Practice Oriented Science:
UAE – RUSSIA – INDIA

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TECHNICAL SCIENCES

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LOGICAL STRUCTURE OF INSTITUTIONS

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Abstract*. There are a lot of notations of institutions with different understandings of their logical structure. The purpose of the study is to review the one of the most solid interpretations of the logic of institutions, presented by John Searle. The object of the study is the very essence of this logic. The subject of the study is the characteristics of the institutional logical structure.*

The paper presents the logic of institutions and considers their logical structure. Following Searle, it is argued that the natural sciences study phenomena independent of the observer, social – dependent. In exploring institutional reality, we are studying observer-dependent phenomena.

Keywords*: institutions as systems, logical structure, institutional facts, observer-dependent phenomena, language, national specificities.*

JEL classification*: B415, B25, B41, Z10.*

There is no unambiguous definition of institutions for at least two reasons. The *first* is that many of them are fragmentary. To avoid this, G. L. Kleiner (2008) proposes a systemic interpretation of institutions, where the system is presented as an integral set of four elements. Starting from the system $S = \{S_1, S_2, S_3, S_4\}$, where S_1 is an object, S_2 is an environment, S_3 is a process, S_4 is a project, we wish to show (Yerznkyan, Akinfeeva, 2014) the validity of the systemic interpretation of a semantically plural institution $I = \{I_1, I_2, I_3, I_4\}$, where I_1 is an institution as an object, I_2 is an institution as an environment, I_3 is an institution as a process, I_4. The *second r*eason lies in the systematic, although most likely unintentional disregard for the national characteristics of institutions (, Yerznkyan, Gassner, Kara,

2017; Yerznkyan, Gassner, 2018). The importance of taking into account cultural and national factors is explained by the fact that, from economic perspective, culture and institutions – especially considering the informal constraints such as "codes of conduct, norms of behavior, and conventions" – are related concepts. In fact, informal institutions are "*a part of heritage that we call culture*" (North, 1990, pp. 36, 37).

The impact of culture on economic behavior regarded from the different positions, including quantified and qualified ones, is studied in (Yerznkyan, 2016). "National and cultural differences of socioeconomic reforms are considered, as well as relations between culture and economic systems, culture and institutions, influence of culture on inter-firm relations on the example of Russian corporations which use hybrid agreements and mechanisms of transaction management" (Yerznkyan, Gassner, Kara, 2017, p. 72).

Let us add to the above that "culture provides a language-based conceptual framework for encoding and interpreting the information that the senses are presenting to the brain" (North, 1990, p. 37).

As experience shows, in real economic practice, it is impossible to do without taking into account national characteristics, since economic agents are not entities isolated from reality, they themselves are inherently a product of this very reality. Their behavior, especially when they operate in conditions of change, is specific for a number of reasons: the incongruence of imported institutions and their own informal institutional environment; the impossibility of quickly switching the national cultural code, inertial in its essence, which determines the norms of their behavior.

And now we will present the logical structure of institutions, regardless of their interpretation, and based on the conceptual apparatus of John Searle and following his work (Searle, 2005) published in the first issue of the journal on institutional economics, published since the beginning of 2005 by Jeffry Hodgson, namely his famous article "What are institutions" (Hodgson, 2006).

The importance of familiarizing yourself with this conceptual apparatus is due to the fact that "each time and each country is different". As claims Joseph Stiglitz countries need to consider the alternatives and, through democratic political processes, make these choices for themselves. It should be – and it should have been – the task of the international economic institutions to provide the countries the wherewithal to make these *informed* choices on their own, with an understanding of the consequences and risks of each" (Stiglitz, 2002, p. 88).

Economics, unlike the natural sciences, deals mainly with *institutional facts*. However, this circumstance is usually overlooked. In the traditional view of economics as a science that studies the allocation of scarce resources, a huge invisible *institutional ontology* is taken for granted.

Its essence lies in the fact that the mode of existence of resources and the mechanisms for their allocation are institutional, which implies that institutional phenomena are central to the economy. But just this seemingly obvious circumstance is traditionally ignored not only by supporters of the mainstream of economic theory, but also by many representatives of institutional theory.

The reason for this is in the approach to language as a given, which is not noticed, and therefore not taken into account. The origins of this approach go back to Aristotle. Institutional facts can exist only in the presence of certain *human institutions*. But what makes these facts institutional?

To answer this question, Searle introduces a number of auxiliary concepts: *observer independence* of a phenomenon, *observer dependence* of a phenomenon, and *objective/subjective difference*. The natural sciences study phenomena that are independent of the observer, while the social sciences study dependent ones. In exploring *institutional reality*, we are studying observer-dependent phenomena.

Further, Searle makes a distinction between epistemological and ontological treatment of objective and subjective phenomena. He argues that there can be an objective science dealing with problems in a field that is ontologically subjective, and that without this possibility there can be no social science. With this in mind, he tries to explain how there can be an objective, in the sense of epistemology, institutional reality of money, the state, property, etc. in conditions when this reality itself is partially constructed from subjective sensations and relationships, and therefore has a subjective ontology.

For an adequate description of the institutional reality, the work (Yerznkyan, Fontana, 2022) develops an approach to the economy, devoid of the extremes of market absolute competition and a price mechanism, on the one hand, and the ecosystem absolution of cooperation and the institution of trust, on the other. It is argued that both extremes are far from reality: the first is caused by the desire to convey the basics of a market economy in a simple form, convenient for its formalization, and the second by the desire to draw attention to business ecosystems as a modern dominating form of organization of production and economic activities with the help of a catchy slogan. A more realistic view of ecosystems allows us to see in it, in addition to cooperative features, also manifestations of competition.

There are, however, other opinions. To explain institutional reality, Searle refers to a special theory of the logical structure of institutional facts “X counts as Y in the context of C” (X counts as Y in C), which was mostly outlined by him in a work ten years ago. To do this, he introduces three simple concepts that explain social and institutional reality.

The *first* of these is *collective intentionality*, which covers not only collective intentions (intentions), but also such forms of intentionality as collective beliefs

and collective desires. Collective intentionality is the basis of any society, human or animal. This concept is needed to define a social fact, which is any fact that includes the collective intentionality of two or more agents. But what distinguishes the general class of social facts from the special subclass that constitutes institutional facts?

To do this, a *second* concept is introduced – *assignment of function*, which serves to denote the ability of people to impose functions on objects; we are talking about the fact that objects have functions not because they are intrinsic, but because they are given to them. Such (imposed) functions are observer dependent. By combining the concepts of collective intentionality and function assignment, one can arrive at *collective assignments of function*.

The *third* concept necessary to make the transition from social to institutional facts is *status functions*. We are talking about the assignment of functions of a special kind, when the objects or individuals to which functions are assigned do not perform them due to the physical structure, but because the assignment of functions represents the assignment of a status shared by the collective consciousness and allowing them to perform the functions assigned to them. Logically, it looks like this: X counts as Y.

In general, this logic needs to be supplemented with context: X counts as Y in context C. When this procedure or practice of representing X as Y becomes settled, it becomes a rule. These rules play a constitutive role for the institutional structure. It is necessary to distinguish between constitutive rules and regulative rules: the logic of the latter can be represented as "Do X" (Do X). Constitutive rules not only regulate the activity of an object, they constitute it, transform a pre-existing object into an existing one.

Without regulatory rules, activity is possible (one can imagine driving on roads without traffic rules; by the way, in many countries, drivers practically do not follow formal traffic rules and there is nothing, in any case, there are no statistics that there are more accidents than in countries where they strictly follow regulatory guidelines). But it is difficult to imagine social and economic activity without constitutive rules (one cannot play chess without first specifying by what rules this game is played; these rules constitute the game as such, make chess a chess, and not checkers, dominoes or just pieces for throwing: who throws further.

For the institutional ontology of human civilization, constitutive rules are of exceptional importance: human institutional reality differs from the social structures and behavior of the animal world in that it contains status functions defined in accordance with constitutive rules and procedures. Institutional facts require structure in the form of constitutive rules "X counts as Y in the context of C", and they exist only through the collective acceptance of something with a certain status. Thus, any fact that has the logical structure "X counts as Y in C" is insti-

tutional, and any system in the form "X counts as Y in C" is an institution. The establishment of an institution provides a framework within which institutional facts can be created.

Another significant point is the linking of status functions with deontic (an adjective from deontology – the doctrine of moral laws, ethics) power (*deontic powers*). The main role of human institutions and the meaning of their existence is, according to Searle, not in limiting people, but rather in creating new types of power relations. Human institutions open up new opportunities because they create power, but of a special kind, in which such concepts as rights, duties, permissions, requirements, etc. are significant. Not every deontic power is institutional, but almost all institutional structures deal with deontic power, they create desire-independent grounds for action. It can be said that the creation of a common field of desire-based reasons for action presupposes the adoption of a system of desire-independent reasons for action.

Let us now turn to language as a fundamental social institution and try to understand the meaning of such an interpretation of language, which is important for understanding the logical structure of other institutions. Thus, a distinction is made between two types of social institutions – language and other, non-linguistic institutions. The relationship between them is asymmetric: language plays a fundamental role, the others do not. This does not mean that other institutions are less important, just that language can exist without other institutions, but the latter are inconceivable without language. It is not difficult to agree with this statement; it is much more difficult to understand the constitutive role that language plays in all social institutions. Language does not simply describe a pre-existing institutional reality. It contributes to that reality becoming existing. Institutional reality becomes such precisely because of the constitutive role of language. A status function, in order to exist at all, must be represented as existing; while language or some other kind of symbolism provides the means of representation. In a condensed form, it looks like this: no representation, no status function (no representation, no status function). It goes on to say that the cognitive ability of humans requires a linguistic or symbolic ability: *no language, no status functions*, *no status function, no institutional deontology*.

In the constitution of institutional facts, language performs *at least four functions*. *First*, a fact can exist only insofar as it can be represented as existing, moreover, in a linguistic (in the broadest sense) form of representation. By the broadest sense, we mean some, not necessarily expressed by means of natural language, a form of symbolization that carries deontic power. No language, no deontology (no language, no deontology). *Secondly*, the forms of the status function are almost invariably a matter of deontic power: they have to do with rights, duties, responsibilities, etc. *Thirdly*, deontology has another specific property: it (i.e. rights, du-

ties, responsibilities, etc.) can exist even after its creation, even if the participants involved in the process stop thinking about the initial act of creation of deontic entities. *Fourth*, the decisive function of language is the recognition of the institution as such.

Particular manifestations of institutional reality are possible as such only because they are examples of a general institutional phenomenon.

So far, we have considered the logical structure of institutions without involving emotional factors. Taking them into account can make the analysis more relevant, but at the same time more complicated. As emphasized by V.E. Dementyev, citing Hodgson, "in explaining the formation of individual intentions, psychological mechanisms must necessarily be present. If they are not there, then there is a temptation to place more emphasis on open coercion and restriction, and not on more subtle mechanisms of social influence, not on the self-creation of concrete agents" (Dementyev, 2020, pp. 5-6). It turns out that the development of the theory of institutional dynamics Hodgson actually connects with the disclosure of "how social institutions can form and reproduce individual goals and preferences" (ibid.).

Let us return, however, to Searle. We summarize the presentation of Searle's position regarding the logical structure of institutions by their definition: "An institution is any collectively recognized system of rules (procedures, practices) that allows us to create institutional facts" (Searle, 2005, p. 21).

Speaking of language as a basic institution, one cannot fail to mention Noam Chomsky. As he notes, in order to solve the institutional problem of regression, i.e. referring one institution to another, the idea of linguistic universals can be useful. The bottom line is that any child is born with a specific ability to learn a language, which in Chomsky's terminology means "is born with a language acquisition device" (language acquisition device). And one more thing: all human languages should be similar to such an extent that any children can learn them. Chomsky called these universal characteristics universal grammar. It is learned that the language consists of a finite set of procedures for generating an infinite number of structures. Thus, knowledge of a language is not a faculty or a set of habits, but something more: it includes the knowledge of these aspects of the language, which belongs to the universal grammar" (Macaulay, p.151-152).

At the end of the story about the language, we will give two quotes (Yerznkyan, Fontana, 2022, p. 76) given as epigraphs in the work (Yerznkyan, 2014, p. 54). "We grow up and learn the words of the language and see the universe through the prism of the language we know: not through the prism of all languages or through the prism of no language – silence, for example, but we lock ourselves in the language we know." William Saroyan. "Seventy thousand Assyrians." The second epigram is taken from Joseph Brodsky's work "Watermark": "One never

knows what engenders what: an experience a language, or a language an experience. Both are capable of generating quite a lot". And since the question of the causality of language and the extra-linguistic world "did not arise today, and it remains largely open," we will make a reference to the work (Yerznkyan, 2014, p. 55) and proceed to further discussion.

Here it is appropriate to quote North's answer to his own question "where do informal constrains come from": "They come from socially transmitted information and are a part of the heritage that we call culture" (North, 1990, p. 37).

In the work (Yerznkyan, Avetisyan, 2008) it is proposed to supplement the linguistic structure with an institutional one, bearing in mind the linguistic logic of the structure of institutions. In a sense, this can be considered a specific generalization of Chomsky's idea to institutions other than language.

Indeed. A person has not only a language acquisition device (*LAD*), but (when the baby begins to babble and then speak without difficulty in a language that is not clear how he has learned), but an institutional acquisition device (*IAD*) since institutions, according to North, are nothing more than mental entities, which we "cannot see, feel, touch, or even measure', 'They are constructs of the human mind" (North, 1990, p. 107). With this in mind, and by analogy with, it is appropriate to introduce the concept of "institution acquisition device". And as it was said, it can be considered an extension, as long as the language belongs to the class of social institutions. The specificity is due to the fact that the language is not just one of the institutions, it is what makes all other institutions possible, and in this sense the following is rather true: . In other words, language appears – however paradoxical it may sound – both as a part and as a whole.

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TRANSFORMATION OF TRENDS IN THE MILITARY-INDUSTRIAL COMPLEX OF CHINA AND TASKS FOR THE DEVELOPMENT OF COOPERATION WITH RUSSIA

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Abstract. *The authors conduct a historical analysis of the PRC military-industrial complex and its impact on the security of China itself, as well as on the space programs of the PRC, interaction with the United States and success in space, partnership with Russia in the field of NBICS and high-tech, science synergy and China's tasks in Industry 4.0.*

Keywords: *China, USA, Russia, USSR, military-industrial complex, space, decoupling, Industry 4.0., AI, Big Data, AUCUS, QUAD, NBICS, CASC, NORINCO, CSIC, CETC.*

The military-industrial complex of any state is a technical term used to describe the combination of a country's military and industrial sectors that work together to produce weapons, equipment, and other military technologies, including space and NBICS knowledge. In recent years, the military-industrial complex of China has become increasingly in demand to solve the problems of China's strategic dominance, due to the escalation of tension between China and the United States,

in particular, in connection with the situation with Taiwan and the ongoing transformations in the Asia-Pacific region for the right of unconditional leadership and strategic dominance countries of the Anglo-Saxon world and Asian giants. The self-governing island of Taiwan has long been a source of conflict between the two countries, with China claiming sovereignty over the territory and the United States supporting Taiwanese independence. In doing so, the idea of Mao Zedong in his negotiations with Richard Nixon that "the small issue is Taiwan; the whole world is a big question" has lost its relevance in international relations between Joe Biden and Xi Jinping, who considers this island one of the "red lines" of the Celestial Empire [1].

