other and with a generalized quality indicator K.

With the quantitative nature of the particular quality indicators X_i, their assessment can be carried out on the basis of a formalized analytical or simulation analog or digital mathematical model. Such models connect the structural, kinematic, dynamic, energy and statistical parameters Y1 ... Y9 of mechanisms and manipulators. However, the assessment of the generalized quality indicator K according to one or two particular indicators X_i, quality or their ratio should be considered as one of the particular examples. Such examples are associated with the modernization of existing technological design objects, the use of more advanced working tools, special purpose mechanisms, drives or elements of their automation.

With the qualitative nature of the particular quality indicators X_i, their assessment can be carried out in points, coefficients or ranks that are associated with functional dependence with processing modes or other prescriptions. In this case, the Edwin-Harrington function [4] is used.

The qualitative assessment of X_i can be used by expert groups [5] or the X_i values can be borrowed from technical, scientific or patent literature.

The algorithm for constructing mathematical models (5) ... (10) for calculations using the calculated requirements is performed in two stages:

identification of essential parameters X_i for comparative analysis of functionally adequate technical objects in the form of kinematic diagrams or various ways of implementing work processes in technological machines;

matrix representation of mechanisms of mechanisms Y1 ... Y9 in the parameter space of parameters X_i and identification of a set of performance indicators X_i, which are preferable to other quality indicators with the widely used method of a priori ranking of factors.

For precision movement of textile parts on sewing machines (manipulation object), the following 10 X_i parameters are selected:

X1 - contact during interaction of a pair of "working tool (toothed rack or call sign) - object of manipulation". Contact presence (X1 = 0) or no contact (X1 = 1);

X2 is the length of the machine stitch when changing the rotational speed of the main shaft. (X2 = 0) when changing the stitch length, (X2 = 1) - the length of the machine stitch does not change;

X3 - the symmetry of the action of the working tool on the manipulation object. Two planes of symmetry (X3 = 1), there are no planes of symmetry (X3 = 0);

X4 - constructive realization of machine stitch length. Smooth adjustment (X4 = 5), step adjustment (X4 = 2), adjustment by replacing one or more links (X4 = 1), no adjustment (X4 = 0);

X5 - the number of worm kinematic pairs N_5 ($X_5 = 1/1 + N_5$) ;

X6 - number of freewheel clutches in the mechanism / manipulator;

X7 - the number of higher kinematic pairs such as cam, gear, worm N_7. ($X_7 = 1/1 + N_7$);

X8 - number of movable links N_8. ($X_8 = 1 - N_8/N_{max}$);

X9 is the number of software controlled drives. (X9 = 0) - two software-controlled drives, (X9 = 1) - one software-controlled drive;

X10 is the vibration activity level of the designed object.

The results of numerical calculations for the construction of K-models (5) ... (10) are summarized in tables 2 ... 5.

Table 2. Matrix of input variables X_i (private quality indicators) for functionally adequate manipulators for moving products on sewing machines

Mechanisms	Parameters X_i										
	K_{0j}	$X1$	$X2$	$X3$	$X4$	$X5$	$X6$	$X7$	$X8$	$X9$	$X10$
Y1	0.23	0	0	0	1.0	1.0	0	1.0	0.57	0	0.90
Y2	0.43	1.0	1.0	1.0	5.0	1.0	1.0	0.33	0.43	1.0	0.80
Y3	0.27	0	0	0	5.0	1.0	0	1.0	0	0	0.90
Y4	0.43	1.0	1.0	1.0	1.0	1.0	0	0.25	0.57	1.0	0.70
Y5	0.35	1.0	1.0	1.0	2.0	1.0	0	0.20	0.57	1.0	0
Y6	0.18	0	0	0	0	1.0	0	1.0	0.29	0	0.80
Y7	0.43	1.0	1.0	1.0	1.0	1.0	0	0.25	0.57	1.0	0.80
Y8	0.83	1.0	1.0	1.0	1.0	0.5	0	0.50	0.57	1.0	0.90
Y9	0.97	1.0	1.0	1.0	1.0	1.0	0	0.25	0.57	1.0	0.85

To build K-models of multiple linear regression, the input data K_{0j} and x_i in Table 2 are converted to standardized input data using the formula:

$$t_i = \frac{x_i - \bar{x_i}}{\sigma_i} \quad (4)$$

where $\bar{x_i}$ and σ_i – is the mathematical expectation and variance of the parameters of manipulators for moving products on the sewing machine.

Refinement of models and estimation of errors were carried out based on the analysis of correlations and sequential elimination by the minimum value r_{ij}, which weakly correlates with the parameters K_{0j} and x_i for manipulators Y_j moving products on sewing machines.

Table 3. The results of calculating the coefficients of pair correlation (r_{iKj}) and elements (a_{ij}) of the correlation matrix $|A|$, taking into account the data in Table 2, recalculated for standardized data by formula (4).

	K_{0j}	Input parameters Xi									
		X1	**X2**	**X3**	**X4**	**X5**	**X6**	**X7**	**X8**	**X9**	**X10**
r_{iK1} a_{i1}	1.0 0.39	0.57 0.08	0.57 0.08	0.57 0.08	-0.16 0.007	-0.46 -0.37	**-0.03** -0.08	-0.42 -0.11	0.39 0.02	0.57 0.08	0.16 0.35
r_{iK2} a_{i2}	1,0 0.48	0.57 0.07	0.57 0.07	0.57 0.07	**-0.16** 0.003	-0.46 -0.40	- -	-0.42 -0.16	-0.39 0.001	0.57 0.07	0.16 0.35
r_{iK3} a_{i3}	1,0 0.48	0.57 0.07	0.57 0.07	0.57 0.07	- -	-0.46 -0.39	- -	-0.42 -0.15	0.39 -0.02	0.57 0.07	**0.16** 0.35
r_{iK4} a_{i4}	1,0 0.88	0.57 0.06	0.57 0.06	0.57 0.06	- -	-0.46 -0.56	- -	-0.42 -0.09	**0.39** -0.02	0.57 0.06	- -
r_{iK5} a_{i5}	1,0 0.87	0.57 0.06	0.57 0.06	0.57 0.06	- -	-0.46 -0.55	- -	**-0.42** -0.08	- -	0.57 0.06	- -
r_{iK6} a_{i6}	1,0 0.78	0.57 0.72	0.57 0.72	0.57 0.72	- -	-0.46 -0.55	- -	- -	- -	0.57 0.07	- -

Table 3 shows the minimum values of the calculated pairwise correlation coefficients between the generalized opinion of experts K_{0j} manipulators and parameters x_i.

The problem of selecting input features that are significant for the model is known as "**feature selection**" [6]. This problem is solved by reducing irrelevant parameters after analyzing the model and recalculating the model without this parameter. Reducing the number of independent variables is intended to reduce the dimension of the model. This removes all irrelevant functions from the model and thus simplifies the model, which does not contain redundant explanatory variables. That is, a sequential construction of a model takes place from all possible combinations of sets of input functions, followed by a choice of a version of the model that will have the best descriptive ability of the resulting property and at the same time will contain a minimum of independent variables.

To construct the *K1*-model (5) ... *K5*-model (10) of manipulators, their sequential refinement and estimation of errors were carried out. All 10 parameters of manipulators x_i are included in the K1-model (5). K-models (2) ... (6) are based on the analysis of correlations and sequential elimination of the minimum value r_{ij}, weakly correlated with the parameters K_{0j} and x_i for manipulators Y_j for moving products on sewing machines.

$$\boldsymbol{K1 = 0.3877 + 0.0817\ x1 + 0.0817\ x2 + 0.0817\ x3 + 0.0067\ x4 - 0.3717\ x5 - 0.0841\ x6 - 0.1070\ x7 - 0.0162\ x8 + 0.0817\ x9 + 0.3537\ x10} \quad (5)$$

After the first refinement of the ***K1***-model and elimination of the weakly correlated parameter **x6**, the following calculated ***K2***-model was obtained:

$$\boldsymbol{K2 = 0.4823 + 0.0714\ x1 + 0.0714\ x2 + 0.0714\ x3 + 0.0072\ x4 - 0.4002\ x5 - 0.1612\ x7 - 0.0011\ x8 + 0.0714\ x9 + 0.3518\ x10} \quad (6)$$

After refining the ***K2***-model and dropping out the weakly correlated parameter **x 4**, the following calculated ***K3***-model was obtained:

$$\boldsymbol{K3 = 0.4851 + 0.0734\ x1 + 0.0734\ x2 + 0.0734\ x3 - 0.3962\ x5 - 0.1539\ x7 - 0.0179\ x8 - 0.0734x9 + 0.3495\ x10} \quad (7)$$

After refining the ***K3***-model and dropping out the weakly correlated parameter **x 10**, the following calculated ***K4***-model was obtained:

$$K4 = 0.8821 + 0.0628\,x1 + 0.0628\,x2 + 0.0628\,x3 - 0.5568\,x5 - 0.0873\,x7 - 0.0211\,x8 + 0.0628\,x9 \quad (8)$$

After refining the ***K4***-model and dropping out the weakly correlated parameter **x 8**, the following calculated ***K5***-model was obtained:

$$K5 = 0.8723 + 0.0618\,x1 + 0.0618\,x2 + 0.0618\,x3 - 0.5555\,x5 - 0.0849\,x7 + 0.0618\,x9 \quad (9)$$

After refining the ***K5***-model and dropping out the weakly correlated parameter **x 8**, the following calculated ***K6***-model was obtained:

$$K6 = 0.7827 + 0.0729\,x1 + 0.0729\,x2 + 0.0729\,x3 - 0.5500\,x5 + 0.0729\,x9 \quad (10)$$

After filtering out insignificant parameters, the *K6*-model of the mechanism (manipulator) contains only 5 significant parameters (private quality indicators). For the integral assessment of the generalized quality indicator, the *K6*-model of the mechanism (manipulator) can be considered the most acceptable for the subsequent development of the design of the design object.

The results of the numerical values of the generalized quality indicator K_j for nine functionally adequate manipulators, calculated using models (5) ... (10), are shown in Table 4.

Table 4. Results of numerical values of K_j , calculated by models (5) ... (10)

Mechanisms	Generalized quality indicator by models (5) ... 10)					
	K1 (5)	***K2*** (6)	***K3*** (7)	***K4*** (8)	***K5*** (9)	***K6*** (10)
Y1	0.2432	0.2414	0.2394	0.2259	0.2318	0.2327
Y2	0.4393	0.4510	0.4493	0.4509	0.4506	0.5245
Y3	0.2607	0.2538	0.2496	0.2380	0.2318	0.2327
Y4	0.5795	0.5776	0.5785	0.5425	0.5426	0.5245
Y5	0.3440	0.3426	0.3415	0.5469	0.5469	0.5245
Y6	0.1916	0.2024	0.2094	0.2318	0.2318	0.2327
Y7	0.6149	0.6128	0.6134	0.5425	0.5426	0.5245
Y8	0.8093	0.8078	0.8080	0.7991	0.7991	0.7994
Y9	0.6325	0.6304	0.6309	0.5425	0.5426	0.5245

The calculated values of the multiple correlation coefficients R_k are shown in Table 5. The values are in the range $0.8 \le R_k \le 0.9$. Thus, it can be argued that the value of the generalized quality indicator K_j using all "K-models" of the considered set of functionally adequate mechanisms (manipulators) for moving

products on sewing machines with a probability close to "1" corresponds to a linear combination of parameters x_i in according to the obtained K-models (5), ,, (10).

Table 5. Multiple correlation coefficients R_k.

Multiple correlation coefficients	Matrix (I,J) I = 1…10, J = 1…9	K_j model
$R_1 = 0.8093$	(10 parameters x_i) 1 2 3 4 5 6 7 8 9 10 (9 manipulators) 1 2 3 4 5 6 7 8 9	(5)
$R_2 = 0.8195$	(9 parameters x_i) 1 2 3 4 5 7 8 9 10 (9 manipulators) 1 2 3 4 5 6 7 8 9	(6)
$R_3 = 0.8129$	(8 parameters x_i) 1 2 3 5 7 8 9 10 (9 manipulators) 1 2 3 4 5 6 7 8 9	(7)
$R_4 = 0.8333$	(7 parameters x_i) 1 2 3 5 7 8 9 (9 manipulators) 1 2 3 4 5 6 7 8 9	(8)
$R_5 = 0.8267$	(6 parameters x_i) 1 2 3 5 7 9 (9 manipulators) 1 2 3 4 5 6 7 8 9	(9)
$R_6 = 0.8682$	(5 parameters x_i) 1 2 3 5 9 (9 manipulators) 1 2 3 4 5 6 7 8 9	(10)

4. Conclusions:

4.1. A comparative analysis of 9 functionally adequate manipulators Y_j for moving products on sewing machines for 10 quantitative and qualitative parameters x_i.

4.2. For the proposed generalized quality indicator K_j (Generalized quality indicator), mathematical regression models are built (5) ... (10).

4.3. The regularities of the quantitative and qualitative dependence of K_j on specific indicators-parameters of manipulators for moving products on sewing machines are revealed.

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SELECTED ASPECTS OF TECHNICAL STATE GENESIS OF HYBRID MULTIMEDIA MOBILE SCENES

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DOI: 10.31891/monograph/2021-10-81

1. Introduction

Improving the operation of Hybrid Multimedia Mobile Scenes (HMMS), in addition to diagnosing, which provides information about the current technical condition of the HMMS and forecasting, which assuming the monotonicity of changes in the values of diagnostic parameters during operation, enables the determination of the proper time and scope of HMMS maintenance service, also requires determining the genesis of the HMMS state.

Considering the genesis of the HMMS technical state, as in the case of prognostic procedures, we couldn't assume the superiority of some methods of genesis over others, because it depends on what object is the subject of research and what is the purpose of genesis of the given HMMS state.

During the research, the criteria concerning the requirements related to:

- the form of genesis (symptom genesis value, estimated state of the machine in the past, the value of work performed by it in the past or another form of the genesis of the HMMS state);
- the impact of changing the operating conditions of the HMMS and maintenance activities on the operating properties of the HMMS, which should be taken into account when selecting the method of genesis;
- possible methods of genesis (e.g. qualitative methods, modified trend extrapolation methods and modified adaptive methods).

The main problems in the process of generating the technical condition of HMMS are related to:

1. Analysis of the HMMS technical condition genesis, i.e. the process of degradation of its technical condition, determination of trends and dynamics of changes in the value of its condition parameters, selection of states in which the machine could be, HMMS decomposition into systems and units, state selection

criteria and probability their occurrence, selection of the "best" diagnostic parameters describing the change in HMMS technical state.

2. Choosing the "best" method of the genesis, determining the technical state of the HMMS.

3. Using the information obtained from the genesis of the state to analyze the cause of the HMMS state at the time of the HMMS examination.

2. Model of HMMS technical condition genesis

The genesis of the technical condition of the machine should consist in determining (with incomplete or uncertain data of diagnostic parameter values) the trend of changes in the values of diagnostic parameters, characterizing the process of the deterioration of the machine condition in the past, equating the instantaneous values of diagnostic parameters to the limit values and on this basis estimating the time of reliable operation of the units and machine systems in the past time of HMMS operation of interest to the user, or analysis of the cause located at the time of testing the HMMS failure.

This solution can be presented in the form of the following algorithm based on literature data:

1. The phenomenon of the deterioration of the technical condition of HMMS units will be represented by a time series $y_t = <y_1, y_2, ..., y_b>$, it is a set of discrete observations $\{y_\Theta = \zeta(\Theta); \Theta = \Theta_1, \Theta_2,..., \Theta_b\}$ some non-stationary stochastic process $\zeta(t)$ [1,2,3,6].

2. Assuming that the mechanism of changes in the value of a stochastic process over time $\Theta \in (\Theta_1, \Theta_b)$ shapes the trend $\mu(\Theta)$ disturbed by various random interactions $\eta(\Theta)$, can be expressed as:

$$y_\Theta = \mu(\Theta) + \eta(\Theta) \quad (1)$$

where: $\mu(\Theta)$ - characterizes the determinate component of the time series y_Θ, it describes the development tendency of the observed diagnostic parameter $y(\Theta)$, $\eta(\Theta)$ - characterizes deviations from the trend and expresses the action of random factors (terrain conditions, climatic conditions, service quality) such an estimate is constructed $\{\mu_p(\Theta)\}$ for an unknown form of the trend $\mu(\Theta)$, which would ensure

the appropriate accuracy of genesis $y_G(\Theta)$, for interpolation (or approximation) $\mu_p(\Theta)$ per HMMS operating time (Θ_b, Θ_G), $\Theta_G = \Theta_b - \tau_2$ [1,2,3,6].

3. Estimation of $\mu_G(\Theta)$ - it determines the values of the observed diagnostic parameters at the genesis moment Θ_G, and thus the genesis of the technical condition of systems or units HMMS $W(\Theta_G)$ [1,2,3,6].

4. As the permissible operating state of units and systems HMMS W_{dop} in the time interval (Θ_b,Θ_G) the value of the time for which the boundaries of the error interval for particular genes is assumed $\sigma(y_t, y_G, G(y_\Theta,\tau))$ specified on a subset $\Omega^y \in \Omega$ the available implementation of the observed parameters $\{y_j(\Theta)\}$ and their genesis $\{y_{j,G}\}$ according to the adopted method of genesis $G(y_\Theta,\tau)$ do not exceed the limit values $\{y_{j,g}\}$[1,2,3,6].

5. Acceptable technical condition W_{dop} the HMMS system or assembly - sets the horizon of genesis τ_j^o, for which the limit of the diagnostic parameter is not exceeded $\{y_{jg}\}$ by the boundary of the error range of genesis determined by the radius of the boundary of the error range r_G as above:

$$r_G = q\sigma_G \tag{3}$$

where: $q_{\gamma,K}$ - constant parameter determined from the Student's distribution table to the required confidence level γ and K-2 the number of degrees of freedom, σ_G - standard deviation of the random error of genesis component e_G [1,2,3,6].

6. In the case of a handling system, the required form of the genesis of the state of HMMS systems or assemblies is information or time (Θ_1, Θ_b) the technical condition was an acceptable condition W_{dop} (on its basis, it is possible to estimate the technical condition of HMMS in the past). Interval (Θ_1, Θ_b) will be the period for estimating the expected value of the genesis error e_G and the radius of the genesis error boundary $r_{\sigma G}$, and the period of time $\Theta_b - \tau_2$ will be a period of active genesis, ie, designation of:

a) the value of the genesis diagnostic parameter for the given genesis horizon time τ_2, $y_{jG}(\Theta_b-\tau_2)$,
b) determination of the radius of the boundary of the genesis error range $r_G(\Theta_b - \tau_2)$,

c) designation of possible times $\{\Theta_{Gi}\}$ the HMMS assembly or system becomes unfit [1,2,3,6].

3. State genesis methods

In the case of situational genesis, the cause of the incapacity is determined on the basis of an inspection carried out immediately after the occurrence of the damage. The information collected in this way (situational data) is used for comparison with the situational data resulting from the modeling of certain damages. Then, data corresponding to the situational data of the input event is searched for. When modeling a given damage, the cause of the machine's failure is known, and at the time of failure, the resulting situational data is collected, creating a base corresponding to certain, sometimes typical failures. This procedure can be used to determine the causes of the machine's failure by comparing the collected information with the situational data corresponding to specific damages (using also the knowledge of the machine user), which allows to determine the probable cause of the failure. [1,4,8,9].