It is especially surprising that US Secretary of State Anthony Blinken, in June 2023, was subjected during his two-day visit to Beijing to a sudden "stab in the back" from his president, who started talking about "dictators and their destinies", earlier, in general, he called President Xi "plug ugly" ruling the "red empire", and also instantly received the expected rebuff from the Chinese Foreign Minister Wang Yi, who informed his American counterpart, despite lotuses as traditional flowers of harmony, peace and supposed interaction, that "the preservation of national unity was and remains the fundamental core of China's interests, where there is no room for compromises and concessions, "meaning the pumping of Taiwan with arms supplies from the United States and constant meetings with politicians from Taipei [2].

This approach also contradicts the previously pursued strategy of the New World in China, which, before the collapse of the USSR, in the late 1960s, was aimed at the mission of turning a world based on the confrontation of two powers into a strategic triangle, in which even Taiwan was perceived by Mao Zedong as quite acceptable. a concession to the US-China global partnership: "We do without it (Taiwan) for the time being and will do so in a hundred years", which led to the birth of the February 1972 Shanghai Communiqué, which gave the Americans and the Chinese a "road map" for the next decade [1;3].

Tensions have escalated in recent years as China has stepped up military exercises near Taiwan and the United States has increased its military presence in the region, drawing TNCs and the elites of Japan and South Korea into the growing AUKUS-KUAD standoff. The Chinese military-industrial complex is playing a key role in this escalation, developing advanced military technologies such as aircraft carriers and hypersonic missiles, as well as increasing sales of weapons to the region, semiconductors, chips and electronic equipment.

The situation in Taiwan has become one of the main flashpoints in the wider geopolitical tensions between China and the United States, as both sides take an increasingly hardline and intransigent stance. The Chinese military-industrial complex and its development of advanced military technologies is likely to play

a significant role in shaping the future of conflict and, in the broader situation, in shaping the security infrastructure in the region [4].

According to the Stockholm International Peace Research Institute (SIPRI), China currently ranks second in the world in military spending with a budget of $261 billion in 2021.[1] The country is modernizing its military, focusing on developing advanced technologies such as stealth fighter jets, modern aircraft carriers and hypersonic weapons. The Chinese military-industrial complex is also expanding its presence around the world, increasing arms sales to countries in Africa, the Middle East, South Asia and Latin America [5].

The importance of the topic of evolution and ongoing transformation of China's military-industrial complex lies in its significance for the current geopolitical situation, the flow of investments between the countries of the "golden billion", the on-going decoupling and de-industrialization of Europe, which most of the "hidden champions" leave in search of new fields and granaries in Asia and in America. The arms production complex itself plays a key role in China's military strategy and in its global ambitions, and also helps to implement the ongoing reform of the PLA (People's Liberation Army of China) for the possible strengthening of the PRC Armed Forces in the desire to become one of the leading global military powers. The development of advanced military technologies and the growing presence of the Chinese military-industrial complex are also likely to have a significant impact on the balance of power in the international system and on the future of current and frozen conflicts and security around the world [6].

The history of China's military-industrial complex dates back to the 1950s, when the country was in the midst of a transition from a predominantly agrarian society to a modern industrial economy. The Chinese Communist Party has recognized the need to create a strong army to strengthen its position and protect the country from potential threats. As a result, the government has created a number of state-owned enterprises (SOEs) and research institutes to develop the country's military-industrial potential.

In the 1950s and 1960s, China focused mainly on developing its own military technology and manufacturing capabilities. The country's leaders believed that reliance on foreign military technology would make it vulnerable to foreign influence and exploitation, so they made it a priority to develop a self-sustaining military-industrial complex. The first successful development of domestic military technology was the production of the jet fighter J-2 (Jianjiji-2), which was manufactured in 1958 [7].

In the 1970s and 1980s, China continued to expand its military-industrial complex, focusing on modernizing its weapons systems and improving its manufac-

[1] MILITARY AND DEFENSE EXPENDITURE IN CHINA https://take-profit.org/statistics/military-expenditure/china/

turing capabilities. During this time, the country has opened its doors to foreign investment and technology transfer to accelerate its development. During this same period, China became a major arms exporter as the country began selling its military technology to other countries in the region and around the world.

In the 1990s and 2000s, China continued to modernize its military and expand its military-industrial capabilities, with a focus on developing new weapons systems and improving its manufacturing processes. The country also continued to open its doors to foreign investment and technology transfer and became one of the largest arms exporters in the world. During this time, China has also invested heavily in research and development (R&D) to improve its military technology and manufacturing capacity, and established a number of military research institutes and universities to support these efforts [8].

In recent years, China's military-industrial complex has continued to grow, focusing on the development of new weapons systems and advanced technologies. The country has become one of the largest military sponsors in the world and has increased its military exports to other countries. The complex has also played a significant role in the development of China's space program, as well as its efforts to develop advanced military technologies such as hypersonic missiles and aircraft carriers.

China's space program is an integral part of its military-industrial complex, as it includes the development of advanced technologies and systems for military and civilian purposes. The program has a long history dating back to the 1950s, when China was one of the first countries in the world to launch a satellite into space. Since then, the country has invested heavily in its space program, focusing on developing new technologies, building new spacecraft, and exploring new frontiers in space [9].

One of the key goals of China's space program is to strengthen its military capabilities, as the country strives to create a modern, high-tech army capable of effectively defending its interests and protecting the country from potential threats. The program has been instrumental in the development of a range of advanced technologies, including satellite communications, navigation and intelligence systems, and in the development of new weapons systems such as hypersonic missiles.

In recent years, China's space program has also focused on developing its human spaceflight capabilities with the goal of eventually establishing a permanent presence in space. The country has developed its own spacecraft and sent astronauts into space on a number of missions, including an extended stay at its Tiangong space lab. The country is also investing in the development of new space launch systems and reusable space vehicles to reduce the cost and improve the reliability of space launches.

China's space program is likely to continue to grow and develop in the coming years, focusing on the development of new technologies, deep space exploration and the creation of new space capabilities. This development will help strengthen China's military capabilities and improve its ability to operate in space.

In addition to military and manned spaceflight, China's space program also focuses on a number of scientific and commercial applications. The country has launched a number of satellites for scientific research and Earth observation, and is also investing in the development of new technologies for use in space, such as space solar power and the exploration of the Moon and other planets [10].

The development and growth of China's military-industrial complex has been at the center of its modernization efforts in recent decades. The Chinese government is prioritizing strengthening its military capabilities and building a self-sufficient defense industry. This was driven by a desire to ensure national security, protect territorial integrity and preserve regional stability, and meet the needs of a rapidly modernizing military.

The development of China's military-industrial complex has been characterized by public investment, import substitution policies, and the promotion of local innovation. This has allowed China to expand its technological capabilities, reduce dependence on foreign military suppliers, and develop a wide range of advanced weapons systems, including aircraft, submarines, tanks and missiles. The rapid development of China's military-industrial complex has not only strengthened its military capabilities, but also stimulated economic growth and created employment opportunities. The defense industry has made an important contribution to China's economy, contributing to its overall competitiveness and technological development [11].

However, the growth of China's military-industrial complex is also raising concerns about its growing military power and its potential impact on regional stability. The Chinese government has repeatedly stated that its military modernization is defensive in nature and does not pose a threat to other countries. However, the rapid development of China's military-industrial complex is likely to continue to be of concern to many countries, especially its neighbors in the Asia-Pacific region.

As for China's military-industrial complex, it consists of a complex network of government agencies, state-owned enterprises, military research institutes, and private companies. Some of the key players in the complex include:

1. China Aerospace Science and Technology Corporation (CASC): This state-owned aerospace and defense conglomerate is one of the largest players in China's military-industrial complex and is responsible for the development of a wide range of military and civil technologies, including satellites, spacecraft and launch vehicles.

2. China North Industries Corporation (NORINCO): This government-owned defense contractor manufactures a wide range of weapon systems and military equipment, including tanks, artillery, and ammunition. It also manufactures civilian products, including vehicles and equipment.
3. China Shipbuilding Industry Corporation (CSIC): This state-owned shipbuilding conglomerate is responsible for the design and construction of a wide range of naval ships, including submarines, destroyers and aircraft carriers.
4. China Electronics Technology Group Corporation (CETC): This state-owned high-tech conglomerate is engaged in the research, development and production of a wide range of electronic and information technologies, including military communications and intelligence systems.
5. China South Industries Group Corporation (CSGC): This government-owned defense contractor manufactures a wide range of weapon systems and military equipment, including tanks, artillery, and ammunition.
6. China National Nuclear Corporation (CNNC): This state-owned nuclear technology conglomerate is engaged in the research, development and production of nuclear technology and equipment, including nuclear power plants and nuclear weapons [12].

Relations between China and Russia are complex and multifaceted, covering a wide range of political, economic and military ties. The two countries have a long history of close relations dating back to the Soviet era, when the Soviet Union provided China with extensive military and economic assistance. The relationship has become increasingly important in recent years as both countries seek to increase their global influence and counterbalance the power of the United States.

Economically, China and Russia are working to deepen their trade and investment ties, with a focus on cooperation in energy, high-tech industries and infrastructure development. For example, China is a major buyer of Russian oil and natural gas, and the two countries are working on building a new oil pipeline and expanding their trade into other areas, such as high-tech industries.

In the political realm, China and Russia are working to strengthen their cooperation on a range of regional and global issues, including a special military operation in Ukraine, the nuclear crisis in North Korea, and ongoing tensions in the South China Sea. The two countries also worked to balance the influence of the United States, especially in the United Nations and other international organizations.

In recent years, China and Russia have also been expanding their military cooperation, focusing on joint military exercises, arms sales, and military-technical cooperation.[2] Some of the key areas of military cooperation between the two countries include the following:

[2] Military cooperation between Russia and China is aimed at peace, not against the United States —https://regnum.ru/news/polit/3711508.html

- Joint military exercises: China and Russia regularly conduct joint military exercises, focusing on enhancing their military capabilities and improving their ability to work together. These exercises covered a number of areas, including air defense, anti-submarine warfare and special forces operations.
- Arms sales: Russia has been a major arms supplier to China, providing the country with a number of advanced weapons systems, including tanks, fighter jets and submarines. This military cooperation has become a key component of the relationship between the two countries and has helped bolster China's military capabilities.
- Military technology cooperation: China and Russia are working to expand their military technology cooperation, with a focus on joint research and development programs. This cooperation includes cooperation in a number of areas, including missile defense, cyber security and space exploration.

In general, military cooperation between China and Russia has been an important component of relations between the two countries. The two countries are working to strengthen their military capabilities and improve their ability to act together. This cooperation has become a key factor in the development of a close cooperative relationship between China and Russia. [3]

The prospects for the future development and growth of China's military-industrial complex and its relations with Russia are very promising. The two countries are working to deepen their cooperation in a number of areas, and they are likely to continue to do so in the coming years.

Some of the key prospects for future development and growth include expanding military cooperation, they will continue to expand their military cooperation in the coming years, with a focus on joint military exercises, arms sales and the development of military technology. This cooperation will help strengthen the military capabilities of both countries and improve their ability to act together. It will also strengthen economic ties as China and Russia are likely to deepen their economic ties in the coming years, with a focus on cooperation in energy, high-tech industries and infrastructure development. This cooperation will help stimulate economic growth and create new opportunities for both countries.

China and Russia are likely to continue to coordinate their strategies on a range of regional and global issues. This strategic coordination will help increase their influence on the world stage and promote stability in the region.

Finally, the military-industrial complex of China and Russia is likely to continue to make significant advances in technology, including artificial intelligence,

[3] How close are Russia and China? Military-strategic cooperation in international relations https://cyberleninka.ru/article/n/naskolko-blizki-rossiya-i-kitay-voenno-strategicheskoe-sotrudnichestvo-v-mezhdunarodnyh-otnosheniyah

quantum computing, and hypersonic weapons. These achievements will help to strengthen the military potential of countries and increase their competitiveness on the world stage. In the coming years, the Russian military-industrial complex is likely to continue to expand its international cooperation, working with friendly countries to develop new technologies, improve military capabilities and, in particular, strengthen regional stability.[4]

There are a number of economic issues that could affect cooperation between China and Russia in the military-industrial complex. Some of these calls include "sanctions and trade restrictions". Both China and Russia are subject to economic sanctions and trade restrictions imposed by other countries, including the United States. These restrictions may limit their ability to cooperate on military and technology projects, as well as their ability to trade with each other and other countries [14].

In addition, the two countries have different levels of economic development, and this may create problems in their economic cooperation. China's economy is much larger and more developed than Russia's, and this could create an imbalance in their trade relations and limit Russia's ability to contribute to joint projects.

In addition, fluctuations in the exchange rate of the Chinese yuan against the Russian ruble may affect economic cooperation between the two countries. For example, exchange rate It is worth noting that both China and Russia are heavily dependent on foreign technology, especially from countries such as the US, Germany and Taiwan. This dependency may affect their ability to collaborate on military and technology projects, as well as their ability to develop their own advanced technologies. Despite these challenges, China and Russia have been working to deepen their economic cooperation in recent years and are likely to continue to do so in the future. This cooperation will help stimulate economic growth and create new opportunities for both countries.[5]

To overcome the economic problems of cooperation between China and Russia in the military-industrial complex, the following solutions can be considered:

China and Russia can work to improve their trade relations, including increasing the volume of trade between them and reducing trade barriers such as tariffs and trade restrictions. This will help create a more balanced and sustainable economic relationship between the two countries.

Diversification of economic cooperation. China and Russia should diversify economic cooperation, including expanding their cooperation beyond the military-industrial complex and into other sectors such as energy, agriculture and technology. This will help create a stronger and more sustainable economic relationship between the two countries.

[4] Strengthening Russian-Chinese military cooperation and ensuring the security of Japan https://www.nippon.com/ru/in-depth/d00836/

[5] Chinese Ambassador to Russia: Let's take military-technical cooperation to a new level https://tass.ru/interviews/14554551

Both countries should work to promote technological cooperation, including the joint development of advanced technologies and the exchange of experience and resources. This will help increase their technological capabilities and support their economic cooperation in the military-industrial complex [15].

Also, encouraging joint ventures, including partnerships between their companies and organizations, will help create new economic opportunities for both countries and deepen their economic cooperation.

One of the important points is to reduce its dependence on foreign technology, especially from countries such as the United States. This will help increase their technological independence and support their economic cooperation in the military-industrial complex.

And there are also a number of political challenges that could affect cooperation between China and Russia in the military-industrial complex. For example, China and Russia have different political systems: China is a one-party communist state, while Russia is a federal semi-presidential republic. This may create differences in their political priorities and limit their ability to collaborate on certain projects. Second, countries have a long history of tension, including territorial disputes and disagreements over political and economic issues. This tension may affect their ability to work together on projects and create additional difficulties in their political cooperation. Third, countries are located in a region prone to conflict and instability, and their cooperation in the military-industrial complex is likely to be subject to geopolitical risks, including conflict, terrorism, and cyber threats. Most importantly, China and Russia are major powers on the world stage, and their cooperation in the military-industrial complex is likely to be seen as a challenge to other major powers, especially the United States, as well as to each other.

To overcome the political challenges of cooperation between China and Russia in the military-industrial complex, the following solutions can be considered:

- Improving diplomatic relations, including strengthening their political dialogue and improving communication at the highest level and jointly coordinating actions that have a geopolitical context. This will help create more stable and trust-based political relations between the two countries.
- China and Russia can work more closely to resolve their territorial disputes, including resolving longstanding conflicts over territory and ensuring that their political cooperation does not create new tensions or conflicts.
- Assistance in advancing the strategic partnership, including strengthening their political cooperation on regional and global issues and supporting each other's political and economic interests.
- Managing global competition for power, including reducing tensions with major powers such as the US and Europe to avoid actions that could dest-

abilize the international system.

- Building trust and transparency, including sharing information and exchanging views on key issues. This will help strengthen their political cooperation and reduce the risk of misunderstandings or miscalculations [16].

By taking these steps, China and Russia can overcome the economic and political challenges of cooperation in the military-industrial complex, as well as in other areas of cooperation, and create a more stable and trust-based political relationship. This will help support their development and growth and promote peace and stability in the region.

In conclusion, China's military-industrial complex has undergone significant growth and development in recent years, with key players in the sector playing an increasingly important role in China's military and economic potential. Cooperation between China and Russia in the military-industrial complex has been important for both countries, bringing mutual benefits in terms of technological and economic cooperation. However, there are also transformational and cooperation problems that need to be overcome, including economic and political cooperation, which should prevent the limitation of scientific and military cooperation between our countries [17].

To overcome these challenges, China and Russia can take steps to improve their interaction in all relevant areas, including strengthening trade relations, promoting technological cooperation, resolving territorial disputes, and building trust and transparency between peoples.

By taking these steps, they can create new opportunities for economic growth and development, as well as maintain peace and stability in the Asia-Pacific region and Central Asia. The future prospects for the development of China's military-industrial complex and its cooperation with Russia are promising, with room for further growth and expansion in the coming years. As the global competition for power continues to evolve and new technologies emerge, it is important that China and Russia continue to work together to build up their technology and digital cooperation to enhance opportunities for the digitalization of new business processes and the post-decoupling push between the US and China. The consequences of such a strategic innovation and investment partnership between our states, the ongoing synergy of scientific schools of cooperation will be significant not only for the two countries, but for the entire international system as a whole. This will also be able to support convergence programs in space and ongoing preparations for the creation of lunar and Martian bases in the solar system, as the pinnacle of the technological success of the military-industrial complex of Russia and China.

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SIGNS AND FACTORS OF THE DIGITAL ECONOMY IN RUSSIA

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Abstract. *The article discusses the signs and factors of the digital economy in Russia. The basis of the research is the generalization and analysis of the works of domestic and foreign economists, the study of information from official websites of public administration bodies, the use of methods of analysis, comparison and generalization.*

Keywords: *economy, digital economy, sustainable development, factors.*

The development of the digital economy in the Russian Federation is implemented on the basis of the formation of a state approach and the implementation of national programs, including the introduction of end-to-end technologies, the introduction of new methods of management, and, thus, the implementation of tasks of strategic importance, primarily in the context of the internal socio-economic well-being of the state and the fulfillment of the key condition for its development - the strengthening of national sovereignty against the background of the implementation of digital competition programs with other players in the global market. In this sense, the process of *digital transformation* has deeply affected key public and industry institutions, because the entire civil society perceives and uses the services of the «digital world» in many respects implementing the concept of «open society» (according to [6]).

The formation of the digital economy is accompanied by powerful technological, legal and resource support, the basis of which is, first of all, the legislation of the Russian Federation, as well as the provisions of other regulatory legal documents of state authorities regulating the field of information and communication technologies.

Domestic researchers [for example, 3] identify the following features of the digital economy:

- formation of a new system of values;
- the emergence of goods, services, markets based on the use of electronic technologies;

- change in the structure of the gross domestic product with an increase in the share of services;
- transformation of business models with the widespread use of digital technologies.

One of the signs of the digital economy can also be called the formation of added value through the creation of digital *economic benefits with the increasing role of the influence* of non-digital factors in ensuring economic growth associated with scientific and technological changes in the field of end-to-end technologies and the desire of states to use their advantages in the level of economic development, high technologies in as an instrument of global competition. In this case, it is important that citizens receive new knowledge and rights related to the protection of their personal digital sovereignty for intellectual property, personal data, assets in material and digital form, etc., the economy of the state and society as a whole, receive opportunities for strengthening their national and public interests, and business could offset the shocks caused by the resistance of the external environment to the business strategies of the players.

According to domestic researchers [for example, 7], including the author of the article, the digital economy is "a new type of economic system that has the signs and levels of an evolutionary economy: micro-, meso- and macro- with an adaptive projection of these signs onto the main institutional characteristics».

In our opinion, the «digital economy» is systematically formed in the organization of the economic activity of society and socio-economic relations within it, and aimed at creating greater value, through the use of technologies of the 6th technological mode, as well as reactive social processes. In this case, it becomes obvious that the use of the same solutions both for national economies and for microeconomics with different levels of political, economic or economic development is not always an effective approach.

An analysis of the economic literature shows that at the moment the conditions and factors influencing the introduction of modern technologies into the economy have not been sufficiently studied, promising directions for a particular stage have not been clearly defined, and there is no assessment of possible negative consequences for society. Let us dwell on these problems in more detail [1].

Obviously, due to the complexity, versatility of the tasks being solved, the need for intersectoral interaction and penetration into all areas, a large combination of factors influences the implementation process and efficiency: financial and economic; production and technological; socio-psychological; organizational, etc. The influence of these factors cannot be ignored or underestimated. At the same time, at the present stage of development of the digital economy, two groups of factors should be highlighted, on which the speed and efficiency of ongoing processes largely depend.

Management factors: the qualifications of decision makers, the effectiveness of corporate governance, the perception of innovations, the degree of bureaucratization and corruption.

Infrastructural factors: the development of ICT (information and communication technologies), the growth of the Internet audience, the readiness of the production infrastructure, the degree of intellectual potential in the field of ICT.

There are also [3] "strategic factors in the development of the digital economy: globalization of the economy and internationalization of business; …. transformation of the value chain structure; emergence and development of business networks; the growing role of intangible assets of enterprises; increased competition in national and international markets; the growing role of the Internet….».

The assessment of the genesis of the transformation of the socio-economic arrangement in the digital economy is inevitably influenced by new factors caused by the evolution of existing ones and the emergence of new ones, reflecting both favorable and dangerous trends and risks of a new stage of development. In the new economic order, in addition to global processes and the trend of digitalization of the economy at various levels, ecosystem factors are activated. Against this background, a dynamic ecosystem of the digital economy and economic interaction is being formed, built on the basis of information-digital and traditional ties that form the processes of either cooperation or confrontation (society, individuals, labor collective, employers). Accordingly, the synergetic aspect (see [5]) of the economic environment is updated, which, in turn, forms the activity aspects, processes of sustainable and holistic development and the existence of the digital economy ecosystem. It is obvious to assume that at this stage, it is the digital economy that creates a new ecosystem.

Therefore, in modern approaches to the management practices of complex (integrated) market systems [4] (to which the ecosystem of the digital economy as a whole belongs at the metasystem level), digital technologies are connected with the priorities of the individual and general cultural and ideological components. In addition, the tasks of creating business process management systems have been updated. Systemic issues that affect the conditions for the manifestation of factors of sustainable and continuous economic development in the digital economy ecosystem are in this case the responsibility of the head of the business unit and, in fact, require the formation of their own roadmap that provides the management concept and other business processes.

"Digital dividends" (economic results and social consequences of the use of digital technologies), such as economic growth, new jobs, budget savings, reduced delivery times and improved quality of services, are possible under certain conditions. The scientific literature considers such conditions as: digital (information infrastructure), and non-digital, «analogue» (business climate, human capital, regulation) [2].

In order to develop effective approaches and directions of the research program for the development and transformation of the digital economy in Russia, in addition to global processes and digitalization trends at the regional level, along with politics, the economic environment, and macro processes, it is important to take into account the totality of factors of the digital economy ecosystem.

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INNOVATIVE INFRASTRUCTURE OF THE REGION AS A TOOL FOR THE DEVELOPMENT OF ECONOMIC ENTITIES AS PART OF CLUSTERS

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Abstract. *The article considers the modern features of the development of the regional innovation infrastructure. The results of the analysis of the experience of developing clusters in individual countries and in the world are presented. A conceptual scheme of the mechanism of interaction of economic entities of the cluster in the innovation infrastructure of the regional economy is proposed.*

Keywords: *region, innovation infrastructure, economic entities, clusters, interaction.*

Introduction.

Today, the Russian economy faces specific tasks related to the need for its accelerated modernization, overcoming the technological gap and transfer to an innovative development path, a significant increase in its competitiveness based on sustainable economic growth. At the same time, the development of the innovation infrastructure and ensuring the effective interaction of its economic entities as part of clusters with the help of a system of tools and forms of economic, social, organizational and legal support, creating an enabling environment for the formation and sustainable development of innovative business are becoming the determining areas of action on the part of the state. The formation of an innovation infrastructure is becoming an important component of the strategy for enhancing innovation activity at the regional level. When creating it, one cannot do without various kinds of supporting institutional, network and cluster structures.

Main part.

The experience of developed countries shows that cluster structures play a leading role in the process of formation and effective functioning of the innovation

infrastructure of the regional economy [10]. In most developed countries, such structures are the most important participants in the industrial innovation policy pursued both at the national and regional levels. In accordance with the national reform programs in most European countries, support for cluster initiatives is provided either in the format of a specialized cluster policy or as part of sectoral policies. At the same time, more than 75% of all workers in the European Union (EU) are employed in clusters, and in some regions this proportion reaches 50% [4]. This circumstance indicates that clusters today are the most important component of the European economy.

The main indicators of the development of clusters in the European Union are presented in the table [8].

Table

Key indicators of cluster development in the EU

No.	Indicator	2014	2022
1	2	3	4
1	Share of investment in research and development (% of EU GDP)	2,01%	3,0%
2	Employment rate in the EU (% of the working population)	69,2%	более 75%
3	Increasing trade turnover with non-EU countries (goods) (% of EU GDP)	29%	56%
4	Increasing trade turnover with non-EU countries (services) (% of EU GDP)	9%	53%

Institutional management of economic entities of developed countries focused on innovative development occurs through their interaction within the framework of information, telecommunications and trade networks, consulting firms, technology parks, business incubators, technology transfer centers and innovation and technology centers, and a number of other structures.

An example of support for the interaction of innovative enterprises, carried out through innovative infrastructure at the state level, is the model of regional development implemented in France, based on the creation of "poles of competitiveness". The pole of competitiveness is understood as the association of enterprises, educational institutions and research institutes in a specific territory for the joint implementation of projects and increasing the competitiveness of its participants in the national and world markets due to the synergistic effect of cooperation [5]. The creation of competitiveness poles was a response to the weakening of France's position in some high-tech sectors of the economy and to disproportions in the economic development of its regions. Currently, there are 71 competitiveness poles in France [7]. The main sectors of the economy where the poles are represented are information technology, aircraft manufacturing, space research,

biotechnology development, energy, agriculture, transport, food industry, healthcare, and services. The middle pole includes about 100 organizations.

In the USA, since the 1980s, a network of innovative infrastructure of industrial technology centers has been successfully operating, which operate as branches of universities or other non-profit organizations to transfer the latest technologies and scientific achievements to industry. In addition, a network of departments was formed at scientific research organizations subsidized by the federal government to apply the scientific and technological achievements they create. The coordination of the network is carried out by the center for the application of federal technologies created under the Ministry of Commerce [1].

In the world practice of managing the innovative development of individual territories, the so-called intelligent Internet cities are used, the investment attractiveness of which allows the development of high-tech industries. Vivid examples of Internet cities are Mobile Valley in Sweden, the Emirate of Dubai in the UAE, TeleCity in Manchester. In recent years, there has been a clear trend towards the creation of global networks of innovation, among which the European business network (EBN) and the network of innovation centers (Innovation Relay Centers - IRC) occupy the leading place [9, 11].

The rapid development of Internet technologies and other new information technologies can significantly increase the efficiency of solving the problem of information support for the processes of interaction between subjects of innovative activity. One of the key elements of the innovation infrastructure of many countries is information technology systems such as ARIST, CORDIS, EPIPOS [6]. These systems are based on databases containing a wide variety of information about economic agents and the results of their innovative activities, including information about innovative products, services, technologies, intellectual property, etc.

The practice of recent years shows that regions with deeper, diversified clusters experience crisis phenomena less painfully, get out of them faster and with the least losses. Using the methodology of the cluster approach makes it possible to increase the efficiency of interaction between the state, research and educational institutions, professional associations and private business in the process of innovative development of the regional economy. These circumstances allow us to expect that in the near future the main role in ensuring the sustainable competitiveness of the national economy will be played by the cluster policy of innovative development of regions.

At present, the experience of using the cluster approach in the development of the region's innovation infrastructure is increasingly being used in Russia. The implementation of large-scale economic transformations and restructuring of large industrial enterprises is carried out on the basis of effective interaction and con-

structive cooperation of private business with universities and research organizations with the support of federal and regional government authorities. The main goal of the creation and functioning of economic entities of the innovation infrastructure is aimed at improving the efficiency and competitiveness of the regional economy through the intensive development of small and medium-sized high-tech businesses. In this regard, the experience of using the cluster approach to form effective mechanisms for the interaction of economic agents of the innovation infrastructure of the regional economy is of considerable practical interest.