The method of genesis on the basis of information collected from the environment consists in determining the causes of the existing state of a given technical object on the basis of the accounts of witnesses of a given damage. For example, in the case of a car accident, the cause of the accident can be determined on the basis of eyewitness accounts. Another case may be the information provided by the person operating the given HMMS, who can provide very valuable data on the behavior of the whole system of HMMS before failure. In industry, industrial cameras are very often used, which can help in assessing the causes of the failure [1,4,8,9].

Genesis based on the recorded values of diagnostic parameters assumes the possibility of registering the values of diagnostic parameters and HMMS states during its operation (e.g. during a passive-active experiment), an information base is obtained in the form of an information matrix: diagnostic parameter values - HMMS states - operation time. At the time when the HMMS loses the condition of airworthiness, it will probably be based on the collected data and the inspection of the HMMS to determine what could have been the cause of the HMMS's unfit condition [1,4,8,9].

4. Methods for determining genesis values of diagnostic parameters

The implementation of the algorithm presented above is possible with the use of appropriate methods of determining the genesis value of diagnostic parameters (assuming an incomplete and uncertain history of their value over time). Θ1, Θb). This problem can be solved using approximation or interpolation methods, respectively [1,2,4,5,8,9].

An approximation is an approximation of a function Y(Θ) called a function approximated by another function Y(Θ) called the approximating function. Of the many approximation methods, based on literature analysis and preliminary research [7,8,9] have been selected: polynomial point mean square approximation and trigonometric approximation.

Polynomial point mean square approximation [7,8,9]:

The data is time points Θ_1, …, Θ_i, …, Θ_j, …, Θ_b different in pairs, i.e. for i≠ j $\Leftrightarrow \Theta_j \neq \Theta_j$ and the data is the values of the diagnostic parameters at these points y_1, …, y_i, …, y_b, where $y=f(\Theta_i)$, i=1, …, b.

The task of the approximation is therefore to find the values of the coefficients a_0, a_1, …, a_m of polynomial $Y_m(\Theta)$ degree of m^{th} form:

$$Y_m(\Theta) = \sum_{j=0}^{m} a_j \Theta^j , \tag{4}$$

so that the mean square error was the smallest, i.e.:

$$e_G = \min_{a_0, a_1, \ldots a_n} B = \sum_{i=0}^{n} (y_i - \sum_{j=0}^{m} a_j \Theta_i^j)^2 \tag{5}$$

The task of mean square point approximation comes down to solving m + 1 equations with n + 1 data unknowns.

Trigonometric approximation [7,8,9]:

Trigonometric approximation is used when the approximated function is a periodic function and the points of the time series are $Y = \{y_i(\Theta)\}$ the observed changes in the value of the diagnostic parameter are equidistant. The approximating function then takes the form:

$$Y(\Theta) = a_0 + \sum_{i=1}^{m} (a_i \cdot \cos \frac{2\pi \cdot i}{n} \Theta + b_i \cdot \sin \frac{2\pi \cdot i}{n} \Theta) \tag{6}$$

where: *n* - number of time series points,

m - degree of trigonometric polynomial, where the parameter m must meet the condition n> 2m + 1.

The problem of approximation then comes down to calculating the values of the coefficients a_0 and also a_i, b_i (i = 1, 2, ... , m). These coefficients are determined from the Euler-Fourier formulas:

$$\left.\begin{aligned} a_0 &= \frac{1}{n}\sum_{j=1}^{n}\Theta_j \\ a_i &= \frac{2}{n}\sum_{j=1}^{n}\Theta_j \cos\frac{2\pi ij}{n} \\ b_i &= \frac{2}{n}\sum_{j=1}^{n}\Theta_j \sin\frac{2\pi ij}{n} \end{aligned}\right\} \qquad i=1,2,\ldots,m \tag{7}$$

Where: Θ_j (j = 1, 2, ... , n) are string elements.

The error of trigonometric approximation can be expressed by the relationship:

$$e_G = B = \sum_{i=1}^{b}(y - y_i)^2 \tag{8}$$

where: *y* - the value of the approximating function,

y_i- value of the approximated function.

Diagnostic parameter value interpolation [7,8,9]:

Suppose the data are the values of the $Y(\Theta)$ function, diagnostic parameter values on a set of time points of Θ_1, …, Θ_i, …, Θ_j, …, Θ_b called interpolation nodes. The task of interpolation is to determine the approximate values of the function $Y(\Theta)$ called an interpolated function at points that are not interpolation nodes. The interpolating function is a function of some given class. Most often it will be an algebraic polynomial, a trigonometric polynomial, a rational function, or a spline.

Interpolation is most often used when the analytical form of the function is unknown $Y(\Theta)$ (it is only in the form of tables) or when its analytical form is too complicated. In the study, on the basis of literature analysis and preliminary research [5], Lagrange interpolation and interpolation using spline functions were used.

The analysis of the above-presented methods for determining the value of genesis of diagnostic parameters and their respective errors of genesis allows to conclude that in order to determine the value of genesis of diagnostic parameters, on the basis of uncertain and incomplete values from the time interval (Θ_1, Θ_b), should be used [1,2,4,5,8,9]:

1. In terms of approximation methods, polynomial point mean square approximation with genesis error r_{ja}:

$$r_{ja} = e_{Gj} = \max_{k=1,K} B = \left| y_{j,a}(\Theta_k) - y_j(\Theta_k) \right| \tag{9}$$

2. In the field of interpolation methods, interpolation with the use of 1st, 2nd and 3rd degree concentric functions for the time interval (Θ_1, Θ_b) about count r_1 with an error of genesis $r_{j,int}$ [6,9]:

$$r_{j,int} = e_{Gj} = \max_{k=1,r2} B = \left| y_{j,int}(\Theta_k) - y_j(\Theta_k) \right| \tag{10}$$

where: $r_1 = \frac{K}{2}$ - number of points to interpolate the values of the time series $y_j(\Theta)$,

$r_2 = \frac{K}{2} - 1$ - number of points for comparing the values of the spline functions with the real value of the diagnostic parameter and for interpolating the values of the time series $y_j(\Theta)$,

K – the size of the time series.

Estimating the value of diagnostic parameters, using the methods of genesis presented above, allows to determine their genesis values $\{y_{j,int}(\Theta)\}$, which then allows for the formulation of the HMMS state genesis algorithm presented below.

5. HMMS state genesis algorithm

1. Genesis of the value of a set of diagnostic parameters $\{y_j^*\}$[6,8,9,10,11]:
   a) using the method of approximation of the diagnostic parameter value y_j^* in the time interval (Θ_1,Θ_b) along with the error radius of the "error channel" approximation r_a with methods (mean square method, trigonometric method),
   b) by interpolating the value of a diagnostic parameter y_j^* in the time interval (Θ_1,Θ_b) along with the error radius of the "error channel" interpolation $r_{j,int}$ with methods (the method of the 1st, 2nd and 3rd degree spline),

c) c) selection of the method according to the minimum or maximum value of the radius of the error of approximation or interpolation (error of fit e_G).

2. Analysis of the condition cause $s_i(T_{LU})$ [6,8,9,10,11]:

a) identification of the collection $\{s_i(\Theta_k),\ i=1,\ldots,1;\ k=1,\ldots,K\}$.

b) determining a common "error channel" point defined by the error radius $r^*_j = \max(r_{ja}, r_{ji})$ and the limit value of the diagnostic parameter y_j^* in the moment $\Theta_S \in (\Theta_1,\Theta_b)$, which means that the cause of a localized condition was the "momentary appearance" of the condition s_i over time (Θ_1,Θ_b);

c) determining the greater number of common points of the "error channel" defined by the error radius $r_j = \max(r_{j,a}, r_{j,int})$ and the limit value of the diagnostic parameter y_j^* in moments $\Theta_s \in (\Theta_1,\Theta_b)$ means that localized si was caused by a "progressive development" of the condition s_i in time period (Θ_1,Θ_b)

d) in caso of the absence of common points, specifying the minimum distance of the "fault channel" from the limit value at an instant $\Theta_S \in (\Theta_1,\Theta_b)$, which means the probable cause of the localized condition s_i was a "momentary incomplete appearance" of this state in time (Θ_1,Θ_b);

e) analysis of a set of states $\{s_i(\Theta_k), k=1,\ldots,K\}$ and located by T_{LU} technical condition s_i to determine the cause of its occurrence in the context of any "common points" or minimum "close-ups" distance received.

The mentioned above presentation of various possibilities of determining the genesis of the HMSM state allows for the following conclusions:

1. All the presented algorithms allow to determine the optimal, due to the adopted criterion, genesis values of diagnostic parameters in the time interval (Θ_1,Θ_b), for further research the following is proposed:

a) the use of methods of approximation of the diagnostic parameter yj * (mean square method), with the error radius of the "error channel" approximation $r_{j,a}$;

b) the use of methods of interpolation of the value of the diagnostic parameter yj * (the method of the 1st and 2nd degree combined functions) with the error radius of the "error channel" interpolation$r_{j,int}$;

c) selection of the method according to the minimum or maximum value of the approximation or interpolation error radius (fit error).

2. Methods of analyzing the cause of the occurrence condition $s_i(T_{LU})$:

d) determining a common "error channel" point defined by the error radius r^*_j= max (r_{ja}, r_{ji}) and the limit value of the diagnostic parameter y_j^* in time $\Theta_S \in (\Theta_1,\Theta_b)$, which means that the cause of the localized si state was the "momentary appearance" of this state over time (Θ_1,Θ_b);

e) determining the larger number of common points in an "error channel" defined by the error radius r^*_j= max (r_{ja}, r_{ji}) and the limit of the diagnostic parameter y_j^* in time periods $\Theta_s \in (\Theta_1,\Theta_b)$ means that localized si was caused by a "progressive development" of the condition s_i in time (Θ_1,Θ_b);

f) in case ot the common points absence, specifying the minimum distance of the "fault channel" from the limit value at an instant $\Theta_S \in (\Theta_1,\Theta_b)$, which means the probable cause of the localized condition s_i there was a "momentary incomplete appearance" of this state in time (Θ_1,Θ_b);

g) the analysis of a set of states $\{s_i (\Theta_k), k=1, \ldots, K\}$ and located by T_{LU} condition state s_i to determine the cause of its occurrence in the context of any "common points" or minimum "close-ups" distance received.

6. Conclusions

Summarizing the issues discussed above concerning the theoretical foundations of determining the HMMS state generation procedures, the following conclusions can be made:

1. All the presented procedures and algorithms allow to determine the optimal values of diagnostic parameters, due to the adopted criterion of genesis, and to estimate the cause of the HMMS condition;
2. At present, there are no useful methods of genesis of the state of machines that can be used in practice, hence the possibility of using:
   a) in the area of genesis of diagnostic parameter values: approximation methods (mean square point polynomial, trigonometric) and interpolation methods (polynomial, 1st, 2nd and 3rd degree spline);
   b) in the area of analysis of the cause of the HMMS state - testing the distance of the error range of genesis of the genesis value of a diagnostic parameter from its border value.
3. Assuming the basic method of genesis involving the use of registered diagnostic parameter values, approximation methods (mean square point polynomial method) and interpolation methods (1st and 2nd degree spline method) were distinguished to generate the value of the diagnostic parameter.

4. Based on the findings presented above, an algorithm of the HMMS technical condition generation methodology was developed, which is the basis for the development of a computer program supporting the generation of the HMMS technical condition.

Acknowledgements.

This paper has been achieved under the research project “Hybrid multimedia mobile scenes are a chance for decisive innovation” No. POIR.04.01.04-00-0045/17-00.

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POSSIBILITIES OF USING A HYBRID PHOTOELECTRIC SYSTEM WITH A STORAGE BATTERY FOR THE NEEDS OF A LOCAL OBJECT

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DOI: 10.31891/monograph/2021-10-82

1. Introduction

Modern approaches to sources of distributed generation involve the using of energy at the place of generation with the implementation of regulatory functions, which will help ensure the balance of power in the energy system [1]. Local object (LO) with hybrid photoelectric system (PES) connected to AC distributed grid (DG) plays an important role in it. These LOs include small businesses, agricultural enterprises, cottages, services, etc. The using of a storage battery allows the redistribution of energy in time, including the possibility of the planned generation of surplus electricity to DG. Such options of the application of hybrid PESs with SB for LO are perspective: meeting the needs of LO without energy generation to DG and with possibility increasing the power consumed by LO higher than limit of energy consumption from DG; meeting the own needs with possibilities the planned energy generation a day ahead to grid in time of peak loads or during daylight hours.

On the electrical market there is a wide offer of hybrid inverters (GI) [2, 3], which contain the entire set of equipment for connecting a photovoltaic battery (PV) and storage battery (SB). There are no energy redistribution functions; generation control implies limiting the generation of electricity to the grid. The setting of the operating modes is carried out manually, despite the presence of the control function via the Internet. The use of multifunctional stand-alone inverters (VSI), which also provides a power factor close to 1 at the common coupling point (PCC) to the DG, is promising for PES [4-8]. When the LO load is unbalanced in phases, it is expedient to use a three-phase bridge VSI circuit using at the input a source with an average output, which is connected to the neutral of the grid [5, 7], or VSI with 4 arms [6]. This allows the phase currents in the PCC to be balanced.

Additional possibilities for improving the energy management of PES with SB are provided by the use of the forecast [8, 11]. There are open web services with the presentation of a direct forecast of the power of the PV generation with a

discreteness of 1 hour [9] and less [10] at the location point of LO. Possibilities of reducing consumption payment using scenarios of the recommended load for planning the LO load based on the forecast of PV generation are considered in [11]. At the same time, the ensuring of LO needs without generation into the grid is considered and the recommended load depends on weather conditions, which is not always acceptable.

At the same time, the issues on the implementation of combining the functions of providing for the own needs of LO with the planned uniform generation of electricity into the DG at specified time intervals have not been sufficiently studied. The implementation of increasing the LO load power at a limit on electricity consumption from the DG, its capabilities in various weather conditions, including winter, requires additional study.

2. The aim of the work

Substantiation of structures of systems and principles of PES management with the set functions using the data of short-time forecast of PV generation.

The following tasks have been set:

- substantiation of the structure of power circuits and control system of PES of LO;

- substantiation of the basic principles of management when using the function of planned generation of electricity into the DG;

- substantiation of the basic principles of control when using PES to increase the power consumption of LOs above the limit from the power system;

- simulation of energy processes in the system to assess the effectiveness of the proposed solutions.

3. Structure of power circuits and control system of PES with SB to meet the needs of LO

The PES structure (Fig.1) contains three-phase multifunctional grid inverter VSI with output filter OF [7], connected to DG and LO loads (common coupling point PCC). SB and PV are connected to VSI input via converters of direct voltage CPV and CSB. The converter unit is controlled by the CU control block. The setting of the parameters and operating modes, taking into account the time and forecast of the PV generation, is carried out by the program control unit PCU. To communicate with the website, the Wi-Fi module WFM is used. Current and

voltage sensors are not shown in Fig. 1. When the PC voltage is disconnected, the contactor K is disconnected and the FES switches to autonomous operation mode.

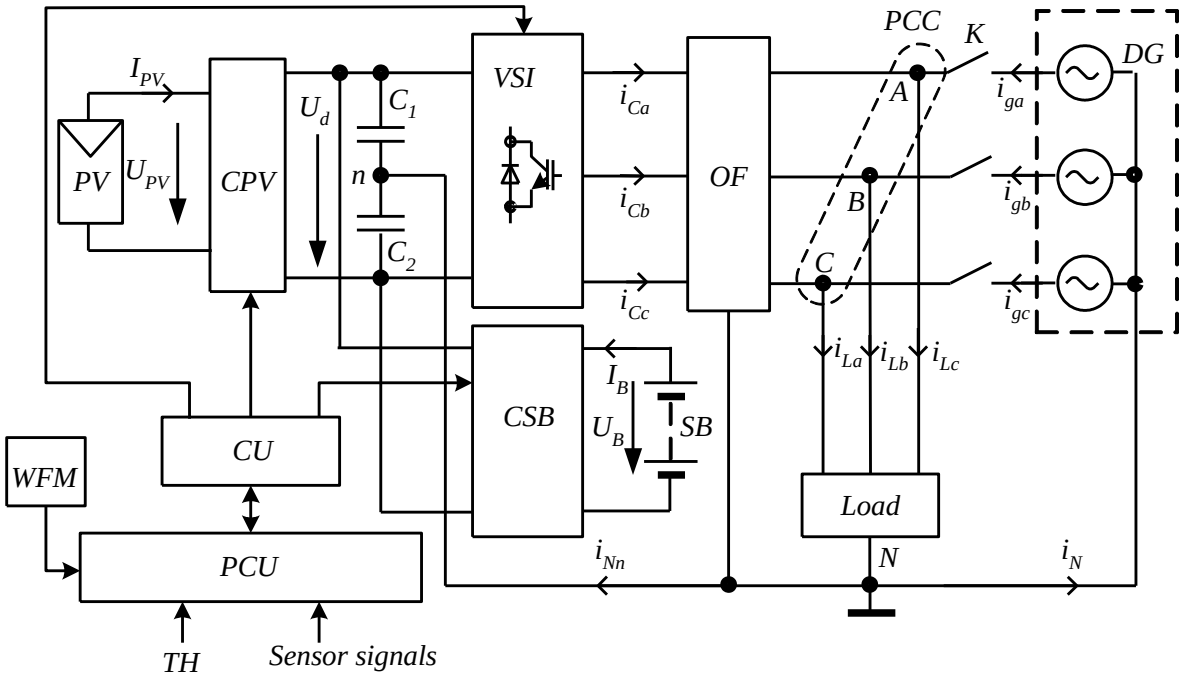


Fig.1. Structure of PES power circuits

PES operation is tied to tariff zones [12] for the season May-August: t_1=7.00 – the end of night tariff; (t_2=8.00, t_3=11.00) – morning peak; t_4=16.00 – the end of intensive solar radiation period; (t_5=20.00, t_6=23.00) – evening peak; t_7=24.00 – the beginning of night tariff zone; (t_1, t_2), (t_3, t_5), (t_6, t_7) – zone of daytime (half-peak) tariff. For April, March, September, October: t_1=6.00, t_2=8.00, t_3=10.00, t_4=15.30, t_5=18.00, t_6=22.00, t_7=23.00. For November-February: t_1=6.00, t_2=8.00, t_3=10.00, t_4=14.30, t_5=17.00, t_6=21.00, t_7=23.00. This schedule of peak loads is generally typical for household consumers and small non-residential objects with a daily work schedule. Setting the validity time of tariff zones is entered in the PCU (TH).

The structure of the control system with an expanded CU scheme is shown in Fig. 2. The control system is made according to the principles described in [8], it has the changing structure depends on operation mode with the regulation of the PCC current, PV current and SB current. The synchronization of VSI with the DG is carried out by the phase-locked loop (PLL). Switching to stand-alone mode is performed by the unit of mode setting (RMU). The PV current control channel includes the CPV control system (CSCPV) with a relay current regulator.

The PV current is set by the maximum power controller MPPT or set by the VC_{PV} regulator using the S2 switch. This allows reducing the power P_{PV} if necessary. The converter CSB is bi-directional and controls by SB current I_B in charge and discharge mode. The I_B reference for the CSCSB control system is set by the regulator VC_{IB} or PCU via switch S3 depending on the operating mode. The VSI current control channel contains a current control loop CCL with current reference unit RCU. The setting of the current amplitude I^1_{gm}, when operating in parallel with DG, is carried out by VCIg regulator or PCU using S4 switch. When operating in stand-alone mode, VSI current is set by the VCAM regulator using S1

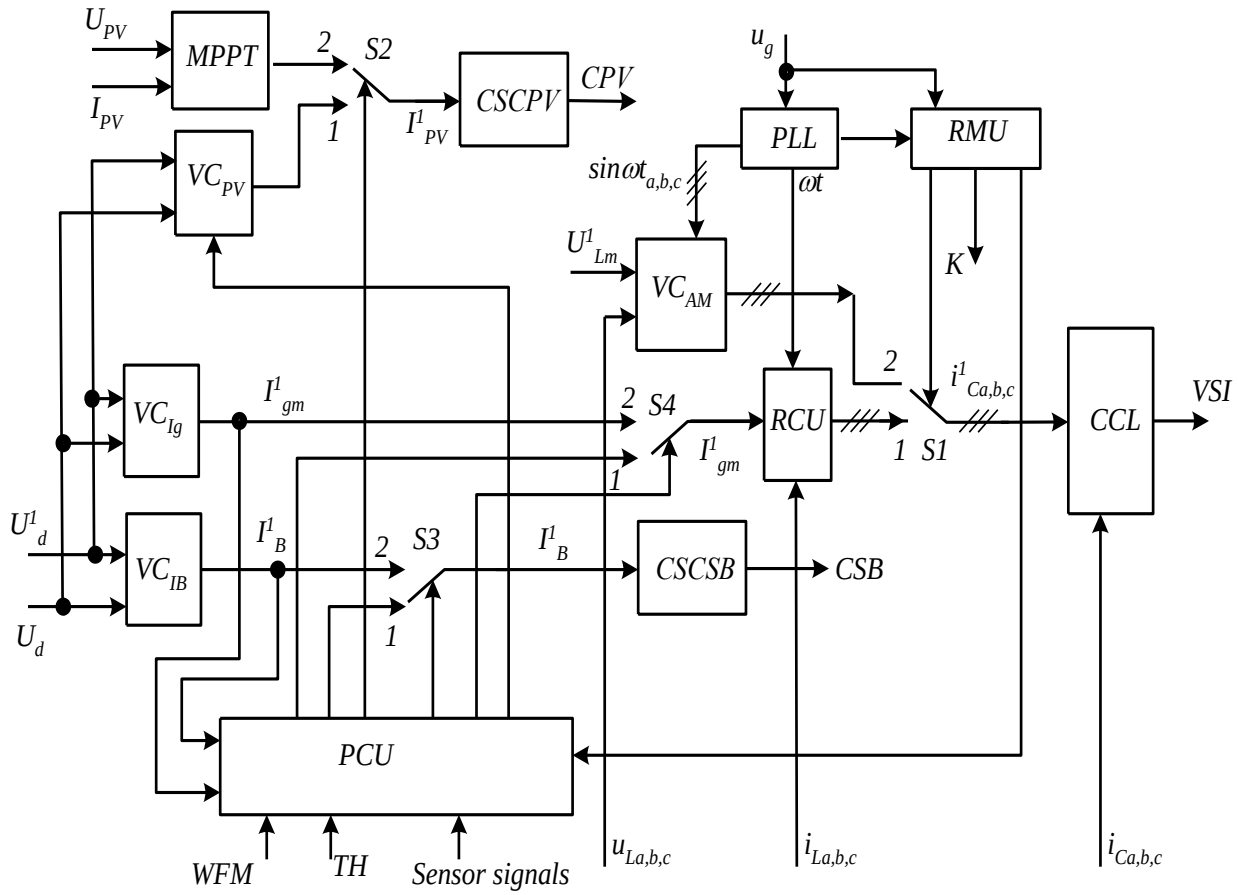


Fig.2. Structure of control system

switch. Regulators VC_{PV}, VCIg, VC_{IB} are proportional-integral and provide voltage stabilization U_d at the VSI input.

The setting of parameters and operation modes is carried out by PCU depends on function to be implemented. In this case, the control of the PES is reduced to the formation of a graph of the degree of charge (discharge) of the SB with a decrease (exclusion) of electricity consumption from DG. The depth of the

discharge degree (DOD) to the end of the morning peak is up to 40% (Q^*_3=100Q/Q_{HOM}≥60%), to the end of the evening peak – in winter Q^*_6≥20%, in summer Q^*_6≥40%.

Planning is carried out at the end of the day based on the forecast of the generation power $P_{PV}(t)$ for the next day. At the same time, the total energy generation W_{PV}, generation in the morning hours W_{PV12}, W_{PV23} are estimated, on the basis of which the initial value of Q^*_2 (at 8.00) is set and the SB charge current is regulated. With the planned generation of electricity into DG, the values of the generation power P_g also are set, according to which the corresponding values of the currents are formed. Starting from 8.00 the formation of the recommended P_L values is carried out according to the current forecast data (with forecast discreteness), taking into account the actual value Q^*. The power generated by VSI is set in the case of the function implementation of P_L increasing.

4. Simulation results

Experimental research in different seasons of the year requires a lot of time and financial expenditures. Therefore, the simulation modeling of energy processes in daily cycle by archive data with using Matlab software package is selected as instrument for the efficiency assessing. Transient processes and higher harmonics in the process of energy conversion were not taken into account.

The structure of model contains: generation block (rated PV power 1 kW) sets $P_{PV}(t)$ in tabular form; SB model; load $P_L(t)$ (in tabular form); calculation and control block; estimation block. SB model is made in accordance with the data-sheet characteristics [13].

The state of SB charge was estimated directly by the current. "Saturation dynamic" realizes the I_B values in accordance with the charging characteristics at the input of which the set value I^1_B is applied. The upper limit is determined by the $I_B(Q^*)$ function, the lower limit – by the maximum value at discharge. $I_B(Q^*)$ and $U_B(Q^*)$ are specified in tabular form.

Simplified methodology [11, 15] with direct determination payment costs was used in the block of estimation of the reduction payments for electricity consumed from the grid. Payment reduction factor $k_E=C_1/C_2$ (C_1 is the total cost of electricity W_L consumed by the LO load at one tariff rate, C_2 is the cost of electricity consumed from the DG W_g for one tariff rate, two (T_d/T_n=1/0.5, T_d is the

day tariff, T_n – night tariff) and three ($T_P/T_d/T_n$=1.5/1/0.4, T_P – peak tariff) tariff rates.

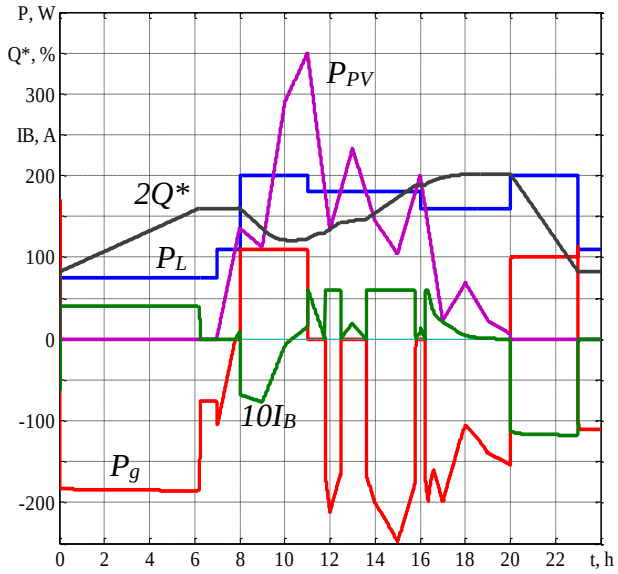


Fig.3. Oscillograms of PES operation for 30.07.15 at W_{PV}=1951Wh. k_{E1}=1.86, k_{E21}=2.74, k_{E31}=4.16

Consider energy generation to grid for different weather conditions. Oscillograms of load power $P_L(t)$, PV power $P_{PV}(t)$, power consumed from DG $P_g(t)$, degree of SB charge Q^*, SB current I_B for 30.07.15 at W_{PV}=1951 Wh [14] are presented in Fig. 3. To match the scales along the vertical axis, it is accepted $2Q^*$, $10I_B$. Generation increases with W_{PV} increasing (Fig. 4, 5).

Consider the increasing the power of LO higher then established limit for consumption from the grid (P_{LIM}=250 W). Oscillograms for winter and summer days are shown in Fig. 6 and Fig. 7 (P_C is the generation power of the inverter).

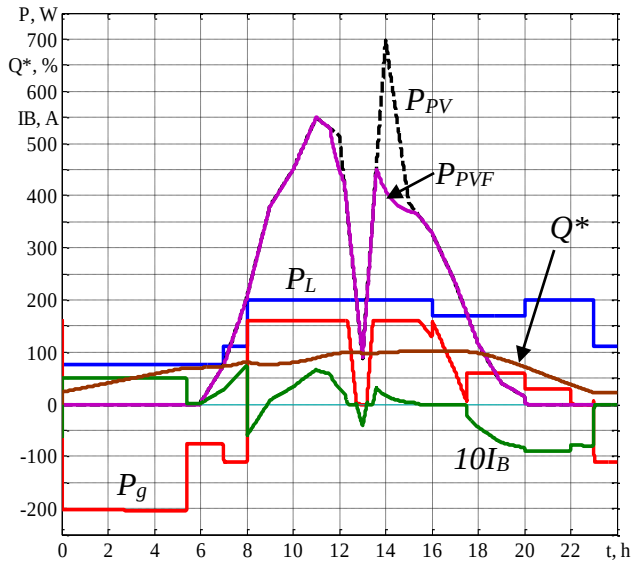


Fig.4. Oscillograms of PES for 22.07.15 at W_{PV}=4.756 kW

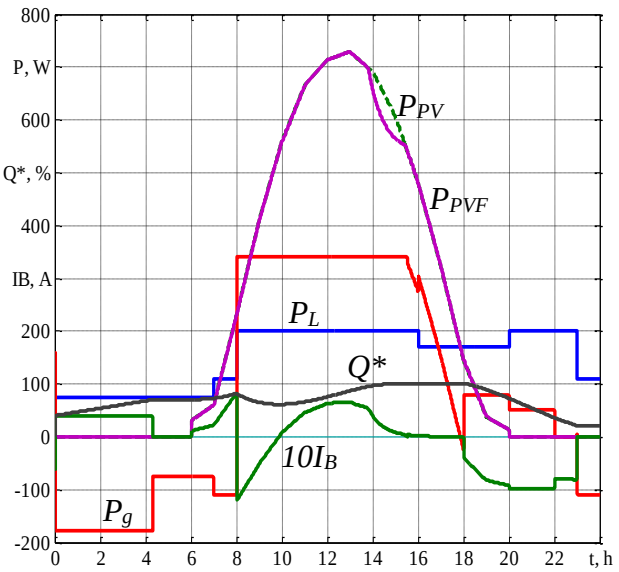


Fig.5. Oscillograms of PES in clear day at W_{PV}=6 kW

A detailed model has been developed to study the transient processes during switching in the PES control system. A model of a single-phase multifunctional inverter was used.

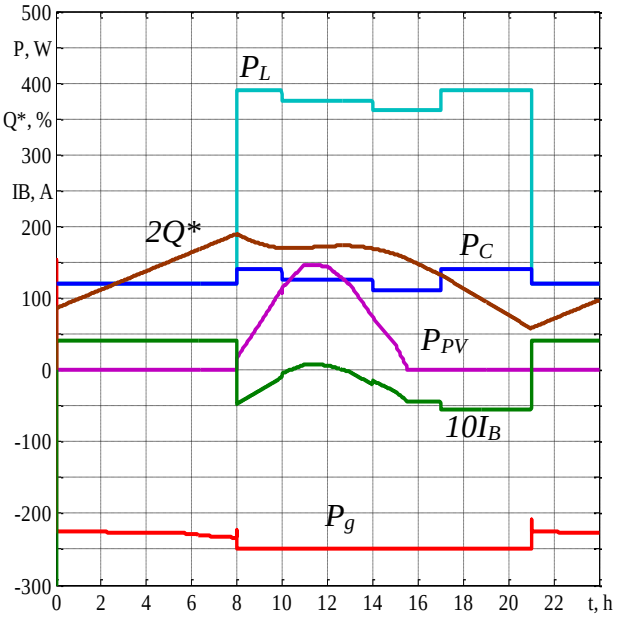


Fig.6. Ocsillograms of PES operation for 02.12.20 at W_{PV}=750 Wh

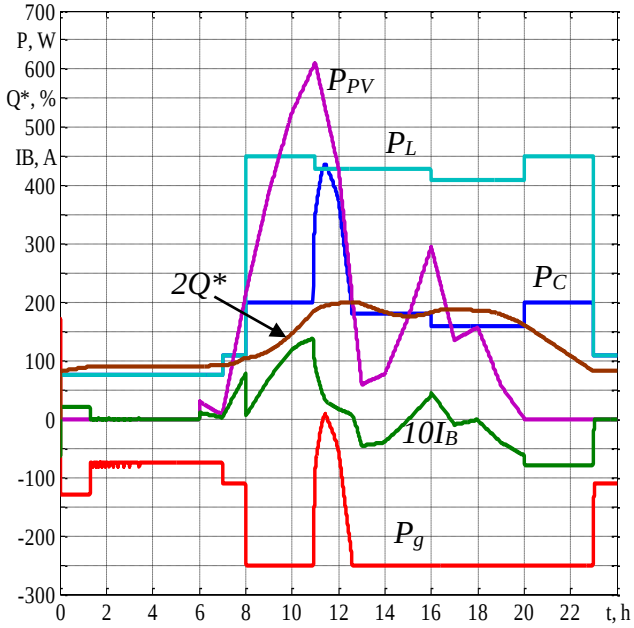


Fig.7. Ocsillograms of PES operation for 01.07.15 at W_{PV}=3367 Wh

PV and SB models are simplified in the form of constant voltage sources connected to VSI input (U_d=405 V) through impulse voltage converters with relay input current regulators. SB converter is bi-directional. Regulation of P_{PV} is carried out by changing the output current. The SB model also contains an adjustable limitation set by the charging characteristic $I_B(Q^*)$. At the same time, up to the boundary value of the degree of charge $I_B \leq I_{BMAX}$ (limited only by the maximum value), upon reaching Q^*=92% the SB current is limited by $I_B(Q^*)$. The load is active-inductive with cosφ=0.9. To calculate the power, standard procedures were used: calculation of the instantaneous power value by current and voltage, averaging (mean block) with a fundamental frequency of 50 Hz.

Oscillograms of PES operation at load changing and constant PV generation are shown in Fig. 8. With increasing the LO load, the value of the power consumed from the grid increases until the limitation of consumption from the grid $P_g \leq$5.5 kW is reached. In this case, at P_L=10 kW P_C value increases to compensate the increasing of consumption from the grid.

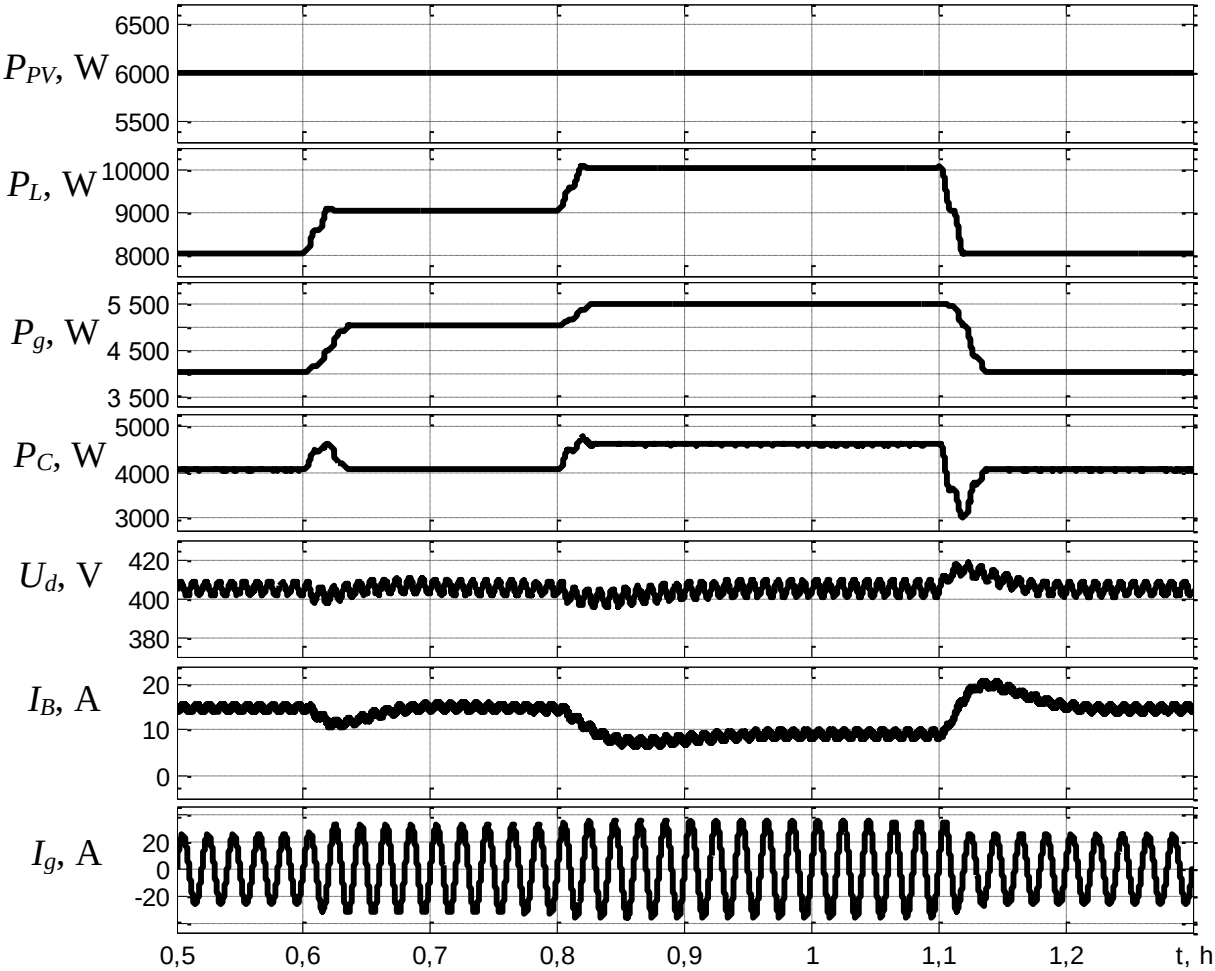


Fig.8. Oscillograms of PES operation at load changing and invariable PV generation

5. Conclusion

The use of a multifunctional grid inverter with the maintenance of the power factor in the PCC close to 1 is preferred in the PES structure. This helps to reduce energy losses in the DG and ensures the equalization of consumption in phases. The structure of the control system of the PES converter unit contains three channels with regulation of the current consumption from the grid, SB current and PV current. The changing of the structure is carried out according to the fulfillment of three (two) conditions: voltage deviation at the input of the inverter, saturation of the regulators.

When implementing the function of the planned generation of electricity into the grid, three modes are used: with guaranteed generation only during the evening peak load and ensuring the minimum consumption from the grid during the hours of the daytime tariff; with uniform generation during peak hours; with generation

during daylight hours. In this case, the calculation of the generation capacity is carried out in accordance with the forecast data with a constant load schedule throughout the year.

When implementing the daily increase in the load power of LO over the limit for consumption from the grid, the graph of the power generated by the grid inverter is used as a baseline. It is calculated in accordance with PV generation forecast data.

The possibility of implementing the proposed solutions under various weather conditions is confirmed by the results of energy processes simulation in the daily cycle of operation using archived data. The efficiency of solutions for the implementation of the control system is confirmed by modeling of electromagnetic processes using the detailed model "grid – converter unit – PV – SB – LO load".