For Russian economic science, the cluster approach to innovative development and increasing the competitiveness of the regional economy is still relatively new. Features of the economic development of the country and its individual regions, which are characteristic of sectoral and departmental approaches, significantly hinder the introduction of economic innovations. To the greatest extent, this affects the increase in the efficiency of the processes of interaction between economic agents of the innovation infrastructure of the regional economy. So, to date, specific methods for building innovative clusters and mechanisms for their support at the national and regional levels have not yet been developed. The issues of systemic development of the innovation infrastructure of the regional economy and improvement of the interaction of economic entities within clusters, as well as other problems of the formation and infrastructure support of innovation clusters, have not yet been resolved.

From the point of view of combining regional and sectoral interests in the development of the Russian economy, it is advisable to use the logic of the cluster approach to the organization of economic space and the structural and functional model of the mechanism of interaction between cluster subjects in the innovation infrastructure of the regional economy. The development of regional clusters in Russia is one of the determining conditions for increasing the competitiveness of the domestic economy. To realize the innovative potential of the regions and increase their competitiveness, the Strategy for the Economic Development of Russia until 2035 provides for the creation of a network of territorial production clusters [3].

An analysis of the economic and organizational component of the cluster approach made it possible to identify the optimal system of production and cooperation interactions between economic entities of the innovation infrastructure of the regional economy, as well as to reveal a complex combination of competition and cooperation between them within the cluster and beyond. Modern cluster structures provide the economic entities participating in them with a number of serious competitive advantages:

- sustainable system of distribution of new knowledge, technologies and products;

- the possibility of internal specialization and standardization;
- minimization of costs for the introduction of innovations;
- access to capital;
- access to interregional and international markets, etc. [2].

Taking into account the need to intensify the processes of formation of innovation clusters as part of the innovation infrastructure of the regional economy, it is advisable to consider opportunities for the creation and development of such economic agents as specialized technology parks, technology transfer centers, business incubators and other institutional and network structures.

As a rule, many objects of the innovation infrastructure of the regional economy are closely connected with one or more research institutes, universities (if any in the region) and (or) research centers specializing in specific areas of scientific and technological development, as well as with industrial enterprises, engaged in the development of innovative technologies and engaged in the production of innovative products. The economic entities of the innovation infrastructure of the regional economy contribute to the formation of a modern innovation environment, as well as provide support and development of innovation activities by creating a material, technical, service, financial and other basis for the effective development of innovative enterprises, commercial development of the results of scientific and technical activities and their output to the internal market. and foreign market. On this basis, it is the economic entities of the innovation infrastructure of the regional economy that can be considered as the core that can potentially form one or another cluster for the development of innovation activity.

The main goal of the functioning of economic entities of the innovation infrastructure of the regional economy as the core of the innovation cluster is to form competitive advantages both for the cluster as a whole and for its individual participants. It can be achieved through integration in a limited area, for example, within a region, the interests of executive authorities, scientific and educational institutions, banks and other financial institutions, as well as representatives of private business to ensure effective interaction between them. For this purpose, the following tasks will have to be solved in the activities of economic entities of the innovation infrastructure of the regional economy:

1. To ensure the geographical concentration of economic entities of the innovation cluster by placing them in the region and effective information exchange between them within the innovation infrastructure of the regional economy and creating a unified information space.

2. Based on stable diversified links, create network structures capable of promptly ensuring the transfer of knowledge and technologies between all cluster members.

3. To increase the efficiency of using the innovative potential of economic entities of the cluster through the commercialization of the results of scientific

and technical activities and expanding the range of forms of financing promising innovative projects.

4. To ensure the stability and efficient functioning of economic entities of the cluster based on the coordination of internal relationships between them, dynamic development, cooperation and competition.

The conceptual scheme of the mechanism of interaction of economic entities of the cluster in the innovation infrastructure of the regional economy can be represented as a functional model "core - shell". At the same time, we will understand the "core" of an innovation cluster as a group of economic entities that, due to their own potential, provide centripetal dynamics and concentrate other potential members of the cluster around themselves. In the "core" of the innovation cluster, on the one hand, economic entities of the region's innovation infrastructure, and on the other hand, their key partners, such as specialized universities, research centers, large industrial enterprises, banks and other financial institutions, can be represented.

The "shell" of the cluster can be represented by various service organizations whose profile of activity coincides with the specialization of economic entities of the cluster and which provide its participants with a wide range of high-quality services. The cluster shell can also include the executive authorities of the region responsible for the development and implementation of the innovation policy of its development.

Conclusion

Improvement of existing and creation of new mechanisms for the development of interaction between economic entities of clusters within the innovation infrastructure of the region, as well as the proposed conceptual scheme for their interaction will contribute to an increase in the share of competitive high-tech products, the creation of new jobs, convergence of interests of science and business and, ultimately, increase efficiency functioning of the innovation sector of the regional economy.

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DIGITALIZATION AND INNOVATION ACTIVITY OF SMALL ENTERPRISES IN RUSSIA

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Abstract. *The article discusses the role of small enterprises in the economic growth of Russia, the importance of their innovative activities. The structure of costs for technological innovations of small enterprises is analyzed, including by types of economic activity. It is shown that the level of digitalization of small enterprises at the present stage plays a key role in increasing the efficiency of their business.*

Keywords: *innovation, small businesses, digital technology, big data.*

A feature of the modern world economy is the widespread use of innovations to obtain a significant competitive advantage, the effective development of social reproduction processes at all levels of economic management. Creating favorable conditions for the introduction of innovations is necessary in the interests of both individual enterprises and the economy as a whole. The development of innovation activity in Russia is more relevant than ever in the context of sanctions and global instability in the world.

A special place in this process should be given to small enterprises (SE), whose share in a number of countries is significant. For example, in Canada in 2021, the share of small enterprises accounted for 63.8% of the employed in the country, 20.2% of the value of exports of goods, and for the period 2015-2019, the contribution of SE to Canada's GDP was 38% [1]. In the US, at enterprises with up to 100 employees in 2012-2017. about 30% of all workers were employed and 38% -42% of the total volume of products and services were produced [2].

Small businesses create new jobs, effectively use local resources and free production capacity, contribute to the development of competition. However, the activities of small enterprises are more exposed to risks, especially during economic and political crises. For example, during the coronavirus pandemic, small

businesses faced a shortage of labor and production resources, which negatively affected their sales and ability to meet their financial obligations. At the same time, there was a decrease in consumer spending due to a decrease in consumer income. As a result, some businesses went bankrupt [3].

A number of studies argue that for successful innovation activities, SEs must have a well-thought-out innovation policy, be associated with knowledge centers and have access to funding and budgets for research and development [4]. Other authors cite their strong market orientation, consideration of the interests of customers and attention to the business of competitors, as well as the presence of highly qualified employees as factors influencing the success of innovations of small enterprises [5]. In addition, an important factor is the widespread use of digital technologies, which allow for more efficient management of the company and contribute to the dissemination of information about its products, as well as communication with business partners, the conclusion of new contracts and agreements. According to a number of researchers, the introduction of new digital technologies stimulates the development and acquisition of new skills, competencies and knowledge, which are significant factors in the innovative activity of firms [6].

However, the digital transformation of small businesses has its own specifics. On the one hand, SEs are less subject to the need for rapid digitalization. On the other hand, they lack material, financial and human resources for the successful application of digital technologies in practice. According to some authors, in companies conducting internal research and development, digitalization does not have a direct effect on the likelihood of product or process innovation entering the market [7].

Small enterprises in Russia.

Small enterprises in Russia include individual entrepreneurs or legal entities with up to 100 official employees and a total income of no more than 800 million rubles. per year [8]. Their contribution to the Russian economy is presented in Table 1.

Table 1.

The share of SE in the economic indicators of the Russian Federation, %

Index	2015	2017	2019	2021
Number of enterprises	44,1	60,4	…	…
Average number of employees	25,2	24,5	25,4	24
Turnover of enterprises	31,2	26,6	24,1	20,8
Capital and reserves	…	10	27	33,3

Source: [9]

On average, SE accounts for about 24% of the average number of people employed in the Russian economy. In 2021, there was a decrease in the share of turn-

over of small enterprises (up to 20.8%) and an increase in the share of their capital and reserves (up to 33.3%). Most of SE's turnover came from wholesale and retail trade (51.7% in 2021) and manufacturing (12.4%). Comparing the structure of investments in the fixed capital of SE for 2019 and 2021, it should be noted an increase in the share of investments in machinery, equipment and vehicles (from 38% in 2019 to 55% in 2021) and in intellectual property (from 2 .1% to 2.6% over the same period, [9]).

The interests of the national economy in recent years have increased the importance of the innovative activity of SE. It is more focused on improving and modifying innovations, which include the development and implementation of innovations in the field of software, Internet technologies, maintenance of new equipment, engineering and other science-intensive areas. In recent years, the share of innovative goods new to the world market shipped by SE has increased (from 1.44% in 2015 to 2.68% in 2021), but at the same time, the share of innovative goods new to the sales market of the enterprise has significantly decreased (from 76 .53% in 2017 to 47.87% in 2021, Table 2)

Table 2.

The share of shipped innovative goods, newly introduced or subjected to significant technological changes by SE over the past three years, %

Type of innovations	2015	2017	2019	2021
enterprises new to the market	63,38	76,53	41,29	47,87
new to the world market	1,44	2,99	2,81	2,68

Source: [9]

The costs of small businesses for innovation in 2021 almost doubled compared to 2019, and their structure was dominated by the costs of purchasing machinery and equipment (37%) and research and development of new products (22.8%). In constant prices in 2010, the growth in the cost of innovation was 69.7% [10]. At the same time, 93.2% of SEs carried out innovative activities at their own expense (in 2020 - 69.8%). The share of innovative goods in the total volume of goods shipped by SE increased from 1.64% in 2015 to 2.8% in 2021, and the share of SE implementing technological innovations increased from 4.5% in 2015 to 7.1% in 2021 (Table 3).

Table 3.

The contribution of small enterprises to innovation activity in Russia

Index	2015	2017	2019	2021
The share of small enterprises that carried out technological innovations, %	4,5	5,18	5,91	7,1

The share of innovative goods, works, services in the total volume of shipped goods	1,64	1,59	2,36	2,8
The share of newly introduced or subjected to significant technological changes of innovative goods, works, services in the total volume of products of own production, %	1,27	1,11	1,77	2,18
The share of innovative goods, work performed, services subjected to improvement in the total volume of shipped goods, work performed, services of small enterprises, %	0,37	0,48	0,59	0,62

Source: [11]

The share of expenditures on product innovations in the total costs of innovation increased (from 73.9% in 2019 to 76.2% in 2021), while the share of process innovations decreased.

The highest values of the indicator of the level of innovative activity of SE in 2021 (the share of enterprises that carried out technological innovations in the total number of organizations surveyed) were noted at enterprises producing tobacco products (66.7%), medicines and materials (24.7%), computers, electronic and optical products (20.5%), electrical equipment (13.5%), chemicals and products (12.1%). The most significant increase in the share of innovative enterprises was in the production of coke and petroleum products (the increase in the share of innovative enterprises in 2021 was 229.4% compared to 2019), metallurgical production (117.1%) [11].

The share of innovative goods, works, services in the total volume of shipped goods, work performed, services of SE in 2021 was the highest for enterprises manufacturing computers, electronic and optical products (8.94%), medicines and materials used in medical purposes (5.79%) and water supply enterprises; water disposal, organization of collection and disposal of waste (5.38%). At the same time, the share of innovative products of enterprises producing electrical equipment has almost halved.

The innovative activity of small enterprises in Russia is limited due to the lack of its own experimental and research base, economic mechanisms for introducing the results of intellectual property into economic circulation, the lack of highly qualified managers capable of conducting innovative projects, technological and specific market risks. In 2021, 67% of respondents named the uncertainty of the economic situation in the country as the main factor hindering the innovative activity of small enterprises in Russia. A high level of inflation and a high percentage of commercial credit occupied the following 2 places in terms of the degree of

negative impact on innovation activity (they were indicated by 65% and 60% of respondents, respectively) [11].

The innovation process at the present stage is a complex of operations using digital solutions, with the development and use of marketing programs, electronic commercial platforms for additional profit. The digital transformation of the innovation system allows companies to facilitate the introduction of innovation by restructuring the process and increasing the flexibility of the system, its focus on the client.

The introduction and effective use of ICT hardware and software is one form of business innovation, as well as a prerequisite and further engine for other forms of business innovation. Not all digital technologies are relevant for SEs, but, for example, cloud computing allows them to rent IT infrastructure and software services without prior capital investment, big data analysis allows them to be used for business purposes.

In Russia, as elsewhere in the world, the coronavirus pandemic has accelerated the digitalization of enterprises. The remote form of work, the need to develop services for building a business online has led to an increase in the penetration of digital technologies. Cloud services, the development of big data technologies, the use of artificial intelligence technologies have significantly expanded the possibilities for attracting an audience by small companies and simplified their interaction with customers. In 2021, almost 25% of small enterprises in Russia used "cloud services", 23.2% - technologies for collecting, processing and analyzing big data, 5.3% - artificial intelligence technologies [9].

In 2021, a program was launched to support the digitalization of small and medium-sized businesses in Russia. During this time, more than 400 thousand licenses were acquired

for Russian-made digital solutions with a 50% discount in the amount of more than 900 million rubles. [12]. In addition, the system of state support for small and medium-sized businesses in the field of information technology allowed the number of SEs in it to increase by 81% in 2022, and their turnover in August was 17% higher than at the beginning of the year [13].

However, the digitalization of many SEs does not cover such areas as finance and accounting, procurement, personnel issues, and does not provide for the integration of all these areas into a common system. In addition, there is no clear digitalization strategy, an understanding of how to use digital technologies for the benefit of your company. To do this, it is necessary to have specialists in this field, but the share of SE costs for employee training related to the development and use of ICT decreased from 0.32% in 2015 to 0.13% in 2021.

Thus, the insufficient level of development of human resources, the backlog of the production and technological base, weak business cooperation, the lack of

use of digital technologies are factors hindering the growth of innovative activity of Russian SEs.

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DEVELOPMENT OF IN-HOUSE PROFESSIONAL TRAINING OF PERSONNEL IN THE CONDITIONS OF INNOVATION

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Annotation. *The article discusses the theoretical and practical foundations of in-house vocational training in the context of innovation. The author makes an attempt to systematize models, types and forms of in-house vocational training taking into account the changing market economy and adaptation to environmental conditions in order to effectively develop human resources.*

Keywords: *innovations, training methods, labor potential, human resource management, competencies, personnel development, human resources, human potential, human resource assessment indicators, employee engagement, efficiency of the human resource management system.*

Automation and computerization of workplaces, rapid aging of professional knowledge, shortening the time of transition to new work technologies, namely, from 3-7 years in the 70s – 80s of the last century to 0.8 – 2 years now, require multiple training and retraining of a person throughout his working life. A significant increase in the need for additional professional training requires additional costs for updating the knowledge of employees.