The direction of further research is the refinement of the methods for calculating PES parameters and the hardware implementation on an experimental setup with an electronic PV emulator [15].

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NEW TECHNOLOGIES SYNTHESIS OF SPECIAL CAST IRONS FOR HIGH TEMPERATURES

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DOI: 10.31891/monograph/2021-10-83

1. Introduction

That is why the synthesis of materials on the basis of metalthermic processes as well as the investigation of the influence of new technological methods of getting metal on microstructure, chemical composition, mechanical properties of manufactured castings got great practical importance. Metalthermic reactions further and further become of great appliance in science and technology. Under the lack of energetic and raw basis, of special melting and cast equipment such technological processes of creating the materials become economically expedient, and their usage in already existed methods of casting production e. g. in technique of producing steel and cast iron castings with termite addition greatly rises the efficiency of production. Creating of the alloys on the basis of combined (metalthermic+SHS) processes allows getting materials with new technological properties the study of which has both scientific and practical importance.

2. The methods of experiment

While organizing the process of synthesis of steels and cast irons classic [1] termite reactions based on oxidation of aluminum and renovation of iron are used:

$$Fe_3O_4+Al \rightarrow Fe+Al_2O_3.$$

The task was to work up the method of calculating of burden composition on the basis of stechiometric relationship of reaction components with the introduction of suitable coefficients taking into account the component activity and the coefficients of its adoption by metal. The method allows to establish the composition of metalthermic burdens and to calculate adiabatic temperature of its combustion. The main condition of the process is the necessity to have real temperature of burden combustion higher then the temperature of slag melting [2,3] (for Al_2O_3 2400 K). The main structure components in termite cast irons that influence greatly the wear resistance are the carbides. First of all these are cementite and more wear resistanceable carbides Cr, W, Mo, Ti and others.

If we assume that synthesized termite cast irons of carbide class have one-type phase composition, then to determine its ware resistance will be possible using the scheme: the more is their hardness, the more is the wear resistance. But while investigating the components of the structure and their influence on wear resistance it is necessary to use the principle of Sharpi-Bochvar, and, talking into account the necessity to shape the construction part the technological form (we mustn't forget that the rise of hardness leads simultaneously also to the deterioration of machining by cutting). Metal base of the alloy must contain a hard component and must prevent brittle break. Wear resistance of synthesized cast irons under abrasive wear resistance depends on microhardness, form, replacement and quantity of structural components.

3. The directions of studies

Synthesized termite wear resistant cast irons in analogy with the cast irons dot by ordinary methods, can be divided into the following groups: grey, white, including non-alloyed, low-alloyed, nickel-chromium-plated; martensite and high chromium-plated.

Grey special thermite cast irons. It is the most convenient to get grey cast irons by metaltermic or combined (metalloterming+SHS) methods because of the high temperature within the zone of reacting of the components that leads under synthesis of alloys in conditions of micromelting to fast cooling and that in its turn gives the speeds of cooling higher than the critical ones and simultaneously martensite or needle-shape microstructure. These are the structures that are of the highest wear resistance. Grey termite cast iron is being manufactured very well by cutting, much better than chilled and white cast irons. The burden composition for synthesis, chemical composition and components of the burden for getting wear resistant termite cast iron and its mechanical properties are shown in table 1 and 2. Within cast irons 1, 2 martensite is formed just during metalthermic melting without certain temomanufacturing which is furthermore connected with replacement of critical point regarding alloying of Ni.

Cast irons 4, 5 (table 2) contain great amount of austenite but after tempering we get the structure of martensite of tempering with hardness being 280-310 HB. Cast iron 3 is being got with substantial chilled layer of material. Martensite in grey cast iron is being got without additional termomanufacturing (tempering) and this effect decreases with the increasing of mass of the burden for

melting [4]. In fact, it gives the possibility for termite micromelting to decrease greatly the content of alloyed elements (Mn and Mo) not making tempering cracks while doing this.

Table 1. Chemical composition of the burden for synthesis of grey termite cast iron

№	Electrode powder, per cent	Ferrosilicium (ФС 75)	Ferro-manganese (ФМн 75)	Ni powder	Ferrochrome	Ferroalu-minium termite
1	4,0–4,2	1,6–2,0	1,3–1,6	4,2–4,8	0,4–1,1 FeCr	The rest
2	4,0–4,2	3,3–3,8	1,0–1,5	4,0–4,5	0,7–1,4 FeCr	The rest
3	4,0–4,2	1,6–2,0	3,8–4,3	4,8–5,3	0,9–1,6 FeCr	The rest
4	4,0–4,2	1,6–6,0	4,0–4,3	5,5–6,1	–	The rest
5	4,0–4,2	2,0–2,7	4,3–5,1	5,5–6,0	0,7–1,4 FeMo	The rest

Table 2. Chemical composition and hardness of martensite grey cast iron

№	Element content, per cent							HB	
	C	Si	Mn	S	P	Ni	Cr and Mo	In alloyed state	After tempering[1]
1	3,0–3,2	1,2–1,5	1,0–1,2	<0,05	<0,1	4,2–4,8	0,3–0,8 Cr	390–430	–
2	3,0–3,3	2,5–2,8	0,7–1,1	<0,05	<0,1	4,0–4,5	0,5–1,0 Cr	370–440	–
3	3,0–3,2	1,2–1,5	2,7–3,2	<0,1	<0,1	4,8–5,3	0,7–1,2 Cr	270	390–400
4	3,0–3,2	1,2–1,5	3,0–3,2	<0,1	<0,1	5,5–6,1	–	280–292	–
5	3,0–3,3	1,5–2,0	3,2–3,8	<0,05	<0,1	5,5–6,0	0,5–1,0 Mo	290–310	–

[1]Tempering was being done under 550ºC during 12 hours.

Wear resistance of manufactured cast irons may be compared using table 3. Cast iron manufactured by termite method may to some extend be classified as a grey iron not lower than “СЧ 30”, and after tempering in cast irons 4 and 5, the limit of tension strength has been established at the level not less then 500 MPa.

Table 3 data witness the increasing of conditional resistance for martensite termite cast irons and rather great increasing for termically manufactured cast iron. Under the synthesis of white termite cast iron the necessity to get high temperature

in the zone of reacting of burden components is considered, that is why Cr and Mn are introduced not in the shape of ferroalloys but like oxides Cr_2O_3, CrO_2, MnO, MnO_2.

Table 3. Wear resistance of special cast irons

№	Termite material	Conditional value of resistance
1	Carbon steel (analogue of steel “У8”)	100
2	Termically manufactured termite alloyed cast iron	85
3	Martensite termite cast iron	50
4	Alloyed Mn and Mo martensite cast iron	40

Pearlite matrix of such cast iron contains carbides Cr and Fe. Under considerable gradient of temperatures under termite conditions micromelting white cast iron is produced in large measure simply, simultaneously it is the cheapest among the cast irons mentioned above, but its wear resistance is less then that of the alloyed one. Introducing additionally into the burden even a small quantity of chromium in powder state or in the state of low carbon ferrochromium using breakage of graphite electrodes increase greatly wear resistance of mentioned cast iron. Using roentgenostructural analysis method in the structures of these cast irons carbides Fe_3C and $(Fe,Cr)_3C$ as well as carbides $(Fe,Cr)C_3$ and others were detected, that provides the hardness of ~ 15000 MPa. Microhardness of carbides $(FeCr)_3C$ – HV 10000–10500 MPa, $(FeCr)_7C_3$ and $(Fe,Cr)_{23}C_6$ 14500–17500 MPa. Chemical composition of burden and composition of ingots, the properties of some marks of termite cast irons are shown in tables 4, 5 and 6.

Table 4. Chemical composition of burden for synthesis of grey termite cast iron

Mark	Electrode powder, per cent	Ferro-silicium (ФС 75)	Ferro-magnese (ФМн 75)	Powder Ni, B, Cu	Ferrochro-mium (ФХ 100А); Ferrotitanium (ФТи 055А)	Ferroalu-minium termite
“ОИ-1”	2,6–3,1	1,6–2,4	0,2	0,1–0,4	–	The rest
“ОИ-3”	2,6–3,1	1,3–2,0	0,7–1,3	0,1–0,4	2,0–2,6 FeTi	The rest
“ИЧХ4Г7Д”	2,6–3,1	2,0–2,6	8,0–10,0	>0,8Ni, Cu	10,0–12,9 FeCr	The rest

Table 5. Chemical composition and the properties of medium alloyed termite cast irons

Mark	Element content, per cent										Mechanical properties		
	C	Si	Mn	S	P	Cr	Ni	B	Ti	Cu	$\sigma_в$, MPa	σ_u, MPa	Hard-ness
“ОИ-1”	2,5–3,0	1,2–1,8	>0,1	0,1	0,1	–	–	0,1–0,4	–	–	230	550–710	47–52 HRC
“ОИ-3”	2,5–3,0	1,0–1,5	0,5–1,0	0,1	0,1	–	–	0,1–0,4	0,7–0,9	–	210–250	580–700	47–52 HRC
“ИЧХ4Г7Д”	3,0–3,5	1,5–2,0	6,0–7,5	0,05	0,1	3,5–4,5	>0,5	–	–	>0,7	175	370	500–550 HB
“ИЧХ3ТД”	2,5–3,0	1,0–1,5	0,5–1,0	0,05	0,1	2,0–3,0	–	–	0,5–0,9	0,5–0,9	250	510	500–570 HB

Table 6. Mechanical properties of termite highly-alloyed cast irons

Mark[1]	HRC	σ_u, MPa
“И4Х12М”[1]	65–67	670
“ИЧХ12Г5”[1]	64–66	680
“ИЧХ28Н2”	53–57	620
“ИЧХ2Н4” (nickhard)	60–62	660

[1]After proper thermal treatment.

It is necessary to mention that mechanical properties of termite cast iron are better than the properties of highly-chromium cast iron because of additional microalloying by aluminium, which must be introduced into the burden composition.

Within cast irons with a considerable content of manganese disregarding high temperatures of synthesis one can see the aggravation of fluidity under the keeping of shrinkage within the range of 1,6–2,2 per cent. One must bear in mind that the treatment of cast irons with high content of chromium is complicated though it is on satisfactory level.

Cast irons “ИЧХ15М3”, “ИЧХ12М” and “ИЧХ12Г3М” are annealed (for getting the structure of grain perlite) with further hardening. Cast irons “ИЧХ28Н2М2” and “ИЧХ12Г5” with the structure of alloyed austenite are

hardened in an open air and “ИЧХ28Н2” are treated under the medium-temperature tempering. High speed of cooling under getting of not big castings or the castings with wall thickness to 25-30 mm allow to get at once austenite-martensite structure. In other cases the loading into furnace after hardening of casting at temperature 950ºС, endurance 2–3 hours and cooling together with furnace or hardening in an open air is used. Machining and wear resistance of some marks of investigated white termite cast irons are given in tables 7. The probability of graphitization of castings from nickhard under synthesis of alloy by aluminotermic way decreases considerably because of considerable gradient of temperatures and high speed of heat abstraction, i.e. getting of martensite structure under casting goes considerably simpler.

Table 7. Termite alloyed cast iron workability

№	Mark	HRC	Velocity of cutting[3], m/min
1	“ИЧХ28Н2”[1]	57–59	9,2
2	“ИЧХ12М”[2]	38–40	24,8
3	“ИЧХ2Н4”[1]	58–62	10,1
1	“ИЧХ28Н2”[1]	57–59	9,2

[1]Tempering at 350 ºС, 3 hours.

[2]Unnealing.

[3]Cutting velocity at 90 minute resistance of cutting tool at S=0,3 mm/rev; t=2mm.

Hardness of these cast irons is in the limits of 9300–12000 MPa (per HV).

4. Conclusion.

Thus we may make a conclusion that aluminothermic ways can be used for producing of special termite alloyed cast irons expect for high-chromium cast irons during the synthesis of those the problems of technological character appear. Other types of special cast irons have in some cases even better properties than in cast irons produced by ordinary methods.

Designed compositions of termite mixtures are also suitable for technology of termite casting additives of high-temperature gradient [6]. The work that has been carried out allows making a conclusion that for their mechanical properties synthesized specialized cast irons don't yield to “common” and the methods themselves are available for synthesis in principle of any black alloy.

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MECHANISMS WITH VARIABLE LENGTH OF LINKS FOR DRIVE GUIDE NEEDLES OF KNITTING MACHINES

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DOI: 10.31891/monograph/2021-10-84

1. Introduction

Multi-link hinged-beam mechanisms of the second and higher classes according to the Assura classification are widely used in high-speed knitting machines for the drive of looping organs. Such mechanisms ensure, in a certain approximation, the reproduction by the working organs of complex laws of motion, including stops, during the looping cycle. At the same time, in order to increase the accuracy of reproduction of complex laws of motion of working organs, eight, ten and twelve-link structures of mechanisms, as well as mechanisms with several degrees of freedom are widely used. The minimum number of links in the mechanism, which can be implemented stopping the working organ of the desired duration, should be greater than six [1].

The possibilities of hinged-beam mechanisms with "rigid" links, which are formed by stable scheme, are in a sense exhausted [2]. Therefore, the urgent task is to create mechanisms of variable structure with variable metric parameters and the shape of the links. This allows to reduce the number of moving links in the mechanism while maintaining the technological process and open new perspectives for the creation of new technological processes [2]. In these mechanisms, the kinematic scheme changes independently in the required way during the loop formation cycle due to the change in the length of the links, the shape of the links, the type of kinematic pairs, and the degree of mobility of the mechanism.

2. Research results

The expediency of using four-link mechanisms of variable structure to drive the working organs of technological machines in the industry is proven by examples of the use of similar mechanisms with elastic links in sewing machines and knitting machines [1, 3, 4, 5, 6, 7, 8, 9].

An 8-link mechanism of oscillating motion of auricular needles with rotating kinematic pairs was used as a basic mechanism for research [1]. In this mechanism a comb with auricular needles performs reciprocating oscillating motion according

to the law “forward oscillation - displacement before needle hooks - backward oscillation - displacement behind the backs of needles. The offset behind the backs of the needles in the warp knitting (WK) machine occurs when stopping the combs with eye needles, the duration of which ($\varphi_{pr} = \psi 1$) which depends on the WK machine and is approximately ⅓ loop looping (≈ 120 ° angle of rotation of the leading link) (Fig. 1).

The authors of several structures of mechanisms of variable structure are offered as the driving mechanism of working organs of looping of basic knitting machines.

One of such mechanisms is a four-link mechanism with a variable type of kinematic pair, in which the structure changes at certain phase angles of the leading link, ie when laying the warp threads the mechanism is crank-and-rocker, and when performing other stages of the looping process - slider-crank mechanism.

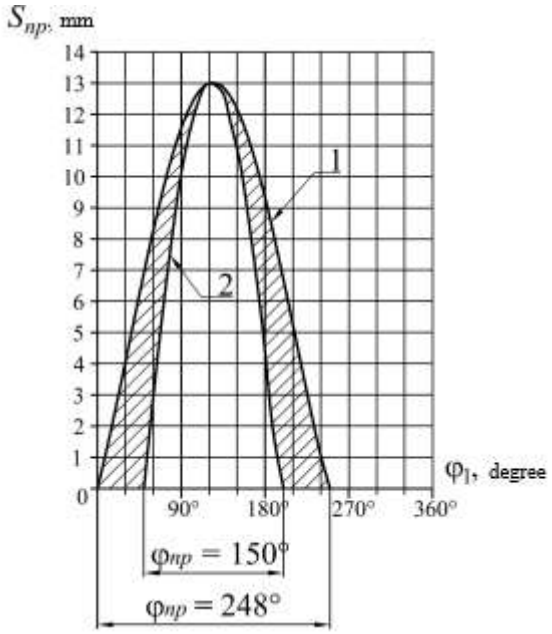


Fig. 1. Combined graphs of movements of the guide needle: the basic WK-machine (curve 1) and according to the typical cyclogram of the WK-machine (curve 2)

At the phase angles of oscillation of the guide needles the rocker arm has a constant length, and at the phase angle of the stop - its movement is limited by a fixed stop. Due to the change in the length and shape of the rocker arm of the mechanism, it is possible to turn when stopping the auricle needles in accordance with the law of motion in Fig. 1.

The block diagram in Fig. 2 contains a leading link fixed on the main shaft 1

- an eccentric 2, a con-rod 3 and a link 4, which at certain phase angles of the main shaft moves as a slider or as a rocker arm. The link 4 sliding part 5 forms a translational kinematic pair with a fixed guide 6, which is made with a cylindrical head. Link 4 guide part 10 and roller 9 can be connected to the shaft of the guide combs 7. On the shaft 7 is fixed to the holder 8 of the guide combs 9. When the mechanism at certain phase angles of the drive link 1, the link 4 interacts with the stop 12. In Fig. 2 does not show the mechanism of displacement of the guide combs.

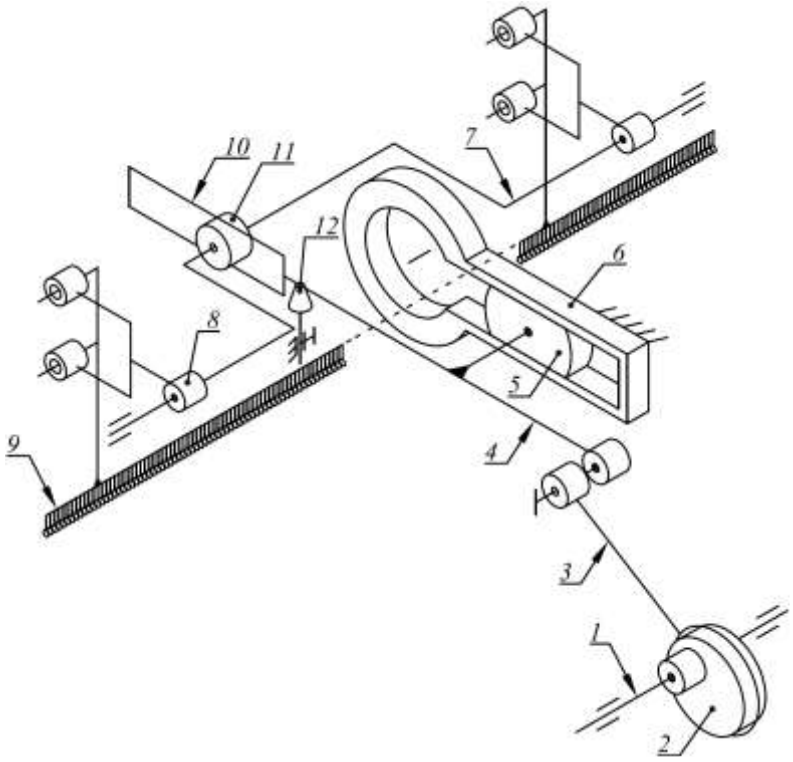


Fig. 2. Block diagram of the mechanism of oscillating movement of the guide needles of the warp knitting machine with a changing kinematic pair

When operating the mechanism from the initial (zero) position, which is taken as the beginning of the oscillation of the guide combs forward, the link 4 sliding part 5 forms a rotating kinematic pair with a cylindrical head of a fixed guide 6. The mechanism works as a crank. The oscillating movement back and forth is transmitted to the shaft 7 with guide combs 9. In this case, the laying of the warp threads on the hook needles.

During the interaction of the stop 12 with the link 4, the latter stops its oscillating motion. With further movement of the leading link there is a change in the kinematic scheme due to a change in the type of kinematic pair: the sliding part

5 of the link 4 moves along a fixed guide 6 and the mechanism becomes a slider-crank. During the stop of the oscillating movement of the link 4 and together with it the guide combs 9, the shear mechanism shifts the guide combs along the front part of the WK-machine.

The next of the mechanisms of variable structure, which is proposed for use in WK-machines, is a four-link mechanism with an elastic con-rod, which at the phase angles of oscillation of the guide comb works as a crank-and-rocker mechanism, and at the phase angles of the stop - as a oscillaiting crank gear (Fig. 3) .

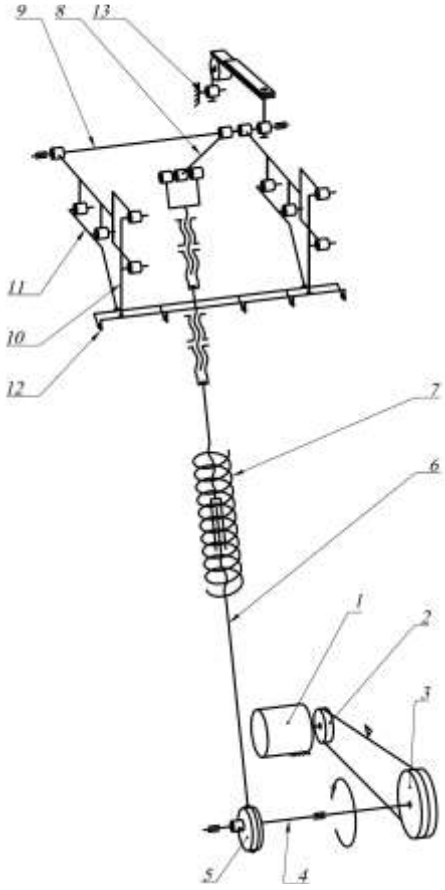


Fig. 3. Block diagram of the mechanism of oscillating movement of the guide needles with an elastic con-rod of the warp knitting machine

Synthesized for the mechanism of oscillating motion of the guide needles of the WK-machine block diagram (Fig.3) contains a fixed on the main shaft 1 drive link - eccentric 5, rocker arm8 and link 6, which at certain phase angles of the main shaft moves as a connecting rod or splits into two links, one of which moves as slider, the other – as alink. Link 6 consists of two parts, which are connected by an elastic element 7. The rocker arm 8 is attached to the shaft of the combs 9, on

which the holder is fixed by the combs 10 and 11. During operation of the mechanism at certain phase angles of the leading link 1 is the interaction of the rocker arm 8 with the stop 12.

During the operation of the mechanism from the initial position of the link 6 works as a con-rod and transmits the movement of the rocker arm 8. The mechanism works as a crank-and-rocker; the oscillating movement back and forth is transmitted to the shaft 9 with guide combs10 and 11. This is laying the warp threads on the hook needles.

During the interaction of the stop13 with the rocker arm 8, the latter stops its oscillating motion. With further movement of the leading link there is a change in the kinematic scheme of the mechanism - one part of the link 6 turns into a con-rod, the other - into a rocker arm, so that with further rotation of the leading link 5 the mechanism does not lose the ability to rotate. During the stopping of the oscillating movement of the rocker arm 8 and together with it the guide combs 10 and 11, the shear mechanism shifts the guide combs along the front part of the WK-machine.

The next of the mechanisms of variable structure, which is proposed for use in WK-machines, is a four-link with variable length rocker arm and riser, in which the structure remains unchanged at certain phase angles of the leading link, ie the mechanism remains crank-and-rocker, and the kinematic scheme of the mechanism changes.

The structural scheme synthesized for the mechanism of oscillating movement of the guide needles of the WK-machine (Fig. 4) contains the leading link fixed on the main shaft 1 - the eccentric 2, the con-rod 3 and the rocker arm consisting of two parts 4 and 5. The two parts of the rocker arm 4 and 5 form a rotating kinematic pair and are pressed against each other by stops 7 and 8 by means of a torsion spring 6 which connects the two parts of the rocker arm 4 and 5. The second part of the rocker arm 5 is fixed on the shaft 9 of guide combs. On the shaft 9 is fixed to the holder of the guide combs 12, which forms a translational cylindrical kinematic pair 13 with guide combs 14. When operating the mechanism at certain phase angles of the drive link 1, the second part of the rocker arm 5 interacts with the stop 11.

When the mechanism works from the initial position, the two parts of the rocker arm 4 and 5 are pressed against each other and work as one rigid link - the

rocker arm. In this case, the oscillating motion at an angle ψ_1 back and forth is transmitted to the shaft of the guide combs 9 and the guide combs 14.

During the interaction of the stop 10 of the second part of the rocker arm 5 with the fixed stop 11, the second part of the rocker arm 5 stops its movement. At the further movement of a leading link there is a change of the kinematic scheme, namely, lengths of a riser and a rocker arm change. The role of the riser is now performed by the stopped second part of the rocker arm 5, and the role of the rocker arm is performed by the first part of the rocker arm 4, which oscillates at an angle ψ_2. During the stopping of the second part of the rocker arm 5 and together with it the guide combs, the shear mechanism shifts the guide combs along the front part of the WK-machine. Then, under the action of the torsion spring 6, the two parts of the rocker arm are connected and work as one rigid link, and the movement is again transmitted to the guide combs 14.

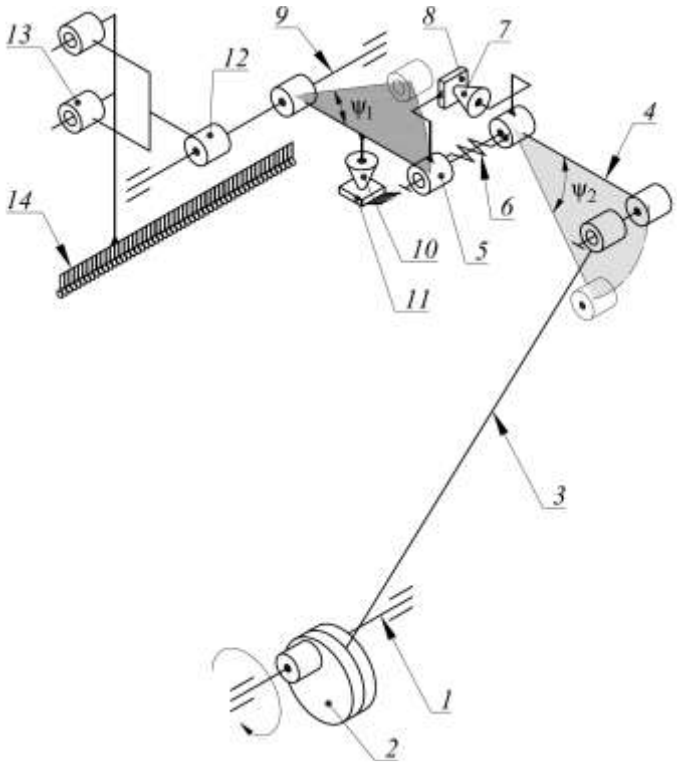


Fig. 4. Block diagram of the mechanism of oscillating movement of guide needles with variable length of the rocker arm of the warp knitting machine

The next of the mechanisms of variable structure, which is proposed for use in WK-machines - a four-link mechanism with a folded connecting rod "breakable" (Fig. 5).

During operation of the mechanism during the oscillation of the guide combs 15, the two parts of the folded con-rod 3 and 8 are pressed together by an elastic element 5 and work as one rigid link - the con-rod. When stopping the guide combs, when the rocker arm 9 interacts with the stop 11 and turns into a riser, part 3 of the folded con-rod works as a con-rod, and its other part 8 - as a rocker arm.

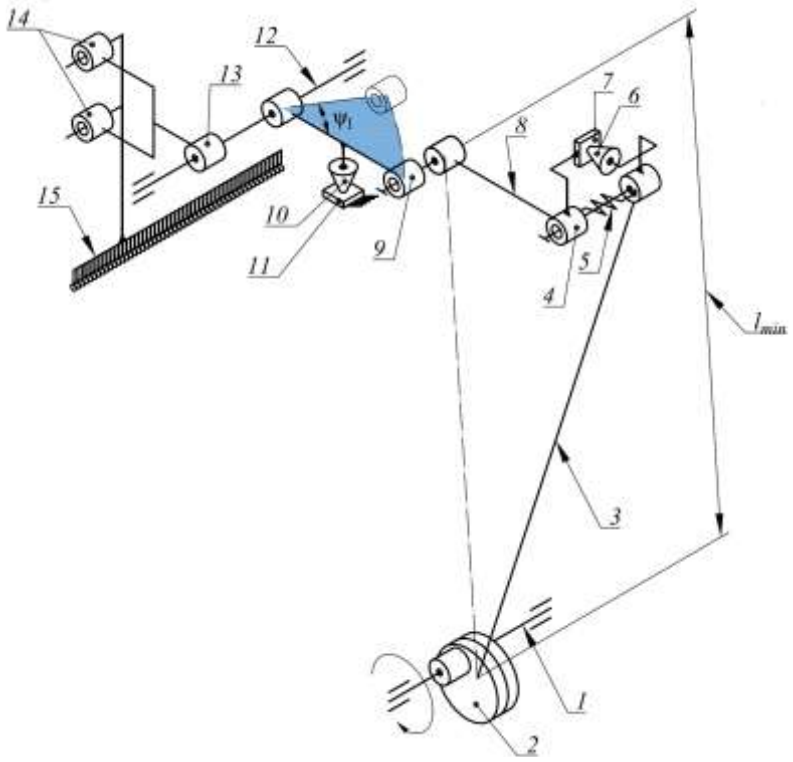


Fig.5. Block diagram of the mechanism of oscillating motion of the guide needles with a variable length of the con-rod of the WK-machine

To determine the geometric parameters of the structural scheme of the above mechanisms of variable structure, which satisfy the necessary kinematic, dynamic and structural features of the mechanism, it is necessary to perform a metric synthesis. The kinematic conditions are the given maximum value of the angle of oscillating motion of the guide needles ψ and the given angles of rotation of the main shaft φ_i, at which the forward, backward movements and stopping of the guide needles take place. The value of the angle ψ depends on the type of needles with which the warp knitting machine is equipped and the number of combs with guide needles. The dynamic condition is the observance of the admissible pressure angles in the kinematic pairs θi. The design conditions are a given distance AD between the main shaft and the oscillation shaft of the guide needles, the nominal

length of the rocker arm *CD* and the coordinates of the stop.

The peculiarities of the mechanism of oscillating movement of guide needles with variable links are the conversion of the leading link into oscillating movement with stopping the combs with guide needles while providing forward and backward oscillation at an angle ψ when rotating the leading link at an angle φ_{3_1} and angle φ_{1_2} position when rotating the leading link at an angle φ_{2_3}. The pressure angles that determine the efficiency of the mechanism should not exceed the allowable values.

It is known that the angles of rotation of the slave link ψ and the drive link φ of the hinged four-link *ABCD* are interconnected by the dependence $\psi = f(\varphi)$. In this case, taking into account the specifics of the structure of the mechanism of the guide needles with variable links, this dependence can be used only in the phases of forward and backward movement of the guide needles. During the stop it is necessary to take into account the change in the length and shape of the variable link (crank, con-rod, rocker arm) during the looping cycle.

For example, if the variable link in the mechanism is a rocker arm, then in the phases of forward and backward movement the mechanism can be considered as a mechanism of a hinged four-link, and in the stopping phases - as a oscillaiting crank gear in which one part of the variable rocker arm acts as a fixed guide. and the other is a backstage slider. That is, a mechanism with a variable kinematic structure is used.

In the synthesis of the mechanism of guide needles with a variable link, the extreme upper position (phase of shift in front of the needle hooks) and two intermediate positions (stop phase behind the backs of the needles) are known, which is the specificity of the synthesis.

Take the length of the crank $r = l_{AB}$ and the length of the con-rod $l = l_{BC}$ for the parameters to be determined during the synthesis. We set the parameters that can be changed during the synthesis: l_{AD} - the distance between the axes of the crank and rocker arm; l_{CD} - the length of the rocker arm; γ_1- the initial angle of installation of the rocker arm; $\Delta\varphi$- the angle between AC_1 and AC_2; $\Delta\varphi = \frac{\varphi_{3_1} - \varphi_{1_2}}{2}$.

3. Conclusion.

Using the recommendations [1, 10, 11, 12, 2], we compose expressions to determine the lengths of the crank *r* and the con-rod *l*:

$$r = \frac{l_{AC1}^2 - l_{AC2}^2}{2 \cdot \left(l_{AC1} - l_{AC2} \cdot \cos\left(\varphi_{1_2} + \Delta\varphi\right)\right)}; \qquad l = l_{AC1} - r. \tag{1}$$

When constructing the mechanism according to the calculated values of the parameters, it may turn out that it will not meet the specified angles of rotation of the crank when moving forward and when stopping the guide needles with satisfactory reproduction of the angle of rotation of the crank, which corresponds to the backward movement of the guide needles. Therefore it is necessary to compare the value of one of the specified angles of rotation of the crank (φ_{2_3} or φ_{3_1}), the value calculated by certain parameters of the mechanism.

Determine the calculated value of the angle φ_{31}^{P} and compare it with the specified angle φ_{3_1} crank rotation:

$$\varphi_{3_1}^{P} = \arccos\left(\frac{l_{AC_2}^2 + l_{AB_2}^2 - l_{B_2C_2}^2}{2 l_{AC_2} l_{AB_2}}\right) + \Delta\varphi. \tag{2}$$

If the difference $\Delta\varphi_{3_1} = \varphi_{3_1} - \varphi_{3_1}^{P} = 0$, the obtained values of r and l, as well as predefined parameters of the mechanism, we take as final. If $\Delta\varphi_{3_1} \neq 0$, you need to change the distance l_{AD}, the length l_{CD} of the rocker arm, which will change the initial angle γ_1 of the rocker arm installation and the angle φ_{31}^{P}.

The obtained dependences allow, as a result of metric synthesis of the mechanism of guide needles with variable links, to establish constant parameters of the kinematic scheme, which provide the law of motion of guide needles according to the cyclogram of the warp knitting machine.

Summary

Based on the analysis of the existing designs of variable structure mechanisms used in light industry machines, the structural schemes of the four-link variable structure mechanism for the drive of the guide needles of the WK-machine are proposed. The metric synthesis of the mechanism is offered.

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IMPACT OF THE DYNAMIC LOADS OF A NEEDLE-WEDGE PAIR OF A KNITTING MACHINE FOR THE LONGEVITY OF THE WEDGES

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DOI: 10.31891/monograph/2021-10-85

1. Introduction.

The key to improving circular knitting machines is to improve their efficiency. A promising direction for improving the existing and creating new types of circular knitting machines is to further increase their productivity by reducing the failures of the working mechanisms of the knitting mechanism (needles and wedges), which will improve the quality of the fabric.

The problem of reducing the dynamic loads in the knitting mechanisms of the knitting machines, despite the existing achievements in its solution, is still urgent. The purpose of this work is to develop a method for assessing the impact of dynamic loads on a needle-wedge pair on the wear of knitting wedges.

The problem of reducing the dynamic loads in the knitting mechanisms of the circular knitting machines, despite the existing achievements in its solution, is still urgent.

Analysis of basic research and publications.

The efficiency of knitting machines (machine performance and quality of knitted fabric) is significantly dependent on the durability of the wedge [1, 2]. At the same time increase of durability of work of wedges contributes to decrease of dynamic loadings arising in a pair of needle-wedge [3].

As shown by studies [2], one of the promising directions of reducing dynamic loads in knitting systems, which leads to an increase in the longevity of the wedges, is to reduce friction in the needle-wedge pair.

Lubricants are used to reduce friction in kinematic vapors, increase durability and prevent the penetration of harmful agents (corrosive liquids, gases, vapors and abrasive particles of dust and contaminants) on the friction surface, as well as protect metal surfaces from corrosion. In general, liquid and plastic lubricants are used.

Liquid lubricants include oils (mineral, synthetic and semi-synthetic).

Mineral oils. The starting material for their production is fuel oil. Additives are added to mineral oils to improve performance.

Additives are used for:

– friction reduction (fatty oils, acids and their esters, etc. are used);

– increasing the durability of parts (cotton, linseed, super oils, animal fats, chloride and phosphorus compounds, etc. are used);

– stickiness increase (resinous hydrocarbons (bitumen) are used);

– protection from corrosion (esters of fatty oils, oxidized petrolatum, barium and calcium sulfonates etc., are used);

– to improve viscosity properties (condensation products of paraffin and naphthalene, acylphenol etc., are used)

The main features of oils (compared to plastic oils) are their fluidity and mobility. These properties allow the oils to be used in circulating lubrication systems, to cool friction vapors, to simplify oil change and cleaning. The disadvantages of oils include a relatively low service life, high requirements for seals, especially when lubricating vertically and obliquely kinematic pairs, or having large gaps. In addition, the values of their parameters are very dependent on temperature, so range of application of oils are from -30°C up to +150°C.

Parameters that characterize the performance of oils are: viscosity, flash points, inflammation and solidification, acid number, stability, the presence of impurities (water, acids, alkalis, mechanical).

Viscosity is one of the most important parameters of the quality of oils, which determines their purpose and conditions of use. If the viscosity of the oil is insufficient, the oil layer may be displaced between the friction surfaces, causing direct contact with them and increased wear. Excessive oil viscosity can cause the friction surfaces to heat up quickly.

The viscosity is dynamic, kinematic and conditional.

Dynamic viscosity characterizes the property of liquids to resist the mutual motion of their particles or layers. The unit of dynamic viscosity [η] = 1 ns / m^2 is equal to the dynamic viscosity of a fluid in which, when moving a liquid at a speed of 1 m /s over a distance of 1 m, the contact voltage is 1 n / m^2.

The kinematic viscosity is determined by the ratio of the dynamic viscosity to the oil density $\tau = \frac{N}{P}$, kinematic viscosity unit 1 m^2/s = 1 stokes.

Kinematic viscosity of oils is included in their marking and is regulated by standards at t = 50°C or 100°C. The kinematic viscosity at any temperature t is determined by the formula:

$$\tau_{T=}65{,}7\cdot \tau_{50}(01\cdot t)^{2,6}$$

Conditional viscosity is an abstract value that expresses the ratio of leakage time from a special container (viscometer) of 200 g of oil, the viscosity of oil is taken at t = 20°C to the time of leakage of the same amount of distilled water at the same temperature. Conditional (relative) viscosity is denoted by conditional degrees [° CD] (formerly Engler degrees [° E]).

Conversion viscosity to kinematic is done using the empirical formula:

$$\tau = 2{,}31°\text{ВУ} - \frac{6.31}{°\text{ВУ}}$$

In viscosity standards, the temperature characteristic of the oil is given by the ratio of kinematic viscosity at 50°C and 100°C.

Flash and ignition temperatures. The first is the temperature at which the mixture of steam of heated oil and the air erupts as the flames rise. The temperature at which not only oil vapors but also the oil itself (and burns for at least 5 seconds) erupt from the exalted flame is called the ignition temperature. These indicators are used to evaluate the fire performance and volatility of oils. The pour point of the oil. This is the temperature at which the meniscus of oil placed in a test tube, when tilted to an angle of 45 ° remains unchanged for 1 min.

Acid value. This is the mass of potassium hydroxide KOH) required to neutralize 1 g of oil. An acid number characterizes the content in the oils of organic acids, the presence of which in the amount of more than 0.35% can cause corrosion of machine parts. The procedure for determining the acid number is given in ГОСТ 5985-84.