The current market relations put forward new requirements for personnel training – it should quickly respond to the changing needs for qualified personnel, become mobile and take into account the needs of the economy and society as a whole with maximum convergence of jobs and training places by creating a special personnel training system.

In-house training is understood as the process of improving the knowledge, skills and abilities of employees under the guidance of experienced teachers, carried out in the real space of the subject's work activity at the enterprise.

The essential features of intra-company training are: objective conditionality of training by the needs of the production process; unity of motivational, intellectual, physical and practical components of activity; conditionality of training by the specific situation prevailing in the organization; the use of a combination of the

most optimal and rational techniques, methods and means of training; the focus of the subject of training on improving methods and techniques for solving special tasks of use in the future activities.

The importance of continuing education is confirmed by the following main factors:

- the introduction of new equipment, technology, the production of modern goods, the growth of communication capabilities create conditions for the elimination or modification of certain types of work. In this regard, the necessary qualifications cannot be guaranteed by basic education;

- the world is turning into a market without borders with a high level of competition between countries. Countries with a modern system of engineering work and continuing education programs are leading in this competition. They have the opportunity to respond to any "challenge" in the shortest possible time by increasing the productivity of engineering work;

- changes in all areas of life are the main element of modernity. Continuous and rapid changes in technology and computer science require continuous training of personnel;

- it is more efficient and economical for the company to increase the return on existing employees based on their continuous training than to attract new employees.

The above aspects determine the relevance of the topic.

In the world economic literature, "innovation" is interpreted as the transformation of potential scientific and technological progress into real, embodied in new products and technologies. The term "innovation" has become actively used in the transition economy of Russia both independently and to designate a number of related concepts: "innovation activity", "innovation process", "innovative solution", etc. There are many definitions of "innovation" in the literature. For example, technical, economic, organizational, managerial, etc. innovations are distinguished based on the content or internal structure. There are such signs as the scale of innovations (global and local); life cycle parameters (identification and analysis of all stages and sub-stages), patterns of the implementation process, etc. Various authors, mainly foreign (N. Monchev, I. Perlaki, Hartman V. D., Mansfield E., Foster R., Twist B., I. Schumpeter, E. Rogers and others) interpret this concept depending on the object and subject of their research. Twist defines innovation as a process in which an invention or idea acquires economic content. F. Nixon believes that innovation is a set of technical, industrial and commercial measures that lead to the appearance of new and improved industrial processes and equipment on the market. Santo believes that innovation is a social, technical and economic process that, through the practical use of ideas and inventions, leads to the creation of products and technologies that are the best in their properties,

and if it focuses on economic benefits, profit, the appearance of innovation on the market can lead to additional income. I. Schumpeter interprets innovation as a new scientific and organizational combination of production factors motivated by the entrepreneurial spirit. In the internal logic of innovations – a new moment of accelerated movement of economic development [4; p. 139].

Currently, in relation to technological innovations, there are concepts that are reflected in International Standards in the statistics of science, technology and innovation [3; p. 223]. International standards in statistics of science, technology and innovation – recommendations of international organizations in the field of statistics of science and innovation, providing their systematic description in a market economy. In accordance with these standards, innovation is the final result of innovative activity, embodied in the form of a new or improved product introduced on the market, a new or improved technological process used in practice, or in a new approach to social services.

Thus, innovation activity is an activity aimed at commercialization of accumulated knowledge, technologies and equipment. The result of innovative activity is new or additional goods (services) or goods (services) with new qualities. The main product of innovation activity is innovation – the final result of this activity, which has been realized in the form of a new or improved product sold on the market; a new or improved process used in practice. We can also say that innovation is an innovation in the field of engineering, technology, labor organization or management, based on the use of scientific achievements and best practices.

In-house professional training of personnel in the context of innovation is a special scheme for organizing personnel training aimed at developing the professional and personal qualities of the organization's personnel in order to best achieve the goals of the organization. As a rule, in-house training programs are created specifically for a specific enterprise and are focused on the development of personnel and their preparation for changes in the organization. It can also be concluded that, firstly, in-house training is a continuous process, and secondly, it is a process initiated and managed by the company itself, based on the desire to achieve unity of interests of each individual employee and the company as a whole.

The goals of in-house training differ significantly from the point of view of the employer and the specialist himself.

The employer's point of view, German specialists V. Bartz and X. Scheibl believes that from the position of the employer, the goals of continuous in-house training are: organization and formation of management personnel; mastering the ability to identify, understand and solve problems; staff reproduction; staff integration; flexible staff formation; adaptation; introduction of innovations.

The point of view of an employee. Bartz and Scheibl define the following goals of continuous in-house education: maintaining an appropriate level and improving

professional qualifications; acquiring professional knowledge outside the field of professional activity; acquiring professional knowledge about suppliers and consumers of products, banks and other organizations that affect the work of the company; developing abilities in the field of planning and organization of production.

The impact of innovations on the processes of in-house vocational training, manifested in the dissemination of innovations. The dissemination of innovations, as well as their creation, is an integral part of the innovation process. At the same time, they proceed from the fact that the introduction of innovations is a difficult and painful process for any organization, but economic entities are forced to introduce one of the new technologies under the threat of displacement from the market. [5; p. 98]. The difficulties of implementation are explained by the fact that for the rapid spread of innovation, a developed infrastructure is needed that has a certain margin of safety and flexibility for change, since innovation implies something new for the enterprise. Accordingly, the lack of experience of interaction with innovative products and processes among the staff, the lack of understanding of the goals and objectives of innovations, their role in innovation, and the benefits received, serve as negative moments in the motivational mechanism of personnel, which reduces their organizational effectiveness. On the other hand, the presence of the above knowledge and skills of the staff, lead to a more favorable attitude to innovations.

Thus, the impact of innovations on personnel management is manifested in the fact that the lack of interaction between the goals of innovations and the mechanisms of personnel motivation management and a poor-quality approach to the organization of in-house professional training by personnel leads to negative results of innovation.

Skriptunova E.A. and Pustynnikova Yu.M. define the types of in-house professional training by personnel in the conditions of innovation, which are grouped by two key parameters, which is presented in Table 1.

The authors call active those methods of in-house professional training in the conditions of innovation, in which students themselves extract and structure information. In contrast to active, with passive teaching methods, the student receives information ready for perception and his task is only to remember it. These include most methods of traditional education, for example, a lecture [11].

Table 1

Types of in-house professional training by personnel in the conditions of innovation

Table 1

Types of in-house professional training by personnel in the conditions of innovation

“Active” teaching methods “Passive” teaching methods

Group training Training “by product”

Individual training - Coaching
-Distance learning
- Self-study Mentoring

The authors believe that there are two more types of in-house professional training by personnel in the context of innovation, which are quite difficult to place in this table, since they are mixed according to one of the criteria. It is an action learning and Learning Center. Learning by action refers to active methods, but involves both an individual and a group part of the work. The training center assumes, as a rule, group work, however, it can use both passive and active types of training, combining them into a single system. Tatulov identifies the classification of types of in-house professional training of personnel in terms of innovation from a functional point of view:

1. Training of newly arrived employees in the organization, which includes professional and socio-psychological adaptation of the employee to new conditions, the development of his own line of organizational behavior. In this case, it is extremely important to inform new employees about the organizational structure of the company, its mission and the main aspects of corporate culture.

2. Training in order to increase the level of competence. It is necessary in two cases: when the competence of an employee does not allow him to effectively and fully implement his competencies; when the competencies themselves partially change due to career development, transition to a new step of the hierarchical ladder.

3. Retraining for the purpose of rotation or development of new types of activities. Retraining mainly involves mastering basic and professional knowledge and skills necessary for mastering another type of activity.

B.E. Tatulov defines the following forms of in-house professional training of personnel in the conditions of innovation [10].

1. On-the-job training in the process of work. This form of training is the most operational, because it provides a close connection directly with the process of the employee's activity.

2. On-the-job training – this form of training can be implemented as follows: training on the territory of the organization, carried out by internal specialists of the organization itself; training on the territory of the organization, carried out by external, invited experts; training in the corporate centers of the organization.

British researchers D. Kenny and M. Reid distinguish three forms of in-house professional training of personnel in the context of innovation and call them "strategies". Strategies, in their opinion, provide an opportunity for development and imply carefully planned and systematic training [11].

1. On–the-job training is mentoring carried out by a line manager or an experienced colleague, the so-called "sitting next to Nelly".

2. The planned study of the organization's activities is usually an auxiliary form in the implementation of another, more general development program, for example, training for career development, etc. Implies the planned participation of the employee in the activities of other departments.

3. Internal training courses are effective if a number of employees connected with a common professional activity are trained at the same time with the participation of management. An alternative to training using information technology is possible: training software packages, expert systems, etc., here training can take place right at the workplace.

T. Y. Bazarov highlighted the functions of in-house professional training of personnel in the conditions of innovation:

1) the introduction of new equipment, technology, the production of modern goods, the growth of communication capabilities create conditions for the elimination or modification of certain types of work. In this regard, the necessary qualifications cannot be guaranteed by basic education;

2) the world is turning into a market without borders with a high level of competition between countries. Competing countries have the opportunity to respond to any "challenge" in the shortest possible time by increasing the productivity of engineering labor;

3) continuous and rapid changes in technology require continuous training of personnel;

4) professional development based on continuous training is more efficient and economical for the company than attracting new employees [6].

I.M. Skityaeva defines as a function of in-house professional training the development of the following qualities in the organization's employees: the skill of forming a management team; strategic business vision; the ability to manage strategic changes in business development; the ability to make decisions in conditions of uncertainty; self-discipline and organization; the ability to delegate authority and control obtaining the results necessary for business; the ability to establish and maintain constructive relationships with external sides; the ability to establish constructive relationships within the team; the ability to negotiate and convince positions.

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STRUCTURING THE HOUSING AND UTILITIES SECTOR AND DYNAMIC MODELING OF NON-EQUILIBRIUM STATES OF ITS FUNCTIONAL SUBSYSTEMS AS A BASIS FOR INCREASING THE EFFICIENCY OF ECONOMIC SUBJECTS

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Abstract. *In modern conditions, the lack of a clear management system and the presence of contradictions in achieving their interests between economic entities in the sphere of housing and communal services (HCS) significantly reduces the results of their production and economic activities. The relevance of the topic of the article is determined by the need to reform the housing and communal services sector and to carry out a comprehensive modernization of its infrastructure as soon as possible, as well as to stimulate economic entities to improve the results and quality of their activities. The subject of the study is the modeling of the activity of economic entities and subsystems of this sphere. The object of the study was the functional features of the activity of economic entities and subsystems of the housing and communal services sector and their consideration in modeling. The methodological basis of the study is presented by methods of structuring economic entities into functionally homogeneous subsystems, as well as dynamic modeling of their non-equilibrium states, taking into account the influence of spatial and temporal factors. A dynamic model of non-equilibrium states of functional economic subsystems is obtained. It can be used in the practical activities of the functional subsystems of the housing and utilities sector and their constituent economic entities in order to increase the efficiency of functioning.*

Keywords: *housing and communal services, economic entities, structuring, functional subsystems, modeling.*

Introduction

Under the conditions of complex modernization, the housing and communal services sector can be represented as a certain set of interconnected economic

subsystems, each of which specializes in the implementation of a certain function [2]. At the same time, each functional subsystem is represented by a sufficiently large set of economic entities with divergent interests in their activities. Given this approach, the state of each functional economic subsystem will be characterized by a set of indicators $x_1^i(t),...,x_m^i(t)$, which are the coordinates of the state vector $x^i(t)$ for *i-th* subsystem. For functional economic subsystems, such indicators can be the volume of serviced housing stock, the supply of communal resources, the provision of housing and communal services (HCS), etc. [4].

The dynamics of the interaction of economic entities within the framework of functional subsystems in the process of comprehensive modernization of the housing and communal services sector can be described by a number of main arguments, which are temporal and spatial factors [1]. By spatial factors we will understand a certain set of parameters of the housing and communal services sector as systems that characterize one or another of its subsystems or economic entities. For this, various indicators can be used, the presence of which in the general case indicates the heterogeneity of this area, since most of these indicators are expressed in different units of measurement. Temporal factors allow, on the one hand, to take into account the dynamics of changes in the states of functional subsystems in a certain time interval, and, on the other hand, the real rate of transformations of the states of functional subsystems in time.

Main part

1. Structuring the housing and communal services sector into functional subsystems

Almost all known approaches to modeling non-equilibrium states of functional subsystems are based on a formalized description and structuring of the housing and communal services sector by type of economic activity and the composition of subjects performing certain functional and spatial components of this activity [5]. The activity of an individual subject is largely affected by random factors, while the activity of some of their associations in the form of functional subsystems is less affected by random factors. Functional subsystems in the field of housing and communal services can be considered, on the one hand, as an integral entity, and, on the other hand, as a set of functional entities. With regard to a separate economic entity, the construction of dynamic models of non-equilibrium states of its activity and the identification of their relationships with models of non-equilibrium states of activity of other subjects is significantly difficult. To overcome these difficulties, simplified models are used that describe the formal behavior of a set of functional subjects in highly aggregated conditions. In the second case, the model of the studied set of subjects is formed on the basis of functional structuring and simple forms of their interaction with each other. Naturally, the second way is less complicated and costly, and therefore more preferable.

The principle of functional homogeneity of the main production and economic activity is the basis for structuring the subjects of the housing and communal services sector and their association into economic subsystems. At the same time, the level of detail and the relationship of a particular subject to a particular subsystem will be determined by a set of functions that are essential in modeling the development of most subjects of a particular subsystem.

The result of this approach to the decomposition of the housing and communal services sector is the allocation of homogeneous functional subsystems D^i (i = 1, …, q). in its composition. At the same time, in the course of its functioning, each of these subsystems experiences multidirectional influences of control factors - V_u^i (t, x), environmental factors - $V_v^i(t, x)$, factors of functioning of other subsystems - $V_s^i(t, x)$, which change over time and space. Taking into account the influence of the specified set of factors ensures the formation of the output result in the production activities of the subjects of a particular functional subsystem - $E^i(t, x)$.