Stability. Oil resistance to aging and its ability to retain physical, chemical and performance properties over time is called oil stability.

The main cause of the aging of the oil is the oxidation of it with oxygen, which leads to an increase in the acid value and viscosity of the oil. The rate of oxidation (aging) of the oil depends on its chemical composition, the area of contact of the oil with air and most of all depends on the operating temperature of the oil. It is established that with increasing operating temperature for every 10°C the oxidation of the oil is twice faster.

The presence of water and mechanical impurities. Water is a harmful impurity, since even the presence of traces of it in oil can cause severe corrosion of lubricated surfaces. Particularly sensitive to the presence of water in oil are the oil feeders such as wicks and tampons. As a rule, water can only enter the oil as a result of careless storage or transportation. Therefore, the water content of the oil should not exceed 0.05%.

Thus, to reduce the dynamic loads that occur in the area of interaction with needles wedges appropriate to improve their lubrication system [4] and designs needles and wedges [2].

Purpose of the study. Given the urgency of improving the efficiency of circular knitting machines by improving the system of lubrication of the needle-wedge pair of knitting systems and improving their working bodies [2, 4], the task of research is to assess the impact of dynamic loads of the pair of needle-wedge knitting machine on durability of wedges.

Presentation of the main material.

Studies [2] show that the life span of a knitting system wedge can be determined depending on:

$$T = \frac{\Delta H_{max}}{60\, n\, z\, K\, f^{t} \rho_{np}^{-0,5\beta t} N_0^{1+0,5\beta t}}, \qquad (1)$$

where:

T – working time of wedge

ΔH_{max} - maximum allowable wear of the wedge, which is measured normal to its working surface;

n – the frequency of interaction of needles with a wedge (for a circular knitting machine - the speed of rotation of the needle cylinder);

z – the number of needles of the needle cylinder;

$$K = 2K_0\left(\frac{4\eta}{\pi}\right)^{0,5} \cdot 0,418^{1+\beta t} E^{0,5(1+\beta t)} \frac{1+\beta t}{1,5+\beta t};$$

$$\eta = \frac{1+\mu_1}{E_1} + \frac{1-\mu_2}{E_2};$$

μ_1, μ_2 – Poisson's ratio respectively for needle and wedge material;

E_1, E_2 – modulus of elasticity of needle and wedge materials;

$$K_0 = C_1\left(\frac{1-\mu_2}{E}\right)^{1+t(\beta-1)}\left(\frac{K_1}{C_2\sigma_0}\right)^t;$$

K_1 – proportionality ratio between the specific friction force and the induced voltage in the needle-wedge pair;

σ_0 – the ultimate strength of the wedge material at a single voltage:

$$C_1 = \frac{1{,}2\nu^{0,5}}{K_2(1+\nu)}; \quad \beta = \frac{1}{1+2\nu};$$

$$C_2 = \left(\frac{b}{2}\right)^{\beta}\cdot\left(\frac{2{,}35}{K_2}\right)^{1-\beta}\cdot\left(\frac{r}{h_{max}}\right)^{0,5(1-\beta)}; \qquad (2)$$

b, ν – ration of working surface of the wedge curve;

K_2 – table ration dependent on v;

r – average radius of vertices and protrusions of the micro-asperities of the working surface of the wedge;

h_{max} - maximum height of micro-asperities;

f – friction ratio in the needle-wedge pair;

t – exponent of the curve of contact fatigue;

ρ_{np} – the radius of curvature of the needle-wedge pair;

N_0 – the specific normal pressure in the area of contact of the needle with the wedge.

Analyzing equation (1), we conclude that in order to determine the efficiency of the influence of the dynamic loads of the pair of needle-wedge on the durability of the wedges of the equation can be represented in the form:

$$T = \frac{A}{N_0^{1+0,5\beta t}}, \qquad (3)$$

where:

$$A = \frac{\Delta H_{max}}{60\,nzKf^{\,t}\rho_{np}^{-0,5\beta t}} = const$$

Taking into account that: $N_0 = \frac{N}{l} = \frac{P}{l\sin\alpha}$

where: N – normal pressure of needle – wedge pair;

l – contact length of the interaction of the test pair; length of the contact contact of the test pair;

P – horizontal of the component dynamic load on the wedge;

α – wedge profile angle,

$$T = \frac{B}{P^{1+0,5\beta t}}, \tag{4}$$

where: $B = A(l \sin\alpha)^{1+0,5\beta t} = const$.

Taking [2, 4] $\nu = 3$ (the working surface of the lock is polished) and $t = 4$, from (2), we find: $\beta = 0,143$.

Then equation (4) finally takes the form:

$$T = \frac{B}{P^{1,286}}. \tag{5}$$

On the basis of (5) we obtain:

$$n_T = n_p^{1,286}, \tag{6}$$

where: n_T – ration of increasing the durability of the wedge,

$$n_T = \frac{T_2}{T_1}; \tag{7}$$

T_1, T_2 – the durability of the wedge in accordance with and after the implementation of the measure aimed at reducing the dynamic loads in the pair of needle-wedge (improvement of the design of the needle or wedge);

n_p – dynamic load reduction ration in knitting systems (needle-wedge pairs) when using new needle or wedge designs,

$$n_p = \frac{P_1}{P_2}; \tag{8}$$

P_1, P_2 – dynamic loads «before» and «after» the modernization of the knitting parts.

Conclusions.

As a result of the performed research:

– the method of estimation of influence of dynamic loads of a pair of needle-wedge of the knitting machine on durability of work of wedges is developed;

– has been identified, that in order to increase the efficiency of knitting machines by increasing the longevity of the wedges, it is advisable to reduce the dynamic loads in the needle-wedge pair;

– dependency obtained to evaluate the impact of improving the working parts of knitting machines on reducing the dynamic loads in a pair of needle-wedges and, consequently, on increasing the longevity of the wedges.

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WEAR RESISTANCE OF NITROGENED STRUCTURAL STEEL WITH LIMIT AND DRY FRICTION

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DOI: 10.31891/monograph/2021-10-86

Introduction and problem statement

The surface should be considered as a special kind of defects, because it destroys the periodicity of the solid in one direction - perpendicular to the surface towards the environment. This thesis is to some extent confirmed by the fact known from the theory and practice of chemical processes of the fact of significant acceleration of the reaction in the presence of solid catalysts on the surface, ie the boundary layer, the structure of which differs to some extent. At the same time, the presence of a real surface as a structure with a certain order characteristic of each specific type, is the stimulus through which most of the physical or chemical processes of interaction of a solid body with the environment. Since the surface as a mathematical concept cannot have a structure, it should be considered as a set of defects or aperiodicity of the crystal lattice, approximated by the chosen type of mathematical model. However, two-dimensional ordering continues to be preserved within each layer [1], and its structure should be understood as the structure of a solid body around the surface. This part of a solid near the mathematical surface (near-surface layer) can be considered as a three-dimensional structure that differs from the solid itself, because within several atomic layers may include atomic nodes other than the atomic nodes of the main volume. In this case, the distance between the layers in the direction normal to the surface is not only slightly different from the parameters of the lattice of the main volume, but also has a variable nature, usually in the direction of increase as we approach the mathematical surface. However, it should not be forgotten that the near-surface layer is a crystalline structure for which two-dimensional periodicity is preserved in planes that are parallel to the mathematical surface. Thus, it should logically follow from the above that the violation of the specified natural periodicity of the near-surface layers inevitably in some way affects all the characteristics of the surface as a whole, including its ability to resist wear. This circumstance was more or less noted in classical works on tribology [2–7], but proper coverage of research results, on the basis of which it would be possible to form practical methods of

experiments to determine the wear resistance characteristics of metal surfaces, neither in these nor in other works. is noted. In addition to the influence of the structure of the near-surface layers directly on the surface wear process, it should also be noted the significant role of this factor for other related processes and types of wear. It is known that during the adsorption of gases, ie the concentration of the components of the gaseous medium on the surface, a monomolecular adsorption layer is formed - a monolayer [2, 6]. The filling of the surface, ie a measure of the continuity of the monolayer, at small pressure values is proportional to the pressure of the adsorbate in the gaseous medium. If gas molecules, due to the presence of a strong chemical or physical bond, are not able to move on the surface, it is localized adsorption with the formation of an adsorption complex. The adsorbate and the near-surface layer can form their own two-dimensional structure. The rate of adsorption depends on the continuity of the monolayer, ie when approaching the state of continuous filling of the surface with the adsorption layer, it gradually decreases to zero and vice versa, in the opposite direction increases the rate of desorption phenomena. Chemisorbed and physically sorbed gas particles on the surface differ in the type of electronic bond between the adsorbate and the base. If the electronic state of the adsorbed molecule undergoes significant changes until the formation of chemical bonds with the surface, then it is chemisorption. In the case where the molecule is held on the surface by Van der Waals forces due to the polarization of the unexcited molecule, this type of adsorption refers to physical adsorption. The upper limit for physical adsorption is only 0,6 eV. The chemisorption energy is usually in the range of 1 ... 8 eV [1]. If the energy of a molecule in the environment is a few electron volts, it will be able to overcome the potential barrier of the near-surface layer, penetrate into its depth, and the exchange of electrons between atoms will create conditions for chemical sorption or chemical reaction [9]. It is obvious that the mechanical impact on the surface significantly changes the parameters of adsorption phenomena, which also can not but affect the wear processes. Significant influence on the course of destruction of the surface has the value of the output, as well as the crystal structure of the surface. Indeed, the concept of output work is largely conditional given the conventionality of the term "outside the surface", because it is from the distance to the surface as a mathematical category depends on the potential energy. In addition, the real surface is structurally heterogeneous, with different crystal

orientation of individual fragments, some of them are in the accelerating field, others - in the brake. Densely packed crystal faces are characterized by high values of the yield, on the contrary, atomically inhomogeneous or loosely packed - small. In the presence of an absorption layer, there is an additional surface double layer, which also significantly affects the magnitude of the electron output.

From the above follows the conclusion about the importance of taking into account the parameters of the wear process and other conditions that characterize this process, the objectivity of the research results.

Research results

In results of wear resistance studies obtained under extreme friction conditions were analyzed. The main conclusions of the analysis were that any wear process is a set of sequential compaction of the surface layers and their removal. The test parameters that should be selected based on the material and pre-treatment of the surface are crucial.

The results of the experiments show (Fig. 2) that at almost any pressure there comes a time when the wear process almost stops, but the resource path at which a similar stabilization is observed is different for different pressure values. The hypothesis that the wear process in conditions when the mechanical component of this process prevails, is actually a combination of two competing processes - surface strengthening and destruction of this reinforced layer, confirms Fig. 1.

The harder the contact surface, the greater the threshold value of the pressure at which the phase of destruction of the compacted layer. However, the effect of pressure at its large values is extreme: in the demonstrated series of experiments, the most dynamic wear process occurred at a pressure of 65 MPa. At pressure values less than and greater than this value (with equal slip speed), the wear intensity was lower. Increasing the sliding speed leads to a decrease in the intensity of wear and acceleration of the onset of the stabilization phase, which can be explained by a decrease in relaxation time of the surface layer compaction processes, which in extreme friction it would be realistic to compare the results obtained for different samples, made of different brands of materials and processed using different technological processes.

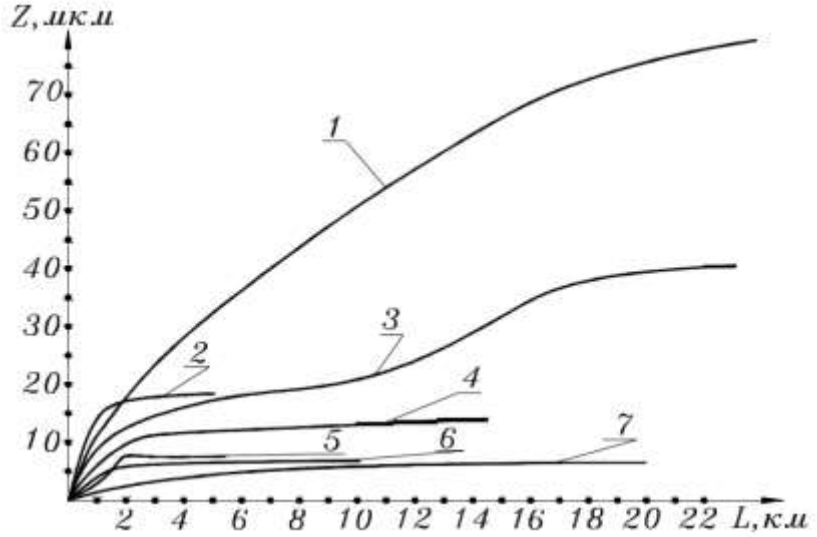


Fig.1. Wear of samples of nitrided steel 45, depending on the path at the pressure in the contact zone and the sliding speed: 1- 65 MPa, 0.1 m / s; 2 - 50 MPa, 0.1 m / s; 3 - 120 MPa, 0.1 m / s; 4 - 80 MPa, 0.1 m / s; 5 - 40 MPa, 0.3 m / s; 6 - 65 MPa, 0.2 m / s; 7 - 20 MPa, 0.2 m

Since the tests provided constant lubrication of the friction zone, a layer of lubricant was present at a certain value of the pressure on the friction surface, which led to extremely low rates of linear wear. However, depending on the characteristics of the modified surface, there was a critical value of pressure at which the oil layer was pushed out of the friction zone, which led to instant setting of the surfaces. The presence of compaction and, thus, structural transformations of the surface is evidenced by the fact that with a gradual increase in pressure it was possible to achieve relatively large values of wear. An attempt to immediately test the new specimens at a pressure close to these critical values inevitably caused the surfaces to set. The reason for this phenomenon could only be the gradual compaction of the surface and its strengthening, of course - with a change in the structure of the subsurface layer. This, together with the impossibility of objectively comparing the results of tests obtained at different pressures, explains the need to move to the scheme of experiments on dry friction. Some results of previous tests are shown in Fig.1.

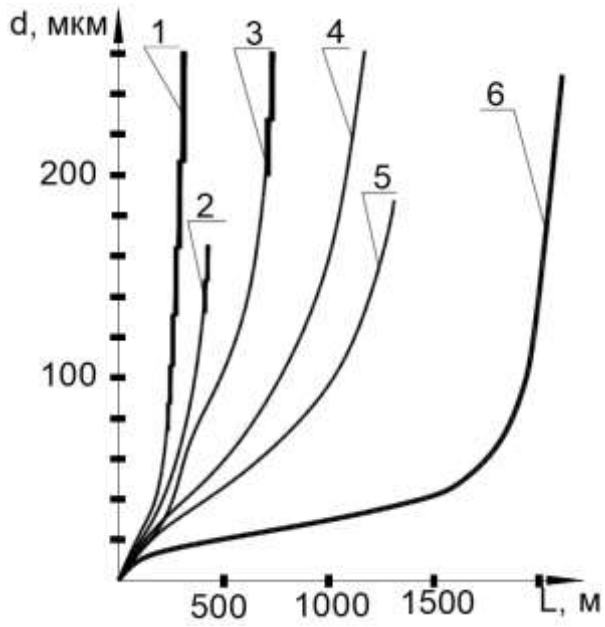


Fig.2. Dependence of linear wear on the path of friction and pressure: 1 - steel 20, p = 16 MPa; 2 - steel 45, p = 16 MPa; 3 - steel 20, p = 10 MPa; 4 - steel 40X, p = 16 MPa; 5 - steel 45, p = 10 MPa; 6 - steel 38X2MIOA, p = 16 MPa

First of all, from fig. 2 it is concluded that in the dry friction mode the intensity of the wear process increases significantly, which leads to a similarly significant increase in the productivity of experimental studies (in some cases one experiment in the friction mode lasted for weeks, in the dry mode - in some cases it was possible to perform several changes). In addition, the thesis concerning the decisive influence on the intensity of pressure wear on the friction surface was confirmed, since the same indicators of linear wear d were achieved with increasing pressure at a significantly greater path of friction L. The brand of material (initial values of physical and mechanical parameters) in combination with the existing surface modification also significantly affected the intensity of wear. For example, for nitrided in the glow discharge steel 38H2MYUA in some cases, the intensity of wear is almost an order of magnitude lower than steel 20. In contrast to the methods of experimental research based on the principle of limiting friction. In the mode of dry friction, the results can be achieved at the same pressure values for almost all steels, which eliminates the question of comparability in the analysis of research results. The importance of this position is evidenced by the comparison of wear curves for the same steels at different pressure values (Fig. 2). Since the same value of linear wear for the same material, but at different pressures, is achieved at significantly different values of the friction

path, the relationship between these factors would be a problem. Graphs in Fig. 2 confirm the effect on the wear intensity of the physical and mechanical parameters of the surface and its modification, while stronger steels, as well as steels that have undergone some modification treatment, wear under the same conditions (pressure and relative velocity, which for all experiments was 0.1 m / c) with a lower intensity, which on the graphs corresponds to the angle of their inclination. The effect of structural transformations of the surface is confirmed by Figure 3, which shows the results of fixing the linear wear with a small interval of the friction path. The wear pattern in this case is a stepped curve of the periods of formation of reinforced structures on the surface, when wear is virtually absent, and the periods of destruction of these surface structures. For modified surfaces, this phenomenon is especially characteristic in the initial period, when the zone of nitrides and internal nitriding wears out. Another important phenomenon for the analysis of the influence of modification results on the parameters of wear resistance of the surface is the effect of relaxation processes in the near-surface layers, which have already acquired some structural transformations under the action of pressure in the friction zone.

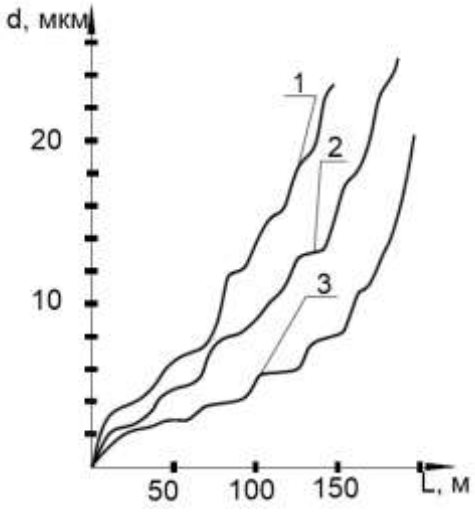


Fig.3. The nature of surface wear in the initial period (1- steel 20, 2 - steel 40X, 3 - steel 39X2MIOA)

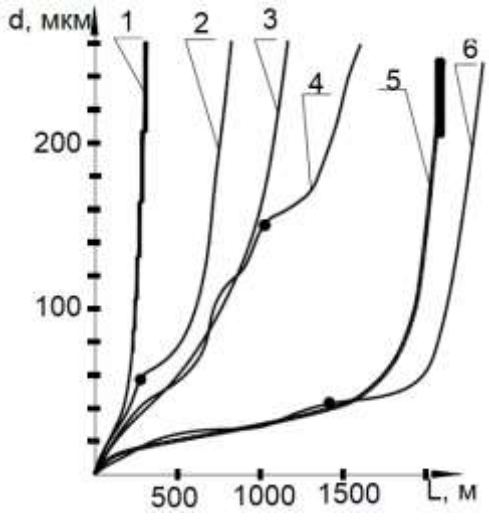


Fig.4. The effect of relaxation structural transformations surfaces (1, 2 - steel 20; 3, 4 - steel 40X, 5, 6 - steel38X2MIOA)

The black dots on graphs 2, 4, 6 show the points when the wear resistance tests were suspended and resumed the next day. For all steels there is some

slowdown of the wear process after a break with a gradual return to the intensity characteristic of a particular grade of steel. The reason for this phenomenon can be only the relaxation of stresses, the alignment of the characteristics of the structure in the near-surface layers, and the consequence of all this may be the strengthening of the surface, which explains the decrease in the intensity of the wear process. Over time, as the destruction of the reinforced layer, the surface condition becomes equal to that which was before the break and the intensity of wear is restored.