The decomposition and structuring of the housing and communal services sector into functionally homogeneous subsystems can be considered as an innovative component of its comprehensive modernization. This approach helps to form the structure of its model for further research in terms of modeling the development of the subjects included in these subsystems. The formal structure of the housing and utilities sector can be represented by a graph that combines the above subsystems and a set of multidirectional influence factors. Its detailing can be conditionally expressed in terms of specific weights determined in the first approximation by the expert method. An important element of this kind of functional structures is the presence of relationships between all or only its individual components. It should be noted that, in addition to graphs, other structures can be used in modeling subsystems of the housing and communal services sector. However, almost all possible structures can be divided into two large groups - with rigid and probabilistic relationships between their elements.

The structure of the elements of the subsystem of the housing and communal services sector (G) will be considered rigid in the case when the interconnections between them take place and do not undergo significant changes during the considered period of its operation. If such a structure is represented by a graph, then a fixed matrix J with elements (0, 1) can be used to describe it, which has the following form:

$$J = \begin{bmatrix} 0001 \\ 0011 \\ 0101 \\ 1110 \end{bmatrix}. \quad (1)$$

Accordingly, the structure of the elements of the subsystem of the housing and communal services sector will be considered probabilistic in the case when the

relationships between them take place, but they are predominantly random. This implies the conclusion that there is not one structure, but a certain set of structures, the elements of which are a certain set of rigid structures G_1, ..., G_m, which are realized with their own probabilities peculiar only to them.

Among the methods of structuring the housing and communal services sector into functional subsystems, hierarchical methods have recently received the most widespread use. Their distinguishing feature is the presence of one or more levels of subordination, each of which can contain almost any number of subsystems. At the same time, the relationship between functional subsystems is unidirectional, in which the upper-level subsystems influence the lower-level subsystems. Formally, with the help of a hierarchical structure, it is quite easy to describe the functional sequence of relations between the subsystems of the housing and communal services sector D^i *(i = 1, ..., q)*:

$$D^{i1} > D^{i2} > ... > D^{iq}, \quad (2)$$

where i_1, ..., i_q – are numbers from the set *1, ..., q*;

$>$ - the operator of the presence of a hierarchical relationship.

The above sequence assumes that there is only one subsystem at each level, which means that it can be used to describe the relationships between rigid hierarchical structures.

For probabilistic hierarchical structures, each subsystem can have its own level of subordination with a certain probability. In this case, the above sequence becomes random [3]. However, the number of such sequences will always be finite due to the finiteness of the number of levels of subordination and the considered subsystems. So, for example, for three levels of subordination and three subsystems, provided that only one subsystem can be located at each level, the number of possible probabilistic hierarchical structures is limited to six options: *D1→D2→D3*; *D1→D3→D2*; *D2→D1→D3*; *D2→D3→D1*; *D3→D1→D2*; *D3→D2→D1*.

Thus, for a probabilistic hierarchical structure, the sequence of interconnection of its elements will be fulfilled with a certain probability

$$P = \{ D^{i1} \succ D^{i2} \succ ... \succ D^{iq} \} = p_m, \quad (3)$$

where *m* – Permutation number from *q* indices (i_1, …, i_q), *m = 1, ..., q*.

This expression defines a discrete probability distribution function (pm) on a set of hierarchical structures.

It seems obvious that the entities that are part of the functionally homogeneous subsystems of the housing and communal services sector will obey the laws of functioning of the subsystems themselves described above. This means that when modeling dynamically non-equilibrium states of the production activity of subjects, the above-described patterns of taking into account the influence of multidirectional factors in the process of model formation can be used.

2. Dynamic modeling of non-equilibrium states of functional subsystems

The relationship between the functional economic subsystems of the housing and communal services sector is realized through the exchange of products or services $u^i(t)$ false, produced by them, the volumes of which are determined depending on the current state of each subsystem. In general, this relationship is dynamic, since the available volumes of products or services are the result of a production process implemented over a certain time interval. However, for a better understanding of the essence of the proposed approach, we initially assume that the relationship we are studying is static, that is

$$u^i(t) = F^i(x^i(t)), \quad (4)$$

where F^i - the production function of each subsystem, which is predetermined.

Since the exchange of products or services is random, it results in random flows of products or services $y_{ij}(t)$ falsebetween the functional economic subsystems of the housing sector i and j. Then the process of exchanging products or services can be characterized by a matrix of flows $Y(t) = [y_{ij}(t)], i, j = 1,...,m$ [7].

Thus, the state of the housing and communal services sector as a heterogeneous macrosystem will be determined by the state of the functional economic subsystems $x(t) = \{x^1(t),...,x^m(t)\}$ false included in it and the state of the relationships between them that are formed in the process of exchanging products or services, namely, the matrix of random flows *Y(t)*. Since the real estate sector is a dynamic heterogeneous macrosystem, it is necessary to take into account the temporal features of the studied processes *x(t)* and *Y(t)*. At the same time, the main idea of modeling non-equilibrium processes in heterogeneous macrosystems is the assumption that the change in the states of functional economic subsystems *x(t)* is slower than the implementation of the processes of exchange of products or services *Y(t)*. Therefore, on a real-time scale, the dynamics of exchange processes can be replaced by a sequence of locally stationary states of functional economic subsystems.

With regard to modeling the functional subsystems of the housing and utilities sector, the process of their change over time can be represented by a system of differential or difference equations, the right side of which will depend on the current state of the economic subsystem *x(t)* and the locally stationary distribution of product or service flows *Y*(t)*:

$$\frac{dx^i(t)}{dt} = F^i\left[x^i(t), Y^*(t)\right], i = 1,...,m. \quad (5)$$

The functions F^i on the right side of these equations will be determined by the functional features of the corresponding economic subsystem of the housing and communal services sector.

To simulate the proposed approach, we fix an arbitrary time t. Since the exchange processes are random in nature, and the locally stationary states of this process are established within a small time interval Δt, then by the time $t+\Delta t$ the stationary distribution $Y^*(t)$ falseof the exchange process will be established. At the same time, the mechanism of random distribution of products or services exchange processes can be considered as a random and independent entry of some volumes of products or services into communication (i, j) with some a priori probability $\alpha_{ij}(t)$. Communication (i, j) in this case will be a set of close states with the corresponding volumes of exchange of products or services G_{ijt}, where G_{ij} is the maximum volume of exchange passing through communication (i, j). Depending on the specific relationship of the considered functional economic subsystems, the volumes of exchange of products or services $G_{ij}\Delta t$, where G_{ij} – the maximum volume of exchange passing through communication (i, j). Depending on the specific relationship of the considered functional economic subsystems, the volumes of exchange of products or services through communication (i, j) can reach the throughput G_{ij} (Fermi macrosystem) or be significantly lower than the throughput (Boltzmann macrosystem). At the same time, the macrostate N of the random distribution of the processes of exchange of products or services can be characterized by the generalized information entropies of Fermi or Boltzmann, respectively [6]:

$$H_F(N) = \sum_{n=1}^{m} N_n \ln \frac{N_n}{\tilde{\alpha}_n} + (G_n - N_n)\ln(G_n - N_n), \tag{6}$$

$$H_B(N) = \sum_{n=1}^{m} N_n \ln \frac{N_n}{e\alpha_n G_n} \tag{7}$$

The parameters of the processes of exchange of prodor services αij, qk, cijk can change over time depending on the organization of production processes in functional economic subsystems. This suggests that the parameters of the distribution process depend on the state of the considered functional economic subsystems:

$\alpha_{ij} = \alpha_{ij}(x(t)),\ q_k = q_k(x(t)),\ c_{ijk} = c_{ijk}(x(t))$. (8)

where $\alpha_{ij}(t)$ – a priori given probability;

$q_k(t)$ – volumes of exchanged products or services;

$c_{ijk}(t)$ – unit costs of exchanged products or services.

The above reasoning allows us to present the model of locally stationary distribution of non-equilibrium states of functional economic subsystems in the following form:

$$H(Y, x(t)) \Rightarrow \max Y,$$

$$\sum_{i,j=1}^{m} c_{ijk}(x(t)) y_{ij} = q_k(x(t))$$

or $\sum_{i,j=1}^{m} c_{ijk}(x(t))y_{ij} \le q_k(x(t)), k = 1,...,r$. (9)

Combining expressions (5) and (9), we obtain a dynamic model of non-equilibrium states for functional economic subsystems, which can be represented as follows:

$$\frac{dx^i(t)}{dt} = F^i\left[x^i(t), Y^*(x(t))\right], i = 1,...,m;$$

$$Y^*(x(t)) = \arg\max\left\{H(Y, x(t))\middle| Y \in D(x(t))\right\}, \quad (10)$$

where the set $D(x(t))$ false is described either by a system of equalities or by a system of inequalities from (9).

Conclusion

Based on the results obtained, the following conclusions can be drawn:

1) the housing and communal services sector can be represented as a certain set of interconnected economic subsystems, each of which specializes in the implementation of a certain function;

2) the dynamics of the interaction of economic entities within the framework of functional subsystems in the process of comprehensive modernization of the housing and communal services sector can be described by a number of main arguments, which are temporal and spatial factors;

3) since the construction of dynamic models of non-equilibrium states of the activities of subjects and the identification of their relationships with models of non-equilibrium states of the activities of other subjects is significantly difficult, it seems appropriate to structure the housing and communal services sector into functional economic subsystems;

4) since the entities that are part of the functionally homogeneous subsystems of the housing and communal services sector will obey the laws disclosed in the article, they may well be used in modeling dynamic non-equilibrium states of their activities;

5) it is established that the relationship between the functional economic subsystems of the housing and communal services sector is realized through the exchange of products or services produced by them, the volumes of which are determined depending on the current state of each subsystem;

6) a dynamic model (10) of non-equilibrium states for functional economic subsystems is obtained, in which their distributions are described either by a system of equalities or a system of inequalities.

The proposed approach to the maximum extent takes into account the real features of the process of exchanging products or services between the functional economic subsystems of the housing and communal services sector. It can be used in dynamic modeling of non-equilibrium states of these subsystems.

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DIGITAL TRANSFORMATION OF COMPETITION PROCESSES IN INTERNATIONAL BUSINESS

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Abstract. *The authors consider the emerging post-COVID trends towards the competitive advantages of various business processes in the informational scientific and technological structure of Industry 4.0., which allows combining robotic-humanoid specialization in the international division of labor, pumping labor resources and capital flight to offshore havens of a polarizing world of various competencies and geopolitical orientations between the hegemony of the Anglo-Saxons and the polycentric world order of the BRICS, SCO and EAEU countries.*

Keywords: *Industry 4.0., BRICS, SCO, EAEU, digitalization, AI, Big Data, competition, 7th scientific and technological mode, Russia, ADF, USA, China, India.*

The ongoing ADF of Russia in Ukraine divided the world forces of various competence, innovation and investment advantages between the poles of the American world [1], the fading Anglo-Saxon dominance going into a geopolitical recession and put forward new forces of technological "know-how" and the digital storm "high- tech" [2] of the growing unity of the possibilities of raw materials and industrial explosive growth, leaving in the convergence of the developing countries of Asia and the Middle East, South America and Africa [3]. The block confrontation of the Cold War is being replaced by regional alliances and military blocs, currency zones and enclaves of deindustrialized territories that are losing their historical dynamics in the competitive struggle of chibols, keiritsu conglom-

erates and Chinese “unicorns and hidden champions” of the Old World, fading to the final chords of the Marshall Plan [4].

A battle for the brains and digital nomads of the leading ICT industry, as the Swiss company Meyer Burger, the European leader in solar panels, is trying to call on the remnants of Europe’s innovative families and creative collectives to move to North America to harness the $370 billion allocated by Joe Biden for Inflation Act and guaranteeing European fresh business forces participation in the division of the climate pie for 64 billion US dollars [5].

In the same place, in addition to involving their skills and competencies in the development and maintenance of current infrastructure transformations of the «green agenda», it is the leaders of the pharmaceutical markets and chemical and drug clusters of the Old World that will be able to create a new innovative backlog of medicines that allow them to contribute and find a compromise between American costs for insurance of middle-class families and to equalize the growing costs of the state budget due to the recession for targeted and targeted medicine - the basis of global competition with Israel and country-specific medical tourism in the Middle East and Asia-Pacific countries [6].

And this means that innovations are followed by technological shifts, which, according to the theory of the same name by Joseph Schumpeter, will solve the issues of overcoming the critical vulnerabilities of the infrastructures of the future, decide the sequence and priority of fragmentation of the formed post-COVID agglomerations of international TNCs, and support the ongoing fragmentation of products and services of international translogistic value added chains. , will make glocalization of transferable advanced production from Europe to the USA a vital mainstream and create a “green light” for it inextinguishable support from the Anglo-Saxons, through the development of common approaches to the unification of protocols and standards, will develop a “friend or foe” code for future technological regulations, today it is actively promoted in the military alliances AUKUS and on the basis of its personnel forge KUAD [7].

These opportunities for innovative transformation and the accelerating digitalization of the modern information society will force the world to choose the best and most adaptive of the classic business processes of the East and West, launch AI neuroalgorithms and big data analytics (Big Data) into the ecosystems of global TNCs and TNBs, which today are increasing their influence through further concentration of capital based on the 6th wave of mergers and acquisitions and the evolution of strategic alliances of different levels of involvement, reflecting the symbiosis of the creative industries of the behavioral economy of Daniel Kahneman and Richard Thaler [8].

Therefore, the ongoing dicoupling between the US and China for leadership in the ICT sector, drawing new players into the NBICS chains, such as Japan, Israel

and South Korea, while seducing them for funding and technological support in the Asian NATO and in new types of weapons and military equipment (B and BT), as well as in the Lunar program of Donald Trump, who gave everyone a chance to join the construction of star-striped bases on the Moon and Mars, give those latent capabilities to each of the hosts in the Anglo-Saxon technological transformations and ongoing digital storms to determine their places in the global niches of digital twins, communities of gamified avatars, the Internet of things, in the metauniverses of existing marketplaces based on virtual and augmented reality, which contribute to the development of in-depth machine learning and access to a new category of resource sufficiency technologies in exchange for the existing class of innovative groundwork that makes the world more volatile and toxic, dangerous and unpredictable [9].

Here it is necessary to mention the problem of the spread of nuclear weapons, the growth of consumers for hypersonic technologies and seismic weapons like climate-controlled DARPA, which already induces many natural disasters in various regions of the planet [10].