Conclusions

1. The process of wear at the boundary friction actually includes two competing processes: compaction of the surface layer with increasing microhardness and destruction of the surface layer with local setting of surfaces.

2. The ratio of these phases in time is significantly influenced by the initial state of the surface and its physical and mechanical characteristics, pressure on the contact surface, sliding speed, and all these parameters for the friction limit are closely related.

3. Due to the above circumstances, tests for wear resistance of samples made of different materials and with significantly different characteristics of the surface layer with the same parameters of the test mode in most cases is impossible, because the results are difficult to compare.

4. Test conditions that can be applied to surfaces with different characteristics and provide results that are acceptable in terms of reliability, cross-comparison and timing should be considered promising.

5. The study of wear resistance in the dry mode of friction provides significantly higher productivity of experiments.

6. Unlike boundary friction experiments, dry friction can be applied to different steels at the same pressure value, which eliminates the problem of comparability of results and contributes to the objectivity of conclusions about the effectiveness of different modification processes. According to the results of previous experiments, such a compromise value of pressure can be 16 MPa.

7. The effect of relaxation transformations of surface structures is established, on the basis of which it is recommended to carry out research of wear resistance during one continuous session.

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MICROSCOPY INVESTIGATION OF MULTILAYER PE FILMS

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DOI: 10.31891/monograph/2021-10-87

1. Introduction

Structures of polymers obtained under different processing set-up and manufacturing processes depends on characteristic parameters like heating-cooling rates, velocity of polymer flow and pressures. Applying additional deformation of material changes the behavior of material and influences the structure. To control structure and hence properties, optimization and prediction of processing is indispensable. Engineering polymeric materials, including nanocomposites, are in great demand in the market as well. Global expenditure of all plastics is still growing up, what can be observed in the world's annual consumption of these materials, which has increased from around 5 million tons in the 1950s to more than 100 million tons nowadays. Manufacturing of films has evolved recently and it’s possible to obtain monolayer, multilayer and also ultra thin films. Development of simulation, possibilities of new precise technology, advantages in polymer chemistry bring popportunity to use advanced coextrusion processes and obtain better properties of multilayer films [1-4].

2. Experimental procedure

Blow molding machine as main technology has been used in the work. Difference between conventional blow molding process and used in the experiment is the advanced head to control the film manufacturing process. The inventive head makes film by joining together materials from 3 independent extruders. As the final material is obtained 3-layer polymer film (fig. 1). 3-layer film can be joined from different materials, fillers and additions, so finally can be obtained innovative multilayer composite. Specific steps of the work focus on control of the process to obtain different thickness of the film. Samples prepared from LDPE and investigated in the experiment are presented in table 1.



Figure 1. Blow molding machine with visible advanced head to obtain 1-layered and 3-layered polymer films

Table 1. Experimental plan

Sample designation	Sample description
1 Lay 60	1-layer film with thickness 60 μm
3 Lay 60	3-layer film with thickness 60 μm
1 Lay 100	1-layer film with thickness 100 μm
3 Lay 100	3-layer film with thickness 100 μm

3. Results

All films were tested on universal testing machine Zwick 020 at room temperature. For each test were used at least 5 samples to get average results. Curves obtained in the test are presented on figures below (fig 2-4). All values and average values of tensile strength test are presented in the table 2 and on the figure 5.

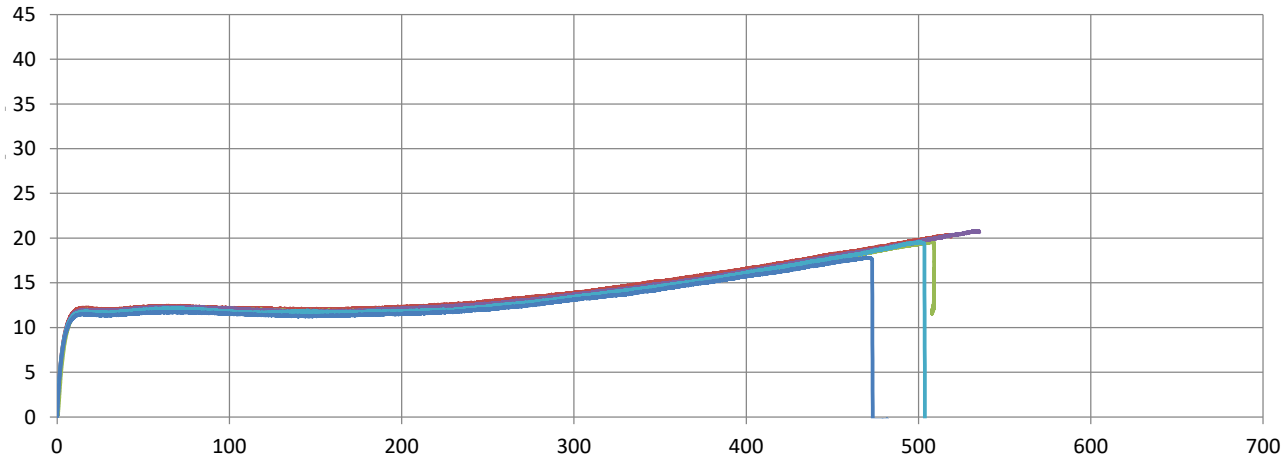


Figure 2. Tensile curves for 1-layer film with 100 µm thickness, standard force [MPa] vs elongation [mm]

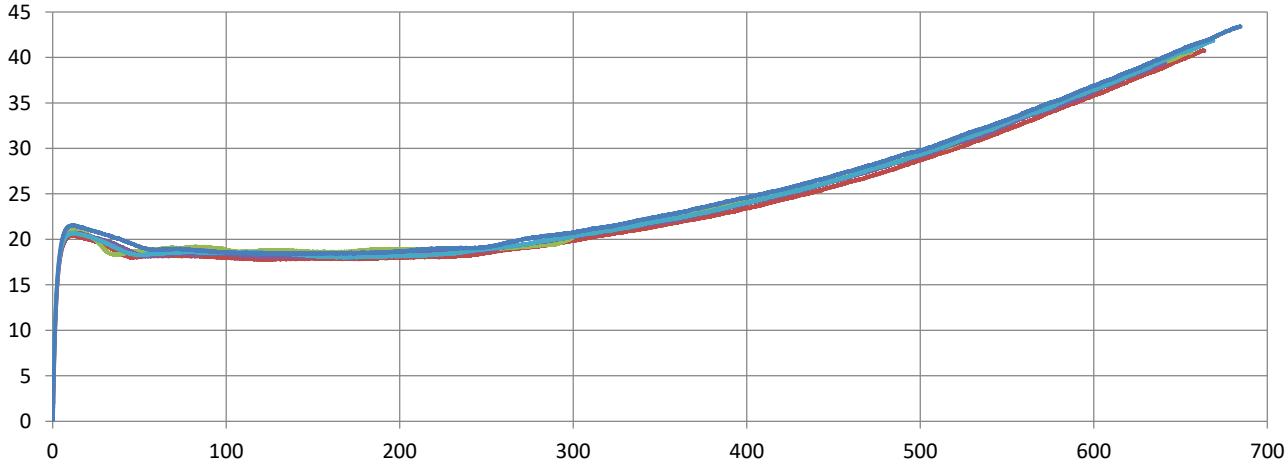


Figure 3. Tensile curves for 3-layer film with 100 µm thickness, standard force [MPa] vs elongation [mm]

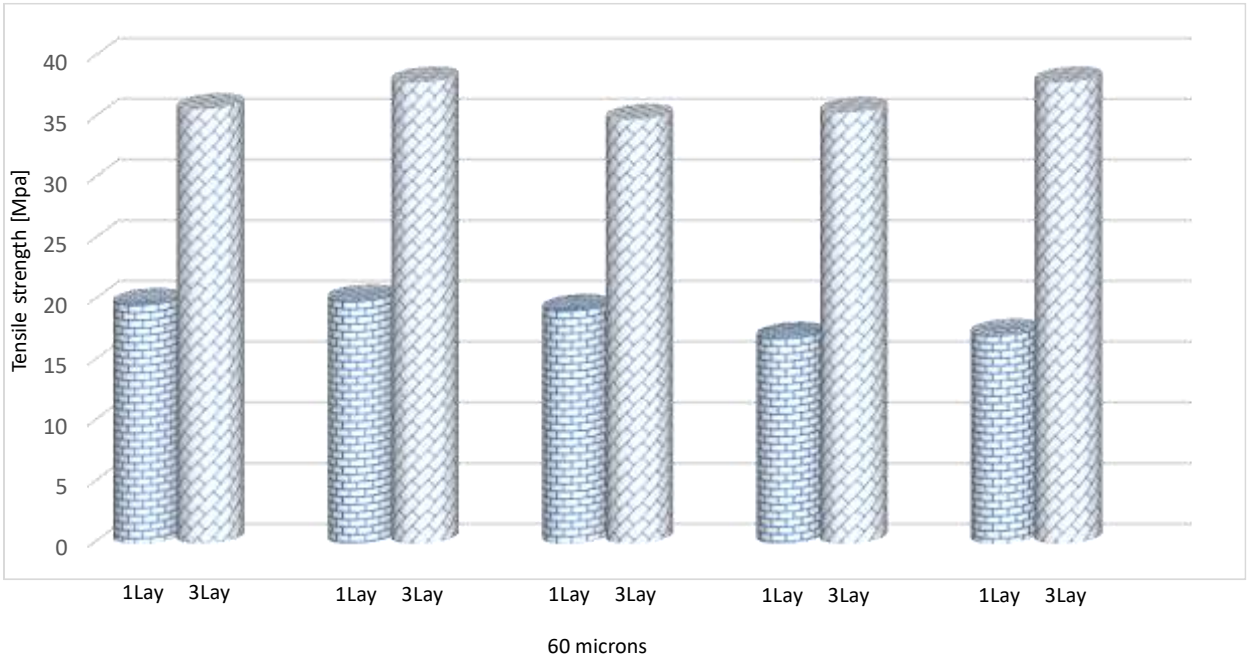


Figure 4. Results of tensile strength for 1-layer and 3-layer film with 60 µm thickness

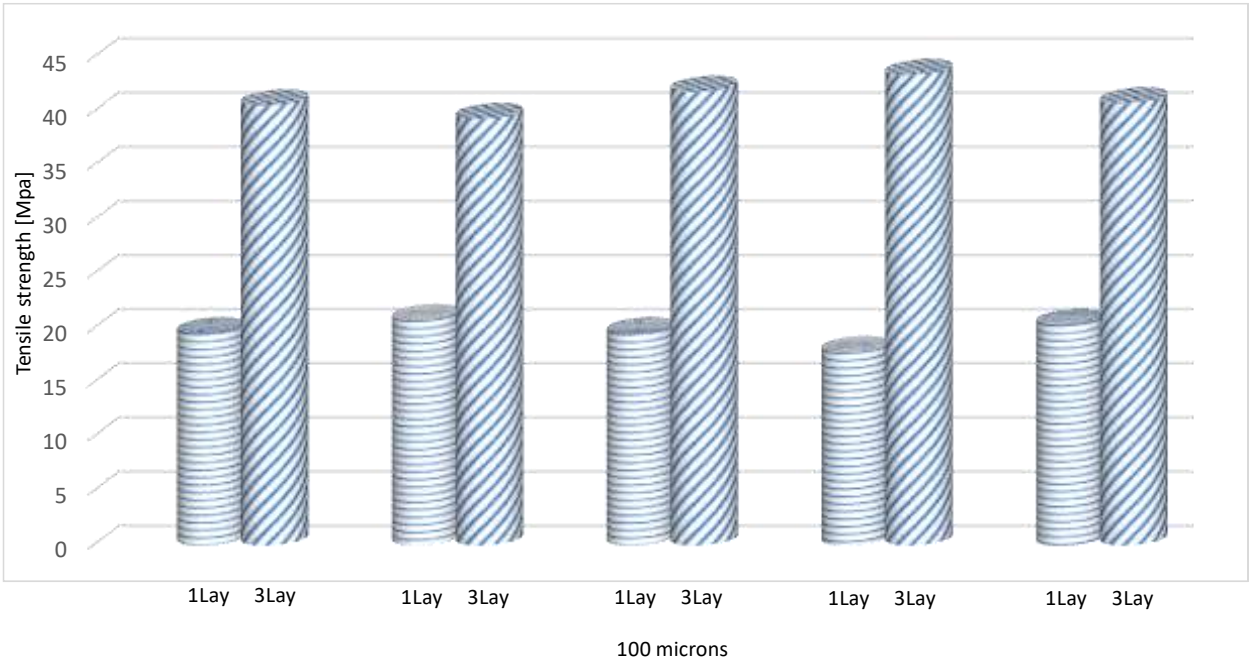


Figure 5. Results of tensile strength for 1-layer and 3-layer film with 100 µm thickness

Table 2. Results of tensile strength of particular samples

Sample	1 Lay 60	3 Lay 60	1 Lay 100	3 Lay 100
1	19,68573952	35,75850805	19,57161522	40,60536957
2	19,99214172	37,96298981	20,78439903	39,36871338
3	19,20668602	34,89029566	19,55408096	41,85724258
4	16,92331505	35,47321637	17,82328224	43,41524506
5	17,17913055	37,97039986	20,35645485	40,80231476
Average	18,59740257	36,41108194	19,61796646	41,20977706

Samples of LDPE prepared in the form of 1-layer and 3-layer films have different elongation. 3 layer samples of 100 μm film have 700 mm elongation, that is 200 mm more that 1 layer film with the same thickness. The difference is in the structure, which is created from 3 different layers . Each layer has its own strength and in the multilayer structure it is multiplied, so the final strength is higher. Joining together many layers makes the material stronger.

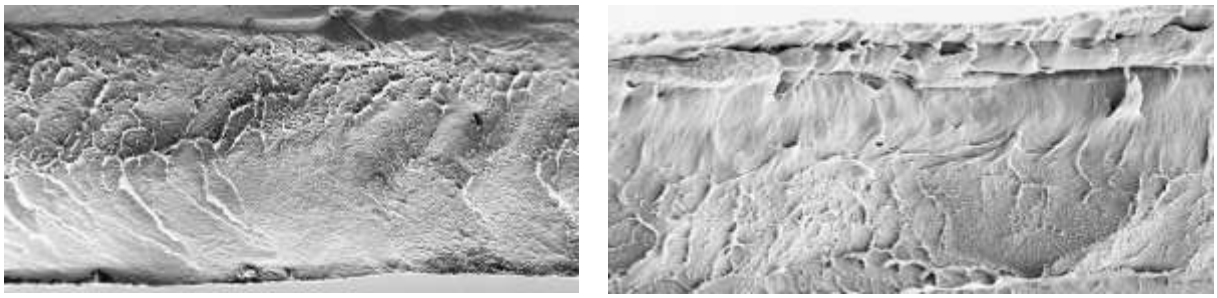


Figure 5. Cross section of the 1-layer film with 60 (left) and 100 μm thickness (right)

Cross section of 1-laer and 3-layer structure, presented on the figure 5 above, shows lightly higher absorption of energy of the 3-layer film. There is no visible border between layers - it proves good adherence between layers. Further investigation using other microscopy is recommended to measure and observe particular layers.

Spectrum done using FTIR spectrometry shows confirmation of material used in the experiment and recognized as PE - visible overlapping of the peaks accordingly to database spectrum.

4. Summary

Evaluation of tensile strength of 3-layer film with thickness of 100 microns comparing to 1-layer film with the same thickness shows increment in elongation equal to 28%. 3-layered film presents slightly more plastic deformation than 1-layer, which resents more flat cross section. Future investigation will focus on phenomena of reinforcing the structure by joining layers together.

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LINEAR CURRENT SWEEP AND MEASURING THE CURRENT-VOLTAGE CHARACTERISTICS OF THE SOLAR PANEL

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DOI: 10.31891/monograph/2021-10-88

A new method for measuring the voltage characteristics of a solar panel based on a linear current is proposed. This method can be used in the development of intelligent solar modules to provide tracking of maximum power points - MPPT.

Keywords: solar panel, measurement, electrical parameters, current-voltage characteristics, efficiency coefficient.

Introduction

It is known that the main source of information about the electrical parameters of the solar panel is its current-voltage characteristic. From it determine the efficiency coefficient, maximum power, short circuit current, open circuit voltage, fill factor, series resistance, shunt resistance, etc [1]. Analysis of the current-voltage characteristics also allows you to control defects at an early stage of their development and to predict the process of degradation of the solar panel [2, 3].

The available methods and tools for measuring the current-voltage characteristics of solar cells and solar panels are intended in the conditions of scientific laboratories and production, but cannot be directly applied to each intelligent solar module during its exploatation. A limitation on the application here is the high complexity, bulkiness and cost of measuring systems.

Note that the MPPT controller circuits have significant limitations in their parameters and cannot provide the requirements for laboratory measurements of current-voltage characteristics. A review of sources on the algorithms and schemes of MPPT controllers can be found in [4].

The objective of this study is to search a universal method for measuring the current-voltage characteristics of solar panels. This method can be provided on the basis of a digital oscilloscope and does not require a specialized measuring system. This method should be tested primarily on crystalline silicon solar panels in natural light, as well as when illuminated by a simulator.

Crystalline silicon is the material for the production of 95% of all solar panels in the world [5]. Therefore, this method can be applied to the conditions of

production solar panels and operation of solar power plants and networks. A version of the method using a microcontroller instead of an oscilloscope can perform the MPPT task for an intelligent solar module.

Analysis of known methods for measuring the current-voltage characteristics of solar cells and panels

Consider the main methods for measuring the current-voltage characteristics. In general, they are divided into two classes [6-8]:

- static measurements (DC-measurements);
- dynamic I-V measurements (pulsed I-V measurements).

Among DC methods, a step-by-step stimulating signal with a discretely increasing amplitude is most often used [9].

Continuous measurement of the I–V characteristic and its output to the screen in the characterograph mode was first carried out in [10].

A special measuring information system for solar cells was created to obtain current-voltage characteristics, as well as capacitance-voltage characteristics [11].

An example of a two-channel measuring system of semiconductor devices is given in [12].

The use of the pulse method for measuring the I–V characteristics of solar cells and panels is considered in [13,14].

An analysis of the I–V characteristics measurement methods showed that even with a pulsed method, an object generates Joule heat. This is the cause of the measurement error. To reduce this error and simplify the measuring system, the authors conducted these studies.

The parameters achieved in the new method were compared with the parameters of the known measuring system: DC I-V, C-V, pulse, and ultra-fast I-V testing in the same flexible environment [15].

Mathematical model of linear current sweep mode method

The method proposed by the authors is based on the application of a transient process in the solar panel with a series connection of inductance to it [16]. In this case, the current of the solar battery will increase at first almost linearly (with a non-linearity error of up to 1%). The short circuit current of the solar panel must be located on the linear portion of the current change. In this case, we get a linear sweep of the current in time (Figure 1).

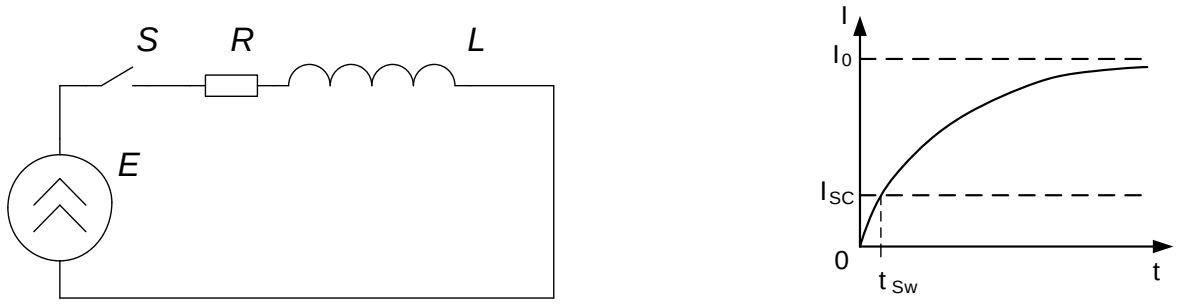


Fig. 1. Linear current sweep mode: a) equivalent circuit: E - voltage source; S - key; R - key and coil resistance; L - inductor; b) the dependence of current on time: I0 - maximum current; Isc - short circuit current of the solar panel; tsw - current sweep time from zero to Isc

Maximum current I0 equals E/R (Fig. 1, b).

On the oscilloscope screen, we display the voltage of the solar panel with a linear increase in current. Thus, we obtain the current-voltage characteristic of the solar battery: its current is on the horizontal axis, its voltage is on the vertical axis.

A diagram of a linear current sweep device is in Figure 2.

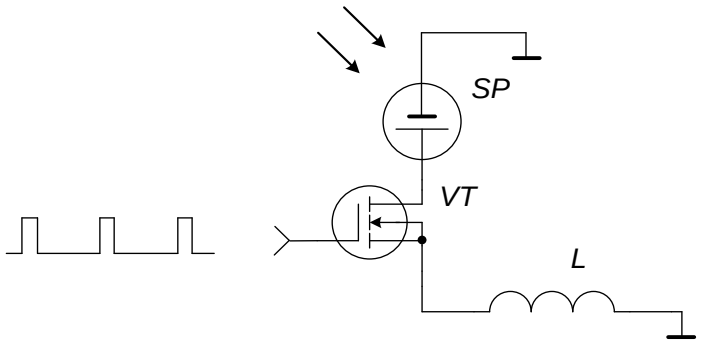


Fig. 2. Circuit of liner current sweep: SP – solar panel; VT – MOSFET; L – inductor

A single pulse or series of pulses comes to the gate of the transistor switch. As a result, the key closes the solar panel to the ground (Figure 2). The current increases linearly to a short circuit.

The block diagram of the laboratory bench for measuring the current-voltage characteristics of the solar panel in the linear current sweep mode is in Figure 3.

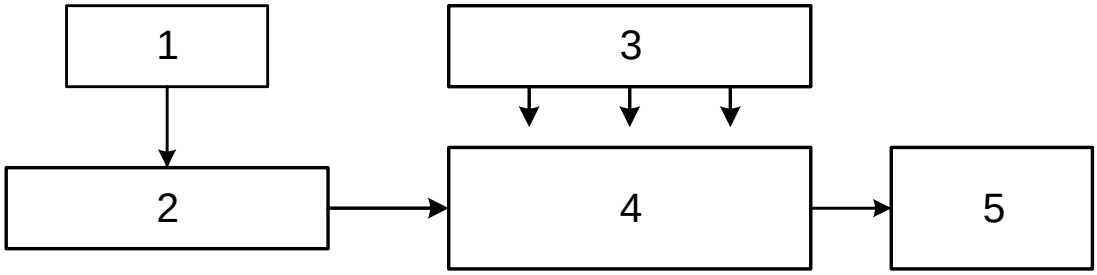


Fig. 3. Block diagram of the laboratory bench: 1- pulse generator; 2 – circuit of liner current sweep; 3 – solar imitator; 4 – solar panel; 5 – oscilloscope

The waveform of the current-voltage characteristics of the solar panel is in Figure 4. It also has a current signal on the measuring resistor.

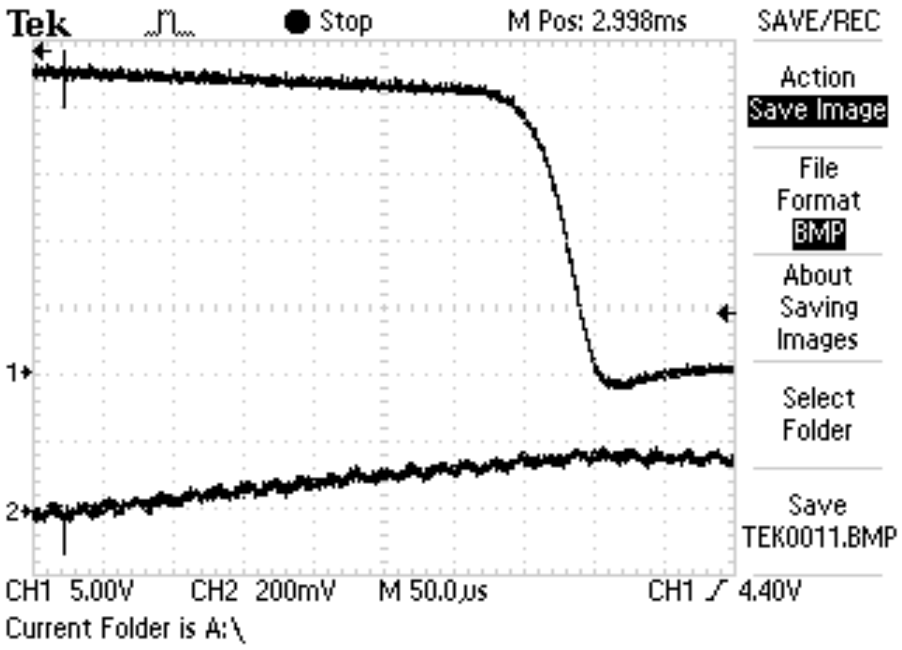


Fig. 4. Waveform of the current-voltage characteristics: solar panel of monocristalline Si (30W, 12V); CH2 – current signal on the resistor 100 milliohm (mΩ)

Experimental conditions (Fig.4): illumination with two halogen-wolfram lamps of 1 kW each; transistor – MOSFET IRF1405; inductance 384 mH; active resistance of the inductor 384 mΩ; short circuit current 1.54 A.

Consider a mathematical model of the process. For the transient process in the RL-circuit (Fig. 1), the differential equation for current is true:

$$R_i + L\frac{di}{dt} = U \qquad (1)$$

Equation (1) has a solution in the form of the sum of the constant and variable parts:

$$i = i_0 + i_1 \tag{2}$$

The constant part is equal to:

$$i_0 = \frac{U}{R} \tag{3}$$

The variable part is:

$$i_1 = -\frac{U}{R} e^{-\frac{t}{\tau}};\ \tau = \frac{L}{R} \tag{4}$$

Complete solution of the differential equation:

$$i = U \Big/ R\left(1 - e^{-\frac{t}{\tau}}\right) \tag{5}$$

The dependence of current on time can be as close as possible to a straight line in the area from 0 to the short circuit current of the solar panel when selecting parameters R and L.

We expand the current function in a Taylor series at the point t =0 and leave only the first member of the series:

$$i = \frac{Ut}{L} \tag{6}$$

To obtain the rate of increase in the current of the solar panel, we differentiate equation (6):

$$\frac{di}{dt} = \frac{U_1}{L} \tag{7}$$

Since the current increases linearly, the voltage U1 is a constant that can be determined from experimental data from the formula:

$$U_1 = L\frac{di}{dt} \tag{8}$$

With a short-circuit current of 0.36 A and a scan duration of 6.3 μs, the scan speed is 0.057 A/μs, measurement resistor 50 mΩ (Fig. 5). Then the current sweep constant U1 is 1.01V. This value is near the short circuit point of the solar panel.

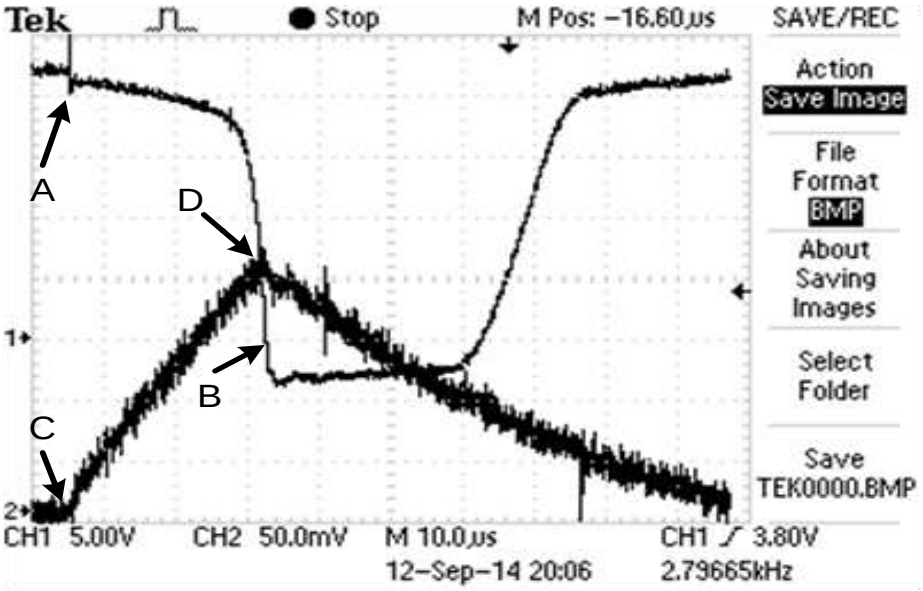


Fig. 5. Waveform of current-voltage characteristic of solar panel (curve AB) and sweep of current (line CD)

For a sweep time of 5 μs and a resistance of 50 mΩ, the calculation of the error of linearization of the current at different inductances is presented (Table 1).

Table 1. Experimental studies results

L, μHn	$A=1-e^{-Rt/L}$	B = Rt/L	Δ = |A-B|	Δ·100%
10	0,02531	0,02500	0,00031	1,24
20	0,01258	0,01250	0,00008	0,64
40	0,00627	0,00625	0,00002	0,32

The calculation results show that the linearization error is inversely proportional to the inductance. To improve the linearity of the current sweep, it is necessary to use coils with a high inductance - from 40 μH or more.

Experimental research of linear current sweep mode method

The authors experimentally studied the parameters and characteristics of the method for measuring the current-voltage characteristics of the solar panel in the linear current sweep mode.

The dependence of the current sweep time on the voltage at the gate of the key is obtained. Experimental conditions: 30W solar panel; lighting from a solar simulator; MOSFET IRF1405; inductance 566 mΩ; coil resistance 384 mΩ; resistance for current measurement 100 mΩ

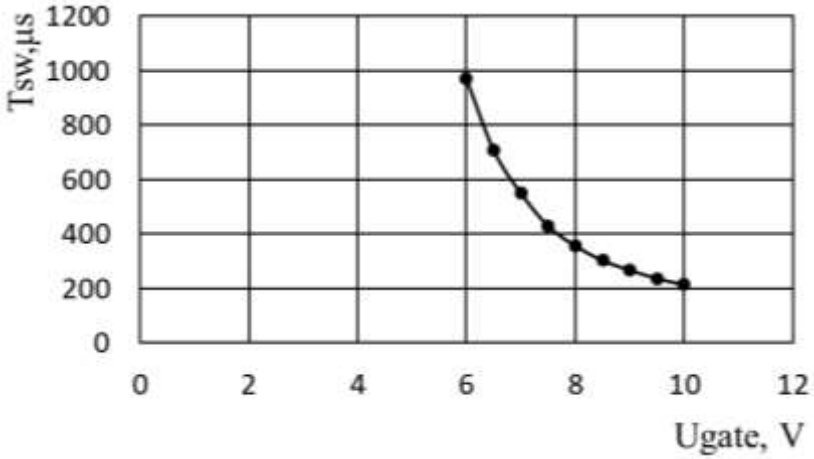


Fig. 6. Waveform of current-voltage characteristic of solar panel (curve AB) and sweep of current (line CD)

The dependence (Fig. 6) is hyperbolic. The current sweep speed is inversely proportional to it and is linear (Fig.7).

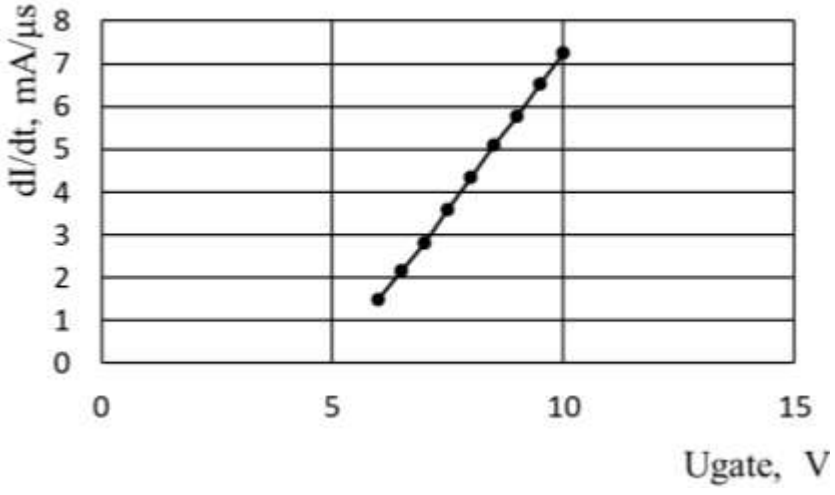


Fig. 7. Dependence of the current sweep speed dI/dt on the voltage Ugate at the gate of the MOSFET

The duration of the current sweep decreases with increasing voltage at the gate of MOSFET. This increases the sweep speed. From the experiments it follows that the current sweep speed can be changed 5 times with a change in the gate MOSFET voltage from 6V to 10V.

The authors measured the current-voltage characteristic under natural lighting of a 270 W solar panel. The measurements were performed on June 12, 2019. Experimental conditions: short circuit current 8.6 A; open circuit voltage 34 V; inductor 233 μH; current sweep time 570 μs; gate MOSFET voltage 7V (Fig. 8).

Current was measured on a 47mΩ resistor (Fig.9).

On the current waveform, you can determine the short circuit current (8,6A) of solar panel (Fig. 9).

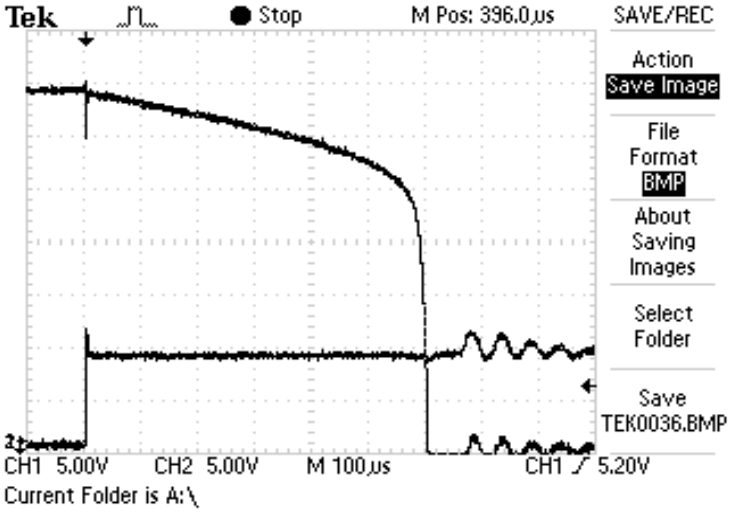


Fig. 8. Current-voltage characteristic of solar panel 270 W (channel 2) and pulse of generator (channel 1)

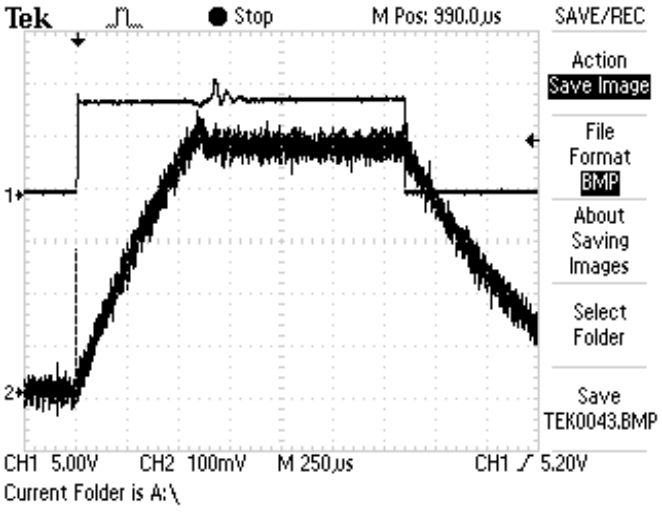


Fig. 9. Current measuring: channel 1 – output signal of pulse generator; channel 2 – current of solar panel

Under the conditions of solar illumination, the current-voltage characteristic of the 270W, 24V polycrystalline silicon solar panel was measured using 5 different inductors from 66 μH to 488 μH. Based on these measurements, the dependence of the current sweep duration on the inductance is obtained (Fig. 10).

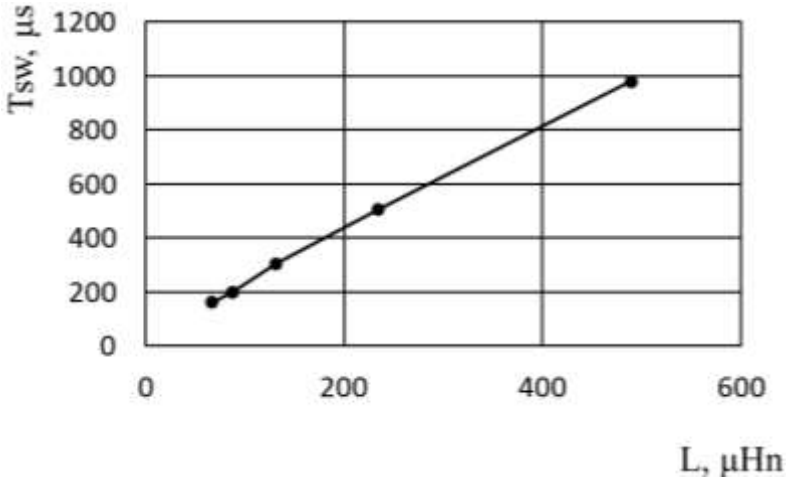


Fig. 10. Dependence of the current sweep duration Tsw on the inductance L

The short circuit current of the solar panel in these measurements was the same and equal to 9.04A. The duration of the current sweep was from 162 μs to 980 μs. The obtained dependence (Fig. 10) is linear, which experimentally confirms the correctness of the mathematical model.

Conclusions

The authors proved that the transient process in the solar panel can be a sufficient source of information about its electrical parameters. With a short circuit of the solar panel through the inductor, a linear current sweep mode is obtained. This made it possible to display the I–V characteristics on an oscilloscope.

The authors propose to call this method "a single-pulse method for measuring the current-voltage characteristics in the linear current sweep mode."

The suitability of the method for laboratory conditions, as well as for the operation of solar panels, has been proven.

The authors believe that this method can be promising for smart solar modules and autonomous and hybrid electrical networks.

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Technical editors*: Serhiy Horiashchenko, Robert Polasik*

ISBN: 978-83-938655-5-0
DOI: 10.31891/monograph/2021-10-1

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