Therefore, the tasks of the competitive struggle itself and the strategies used in it go from the level of stakeholders and insiders to the level of global governance institutions, while the opposition of John Maynard Keynes to Milton Friedman loses its meaning, because the speed of budgeting adoption at the micro and meso levels decides the processes of optimality of the structures of economic actors, and the market managed by the "invisible hand" becomes a reflection of the planned economy of concentration and redistribution of insufficient and increasingly in demand resources that are institutionally divided between the state and the union of corporatocracy, banksters and netocrats [11]. The countries themselves are shedding part of their own sovereignty and the accumulated post-COVID load of social problems, which are replaced by the solution of partially involved users in the illusion of their own management of personal choice in the labor markets, with a "brain drain" and the expected loyalty of the urban industrial zones of the future, giving only loyal labor resources a chance to survival and mimicry in the chains of urban agglomerations of the "closed cycle", which do not allow the true will of the individual to manifest itself, nor make decisions that are different from the stratum of his group or the focus niche of marketing saturation with irrational shocks of the increasingly virtualized creative industry of the consumer society and total irresponsibility [12].

This means that digitalization in matters of new strategies for competitive advantages from Michael Porter is shifting to the area of Sigmund Freud's Superego and Simon Kingsnort's integrated approach digital marketing strategies. This means that capital turnover management will no longer go only on costs or become dependent on the level of innovation of the company itself or the literacy

of its developed optimal structure for survival in the market, but will turn into the optimism of a foregone hopelessness of Philip Kotler's idea of 5 G marketing, in which each from groups of generations based on the experience of Big Data and AI neuroalgorithms [13], being a self-sufficient generation of growing and diversifying demand, will determine the end of their requests and leave the world of real solutions. At the same time, each individual, having moved to the virtual spaces of more interesting and safer worlds of the metauniverses [14], will no longer be able to distinguish between the game and the true state of things, distracting a person from the remnants of his humanity and dissolving in endless requests for an increasingly demanded degree of service satisfaction [15] and dreams of endless and unlimited shopping of a fading mind, receiving a placebo from the "freedom of self-determination" in a society of no real choice [16].

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CLASSIC TRANSFORMATION OF M&A IN INTERNATIONAL BUSINESS. FIRST RESULTS OF FUTURE SOCIETY DIGITALIZATION

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Abstract*. The authors consider the emerging post-COVID trends in building a new global infrastructure of the information society based on the symbiosis of virtual marketplaces and metauniverses, ecosystems and AI, Big Data and the integration redistribution of the world of Anglo-Saxon hegemonism and platforms for cooperative cooperation based on a polycentric world order based on mutual interests and equal opportunity societies like the BRICS, SCO and EAEU countries.*

Keywords: *Industry 4.0., BRICS, SCO, EAEU, digitalization, AI, Big Data, competition, 7th scientific and technological mode, Russia, ADF, USA, China, India.*

The geopolitical transformations taking place in the world, which were provoked by the military confrontation between the countries of the Anglo-Saxon coalition and Russia, in the ADF conducted by it in Ukraine, revealed the uncompromising nature of the two systems to squeeze the existing world order to the state of complete digital slavery with a sole leader or build a more just society. At the same time, the second way should be comprehended by philosophers and economists through the manifestation of two main global trends in international business, such as mergers and acquisitions and the creation of strategic alliances for the production of goods and services of a new quality: «smart city», «smart home», «green energy» , Internet of Things, zones of virtual and augmented reality, online marketing of an integrated approach of digital technologies that deter-

mine the formation of an innovative technological structure in the creative industries with elements of AI and big data databases (Big Data), which further support the explosive growth of productivity through the synergy of the interaction of machines and people [1].

The ongoing digitalization itself, which is perceived as a classic digital storm of inevitable transformations in economic and infrastructure shifts and overcoming the risks of emerging critical vulnerabilities in the search for optimums between real resources, personnel, and scientific and technological advantages, allows the behavioral economics of Daniel Kahneman and Richard Thaler to reveal all the accumulated imperfections of the ending post-industrial order. And the tasks of its further hedging during the transition to Industry 4.0. there will be a set of new business processes that take into account the level of industrial and geographical features, allowing clustering or through glocalization (global localization) of emerging international (translogistic and cross-border) value chains to determine the place of each state in access to the future benefits of civilization at the level of its self-sufficiency and sovereign viability [2].

It is the understanding of one's place in the MRT and in the IER, as the driving forces for the transfer of technologies and competencies of a unique orientation in the "knowledge economy" itself, that makes us approach the processes of regionalization and business transformation of the 5 waves of global mergers and acquisitions that have already taken place, to find our own, targeted motivated and staffed («brain drain» and «capital flight») reality, mastering which each economic actor could occupy a niche worthy of his level of development [3]. For the classical gradation of processes characterized as mergers can be represented as horizontal, vertical and conglomerate, oriented to the market, industry and consumer (from the customer in the form of a simple layman, qualified user, business innovator or public sector), making it possible to pull out of the incoming over the course of its non-stop evolution of each business structure management model to its most expected form - from complete absorption (friendly or hostile) to the same total merger (through the preservation of the ideas of the business itself and a certain internal corporate culture to the isolation of «tadpoles», «eggheads» , carriers of knowledge of unique competencies and qualifications, isolating the future existence of the company in global markets through international marketing towards niche specialization or possible fragmentation with existing businesses of similar business structures) [4].

Classical examples of such mergers from the past in the horizontal plane can be represented by a deal in the American military-industrial complex, where the largest corporations Northrop and Grumman merged in 1994 for 2.17 billion US dollars and became monopolies in the field of military developments in aviation and drones [5]. Their foresight was later reflected in the military and national

security doctrines of B. Obama and D. Trump, who relied on the development of the US Armed Forces and NASA through digital transformation in the form of total computerization and the transfer of combat standards to cyberspace through surveillance systems on robotic objects, including UAVs, reconnaissance aircraft systems and kamikaze drones, as a strike force that does not expose a person to direct danger, as the basis of the technical means of conducting combat operations of the armies of the future [6]. In this horizontal merger, the US government did not see violations of antitrust laws, confirming both politically and economically that encouraging the growth of scientific centers, design bureaus and research institutes with developed production sites and broad support of lobbyists of the militarizing US economy, especially after the terrorist attacks of September 11, 2001, is a concomitant the process of strengthening the national security system of Uncle Sam's country, which guarantees a further surge in the ICT industry and the alignment of tasks to achieve the level of its own critical invulnerability through ongoing dicoupling with China [7].

First of all, of course, in the self-sufficiency of components, spare parts, software and a chip backlog of national origin, which today has not yet been overcome and exposes all departments, agencies and divisions created in America (including the army and NASA) to the danger of cyber penetration through hacker attacks by embedded previously elements of digital infrastructure on gadgets of states that were not always friendly to the United States. It is precisely such fears and concerns, as well as discord and lack of unity of opinion based on three currents in the assessments of American-Chinese dicoupling) that led to securitization and complete fragmentation of technologies and components on the principle of «friend or foe» in the Anglo-Saxon block of NBICS solutions - in AUKUS. In particular, from 27-45% of all government communication channels and communications, including the unsolved tasks of transmitting the "last mile" of strategic and encrypted information, exposed the dependence on Chinese gadgets, Japanese microcircuits, Israeli surveillance cameras, South Korean materials for most operational devices. and local communication (computers, walkie-talkies and tablets) [8]. Even in NASA, up to 40% of the equipment used is of Chinese origin (Xiaomi, Huawey) or Korean technical solutions (Samsung) [9].

An example of classic vertical mergers, the 5th, pre-Covid wave of M&A transactions, can be considered the 1993 deal by Merck, which for $6 billion bought a powerfully built and massively prescription-oriented drug retailer-network Medco Containment Services, which allowed it to become an oligopolist in the market. pharmaceutical production and sales, as a research and production center and distributor of the latest drugs from medicine and dietary supplements for weight loss, which was also not protested by the relevant antitrust regulators and the commission that assesses the risks of market monopolization. Moreover,

such a merger was officially supported by the state itself, which expected an increase in the quality of sales and the drugs themselves, which should only become cheaper due to economies of scale and synergy [10].

The authors have their own version of such a demonstrative loyalty of the country's leadership to a deal that clearly monopolizes a certain segment of the market, because they see this as an attempt to lobby the interests of American pharmaceutical companies as global TNCs in the medical services market and tend to assess that these latent actions to conceal the creation emergent pandemic rapid response structures for the distribution of vaccines and for the early provision of first aid through the distribution of necessary protective items (masks, gloves, etc.). It was during these years that the world already had echoes of future covid outbreaks: swine flu and Ebola outbreaks and homogenous fevers in some African countries.

The remaining type of merger is called conglomerate, when both parties are driven by mutual commercial interest and the parties are not in a seller-buyer relationship. This is a commercial purchase for the purpose of further capitalization and sale, or a consequence of a possible insider for a potential blue ocean business. Therefore, an example of such a conglomerate merger can be the direct purchase by the tobacco giant Philip Morris in 1985 of General Foods for 5.6 billion US dollars [11].

These types of mergers were classical in nature and showed the diversification of assets and risks and the search for competitive strategies from Michael Porter, which later changed and went to the level of unconscious shocks of the behavioral economy through the digital marketing techniques of Simon Kingsnorth [12].

This means that digitalization in matters of new strategies for competitive advantages from Michael Porter and Peter Drucker is shifting to the area of Sigmund Freud's Superego and Simon Kingsnorth's integrated approach digital marketing strategies. This means that the management of capital turnover through new ideas of post-COVID mergers and acquisitions will no longer go only in terms of costs or become dependent on the level of innovation of the company itself or the literacy of its developed optimal structure for survival in the market, but will turn into the optimism of the predetermined hopelessness of Philip Kotler's idea of marketing 5 G, in which each of the groups of generations based on the experience of Big Data and AI neuroalgorithms [13], being a self-sufficient generation of growing and diversifying demand, will determine the end of their requests and leave the world of real solutions. At the same time, each individual, moving into virtual spaces of more interesting and safer worlds of metauniverses [14].

Therefore, the first results of the digitalization of future industries and services from the standpoint of mergers and acquisitions will be the creation of a unified register of future areas of capital turnover of global markets of the future [15]

and the involvement of the manufacturer as the main motivator of the consumer's consciousness in his relentless search for new entertainment and in strengthening his unwillingness to support his morale participation in the processes of modernity [16].

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FORMATION AND DEVELOPMENT OF PEOPLE WITH DISORDERS OF THE MUSCULOSKELETAL SYSTEM BY MEANS OF BALLROOM DANCE

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***Abstract**. At the present stage, one of the urgent problems is the development of people with disabilities in health. Ballroom dancing includes choreography and dancesport, making it a particularly integrated and effective way to work with such people. In working with people suffering from disorders of the musculoskeletal system, dance exercises play an increasingly important role. Dance incorporates elements of physical culture, arts and sports, making it a particularly integrated and effective way of working with such people. The report discusses the main aspects of the formation and development of people with disorders of the musculoskeletal system.*

***Keywords:** Ballroom dance, development of people with disorders of the musculoskeletal system.*

Modern society is learning to understand and accept people with disabilities. Wheelchair dancers receive invitations to appear in music videos, perform at concerts, and take an active part in the creative life of our country.

Today, wheelchair dancing is integrated into completely different areas of art. In all the cities of our large country, where wheelchair dancers practice, they are invited to participate in solemn events with demonstration shows. They perform on large and small stages of Russian cities, on public holidays they dance on Palace Square, on Red Square and in the Kremlin. Memorable for wheelchair dancers was the invitation of the President of the Russian Dance Sport Federation Pavel Pavlovich Dorokhov to perform during the 2002 European Championships in the Latin American program in front of an audience of thousands of people at the Ice Palace in St. Petersburg. This was the first recognition of wheelchair dancers as equals in the art of dance.

In world practice, more and more attention is paid to dance therapy and adaptive dances, in contrast to Russia, where these concepts have only recently begun to attract the attention of specialists in working with people with MSD.

The main goal of the dance coach in the first case is to use dance exercises to correct the emotional state of a wheelchair dancer who experiences psychological problems after fear, overexertion, etc.

Adaptive dancing got its name from the fact that here the exercises are adapted to the problems of people with a violation of the musculoskeletal system who are engaged in ballroom dancing. Adapting dance styles is a very complex and long process.

Dances adapted for this category of people can become not only a means of correcting the psychological state, but also be of great importance in adaptive physical education, for example, for the formation of life competence. In addition, such dances can be used in adaptive sports, allowing participation in competitions, including the Paralympic Games, as well as in adaptive motor recreation, providing active recreation and leisure.

Today, in our country, great attention is paid to the physical culture of the adaptive type. It involves the use of various types of exercises that help people with movement difficulties to adapt to everyday everyday life. Dance exercises are an integral part of all types of adaptive physical education.

Ballroom dancing, which is one of the effective types of adaptive physical culture, has a complex effect on wheelchair dancers. Through ballroom dancing, it is possible to work out certain aspects in the field of socialization and rehabilitation. The following aspects should be noted:

- ***Motor aspects:***
- Improvement of flexibility, dexterity, mobility of body position;
- improvement of body coordination skills;
- the skill of preparing the wheelchair for adequate movement to musical accompaniment.

- Medical aspects:

- improvement of blood circulation throughout the body;
- Compensation for limited movement.

- Psychological aspects:

- increase in self-confidence;
- creative self-realization;
- Expression of individuality.

- ***Social aspects::***

- establishment of communication between partners and groups of dancers;
- Creation of communities of dancers.

A dance coach must have a professional education in order to work with people with MSD who have limited skills and experience. That is why the coach must take into account their capabilities.

In the process of teaching ballroom dancing in wheelchairs, the coach must pay attention to certain tasks. One of the tasks is the social adaptation of the dancer. Through wheelchair dancing, the dancer's self-esteem is increased, self-confidence is formed, courage and a sense of competitiveness are increased. These aspects are an assistant in their rehabilitation in life in general and in learning to dance in particular.

Communicating with other wheelchair dancers, which builds interpersonal skills. The dancer empathizes with teammates, rejoices in their victories and shares the feelings of loss. Due to ballroom dancing, athletes improve blood circulation, which helps improve memory and attention. The creative atmosphere that reigns in the classroom helps to relieve fatigue and psychological stress, overcome shyness.

Also, in the process of ballroom dancing, people with MSD have a growing cultural aspect of perception of the surrounding reality, and an improved aesthetic taste.

Often among wheelchair users there are people who experience serious psychological problems. It is thanks to the energy of ballroom dancing, which is associated with the beauty of movement and rhythm of dance, that a person manages to find a way out of a difficult psychological state.

The adapted general educational general developmental program of the correctional orientation "Wheelchair dances for persons with musculoskeletal disorders" created by us is implemented throughout the year and is based on existing methods of socio-cultural rehabilitation. Sections of the adapted program allow you to solve certain problems and achieve certain results. The program we offer allows people with MSD to adapt to modern society, develop their physical abilities, and increase self-confidence.

The development of the motor and aesthetic capabilities of any person is the goal of ballroom dancing. According to the results of the approbation of the adapted program, the level of development in people with musculoskeletal disorders increases both physically and psychologically.

Wheelchair dancing helps people with MSD not only develop their skills, but also shape their personality, socialize and immerse themselves in the world of dance. In the process of training, they not only try on various images and enter into various roles, but also communicate with their training mates, regardless of their abilities. All this allows them to better understand the inner world of a person, his relationships and interactions.

For people with a violation of the MSD, the joy of victory and the bitterness of defeat occupies an important place for personal growth and the special importance

of communication, a social process, where it contributes to the development of mutual understanding and support between people.

Each person has a need for communication, which provides a sense of inclusion in a common activity. In adaptive dancesport, this need can be realized at several levels. First, non-verbal communication plays an important role. It is an integral part of movement training. Secondly, the need for communication and inclusion are achieved through common interests and goals, which take on a large-scale nature at competitions.

Also, an important role in communication is played by the joint experience of the results of common activities. Nothing is a barrier here. People with MSD communicate without paying attention to gender differences, national or age characteristics.

Socialization and the desire to achieve the highest sportsmanship, professionalism in the chosen sport, improvement of physical skills. Preparation for such competitions should be carried out with the help of various pedagogical approaches.

Ballroom dancing classes in wheelchairs also provide an opportunity to concentrate on new goals and switch from everyday problems, creating emotional balance and the desire for self-improvement, moral resources and spiritual strength, physical activity as a natural stimulus for life, maximum realization. Wheelchair ballroom dancing develops physical qualities and a system of movements, helping to create an individual style in performing activities.

With disorders of the musculoskeletal system, visual and vestibular systems suffer, muscle function is impaired - plasticity, hypotension or dystonia; cuts or paralysis appear; hyperkinesis, tremor, therefore, the basis of choreographic training includes exercises for the development of coordination of movements. The role of coordination of voluntary movements is extremely important, as it contributes to the precise determination of the direction of movements towards the final goal - speed, smoothness and synergy (a combination of different muscle groups of the body). In the development of movements, the visual apparatus is of great importance, thanks to which the visual perception of space is formed, that is, the idea of the surrounding objects - their size, color, shape, distance, direction of movement in space. In each spatial orientation, there is a leading and additional participation of analyzers. Only such coordinated activity contributes to the normal control of movements. The preserved function of the visual analyzer is ensured by the necessary mobility of the gaze, its fixation on a certain object and sufficient fields of view, i.e. space, all points of which are visible at the same time with a fixed gaze. Various types of strabismus, slow gaze mobility, limited visual fields, reduced visual acuity disrupt orientation in space and coordinated motor activity. None of the analyzers - motor or visual - can be leading, the activity of

both is impaired. Therefore, when teaching ballroom dancing in wheelchairs, it is necessary to include classes for the development of spatial relationships, for improving the rhythm of movements, coordination of movements, the formation of correct posture, strengthening the muscle corset, as well as the development of accuracy and clarity of movement, the development of strength, speed, reaction of movement, flexibility, etc. Due to movement disorders, wheelchair dancers have certain physical and psychological difficulties. These include: limited experience that interferes with mastering the dance and mastering your body.

For people with MSD it is important to show emotionality, creative activity and mobilize all physical and spiritual forces.

Therefore, one of the most important tasks of a dance coach is the adaptation of people with musculoskeletal disorders to this type of activity, increasing their self-confidence. This has a positive effect on the results of the formation and development of people with musculoskeletal disorders by means of ballroom dancing.

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ON THE PROBLEM OF FORMING A HEALTH-SAVING EDUCATIONAL ENVIRONMENT IN FOREIGN LANGUAGE CLASSES AT THE UNIVERSITY

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Abstract. *The article discusses the main goals, principles and techniques of health-saving technologies. Some difficulties of mastering the discipline "Foreign language" by students are revealed. Specific examples of tasks aimed at improving the level of psychological comfort of students are given. Special attention is paid to the use of interactive learning methods based on a differentiated approach. The necessity of attracting multimedia means as the requirement of the modern time is emphasized.*

Keywords: *health care, differentiated approach, personality-oriented activity, multimedia technologies, methods of active learning, relaxation.*

In the modern world, in order to withstand fierce competition in all spheres of life, it is necessary to have good health. However, the faster scientific and technological progress develops and the informatization of society increases, the faster the physical and psycho-emotional health of people, especially of the younger generation, is destroyed. Statistics show that 65% of students in Russia today have chronic diseases [1, p. 15].

Frequent skipping of classes due to poor health leads to the fact that in the future students have to learn the missed material independently, which entails an increase in their workload, fatigue and stress, and a decrease in the adaptive capabilities of the organism, in general [5, p. 105].

The discipline "Foreign Language" is known to be one of the most difficult subjects at the university, requiring many efforts to constantly concentrate one's attention, repeatedly perform training exercises and memorize a large amount of material.

In the course of working with students of technical specialties, we noticed some external signs of student fatigue: yawning, frequent change of posture, chat-

ting with a neighbor, frequent looking at the watch while waiting for the end of the lesson, an increase in the number of errors in answers, etc. Against this background, psychological discomfort increases, discipline worsens, academic performance and motivation to learn new material decrease. All this makes it necessary to form a health-saving educational environment in a foreign language class.

Let's turn to our experience of using health-saving technologies in foreign language classes.

First of all, it should be noted that the purpose of health–saving education is to ensure the mental health of students, form the knowledge, skills and abilities for a healthy lifestyle, and teach them to use the knowledge gained in everyday life.

The basic principles of health-saving pedagogy are as follows:

1. The principle of no harm
2. The principle of long-life learning
3. An integrated, interdisciplinary approach
4. The principle of pragmatism
5. The principle of consistency
6. The principle of personality-oriented activity
7. The principle of results control
8. The principle of creativity and active teaching methods, etc.

The health-saving component in teaching a foreign language is achieved through such means as taking into account the individual characteristics and interests of the audience, a differentiated approach to students with different educational background, creating a favorable psychological climate in the classroom, alternating various activities, etc.

There are the following criteria for the effectiveness of a health-saving activity:

- active mental activity;
- ensuring the emotional involvement of students in their own activities and the activities of others;
- motivation of cognitive activity;
- providing reflection and self-control;
- availability of independent work, etc.

So, first of all, our efforts are aimed at turning a foreign language lesson into a psychological comfort zone.

For this purpose, at the beginning of the lesson, methods of emotional rocking, exercises for reflection, visualization and relaxation are used. Here are some examples of these exercises:

- "Compliments". Students are invited to take turns to compliment each other starting with the first letter of their first or last name.
- "Morning gathering". Students share their plans for today with their groupmates, congratulate them on their birthdays, etc.

- "News of the day". Students exchange news related to any event in the life of the English-speaking countries, discoveries in the field of science and technology, celebrities, etc.

One of the important means of creating a favorable microclimate is the praise of students, expressed by verbal means ("Well done!", "Good job!", "Good for you!", etc.), as well as non-verbal methods of encouragement (applause, smile, facial expressions, gestures, etc.). In addition, in foreign language classes a wide practice of self-assessment and mutual assessment should take place.

Moreover, an element of emotionality and positive mood is introduced through the use of rhymes, tongue twisters, proverbs, songs, etc. It is possible to invite students to read a small poem with different intonation (surprise, joy, resentment, anger, etc.). Rhymed texts help to develop not only phonetic skills, but also serve as a good illustrative material when working out vocabulary, as well as the grammatical aspect.

Obviously, when learning a foreign language, it is very important to get away from formal cramming. So, many experts suggest using the method of mnemonic associations when memorizing new foreign words. For example, students can try to pick up a consonant word from their native language to the word that needs to be remembered, and, usinging imagination, come up with some funny story, rhyme or phrase with the correct association and competent translation. The students have only to get to remember the story. The main rule when making associations is their provocation, exaggeration, the so-called element of "forbidden fruit", etc. [2, p. 39].

As an example, we can cite the word *invent,* which is very easy to remember in such a phrase: "invent *инвентарь*".

Let's consider the use of a differentiated approach in teaching a foreign language as a way to preserve the health of students.

So, at the beginning of the course of study, we always conduct diagnostic testing, on the results of which we divide students into groups according to the level of foreign language proficiency.

Throughout the learning process, we try to use individually oriented tasks. As for the test and control tasks, in order to avoid additional stress at the end of the semester, we distribute them evenly throughout the entire period of study.

When selecting text materials, we try to take into account the gender factor. Since most of the audience consists of young men who have a rather narrowly focused and specific type of perception, we attract texts containing a significant number of visual means (graphs, charts, drawings), which remove a number of difficulties in extracting information from the text.

An important point in maintaining students' working capacity during the lesson is the change of types of work (independent work, work with a textbook (orally and in writing), creative tasks, brainstorming, etc.) for even a small period of time.

In addition, teaching a foreign language involves different modes of work (individual, frontal, pair, group). As you know, the subject "Foreign Language" is not easy for all students, so it is advisable to organize work in pairs or groups so that stronger students can support those who are not completely confident in their abilities. Such work contributes to the prevention of stress.

In our opinion, the organization of students' educational activity should cause them to experience the significance of their work. Research shows that a very difficult task reduces motivation, so we offer students only adequate tasks. To increase the self-esteem of their participation in the work, students can be interested in the prospect of receiving some kind of award, recognition (a prize-winning place at the Olympiad, conference, an article in the Conference Proceedings, etc.) [3, p. 36].

The implementation of the differentiated approach is facilitated by the organization of games, competitions, the creation of special pedagogical situations that help to reveal the merits of each student.

A foreign language makes it possible to promote a healthy lifestyle when discussing such topics as "Human, Housing, Transport Ecology, etc.", "Sports", "My Working Day". In the form of debates and round tables, you can discuss the impact of modern gadgets (phones, computers, televisions) and ecology on human health.

The objective reality of our time have become various multimedia tools, so any foreign language teacher cannot fail to take advantage of their capabilities [6, p. 119]. It is multimedia tools that have the strongest impact on students, contributing to increasing their motivation, activating their attention, and creative processing of the new information [4, p. 457].

It should be noted that students of non-linguistic specialties make with great interest PowerPoint presentations on such topics as "My Hometown", "My University", "My Specialty", "Outstanding Scientists", etc.

Some other popular activities are the creation of videos, contests of environmental posters, essays, translations of poems, quizzes, etc.

To improve the health of students, a clear organization of classes is of great importance. At the Department of Foreign Languages, Linguistics and Translation of Perm National Research Polytechnic University, there is a practice of mutual attendance of classes in order to exchange experience. A mandatory element of this procedure is filling out a questionnaire for the subsequent analysis of the lesson from the point of view of using health-saving technologies:

Lesson Quality Questionnaire

The organization of the lesson:

1) The teacher has a lesson plan

2) The structure of the lesson, its individual elements, their sequence and time proportioning, the correspondence of the lesson structure to its content and the set goal

3) A variety of types of educational activities for students

4) Forms of work with students (frontal, group, individual)

The lesson content:

1) The compliance of the content of the lesson with the requirements of the discipline work program

2) The adequate selection of materials for the lesson

3) The connection of theory with practice (disclosure of the practical significance of knowledge, the application of knowledge in practice)

4) Intra- and interdisciplinary relations

5) Access to various sources of information, including Internet resources

The methodology of the lesson:

1) The use of technical training tools and information technologies during the lesson

2) The use of visual aids, didactic material

3) The compliance of the methods with the content of the lesson, the level of students' proficiency

4) The use of innovative teaching methods (active and interactive forms of classes, computer simulations, business and role-playing games, case study, psychological and other trainings, etc.)

5) The activation of students in the classroom, a differentiated approach to working with them

6) The organization of students' independent work

7) The control of students' knowledge

8) Summing up the lesson

9) The discipline and attention of the audience during the lesson

As a rule, the results of this questionnaire are quite positive. Most teachers receive a "plus" in 15-16 positions from this questionnaire, which indicates that they pay great attention to the problem of preserving the health of students.

Summing up, it should be stated that health care should be one of the priorities of foreign language teachers at the university.

Thus, a health-saving approach to organizing foreign language teaching helps students to reveal their inherent abilities, teaches them to adapt in a rapidly changing world and minimizes the role of stress factors. Thanks to the wide possibilities of the subject, it is possible to teach students various behavioral models and try on different images in a role-playing game, increase their self-confidence and initiative, as well as develop their creative potential taking into account individual characteristics, etc.

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THE EURASIAN ECONOMIC UNION AS A POLE OF A MULTIPOLAR WORLD

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Annotation. *The world political system is in the process of transition from a unipolar to a multipolar world. There are scientific discussions about how new poles of the world can appear / form, among which the option of the emergence of a pole through the corresponding development of the integration structure of the Eurasian Economic Union (EAEU) is discussed. It is shown that the EAEU can form the pole of the new world in the event of the transition of the economies of the member countries to the sixth technological order.*

Keywords: *Multipolar world, technological and world economic structures, integration process, political and economic potential of the state and associations.*

The opinion that the Eurasian Economic Union could become the pole of a multipolar world was expressed relatively long ago. The discussion on this issue either fades or starts with renewed vigor, depending on current events in international relations. The fact that such a transition is possible in principle has repeatedly been expressed by the Minister of the Russian Foreign Ministry. S. Larov has repeatedly said that the West, led by the United States and Great Britain, "is trying to go against the objective historical processes, which can slow down the formation of multipolarity, but will in no way stop it" [1].

The Foreign Policy Concept of the Russian Federation (dated 2023) speaks of the formation of a fair and stable system of international relations, which should be multipolar" [2].

In the current year, this opinion is heard more and more often; this is apparently connected with the adaptation, first of all, of the Russian economy to the sanctions of the West and the course of the Ukrainian conflict. Already in his first speeches this year, and Russia is chairing this association in 2023, the words were said that "the Eurasian Economic Union (EAEU) has all the capabilities to

become one of the powerful, independent and self-sufficient poles of the emerging multipolar world" [3], the Russian president said.

What was said was also supported by the President of Belarus: "I am convinced that by joint efforts we will be able to fully realize the potential of our union both within the association and on the external circuit. Thus, we will be able to create one of the full-fledged, responsible centers of the new multipolar world," said Lukashenko, speaking at a meeting of the Supreme Eurasian Economic Council in an expanded format [4].

The political and expert community also did not stand aside. "Internal integration in the Eurasian Economic Union (EAEU) will make it a powerful pole of the multipolar world," said the head of the State Duma Committee on International Affairs, Leonid Slutsky, speaking at parliamentary hearings "On the priorities of the Russian chairmanship in the Eurasian Economic Union in 2023" [5].

In the political discourse of recent years, multipolarity or multicentricity is mentioned quite often.

For example, greatly simplifying the issue, we can say that theoretical constructions go back to the problem of understanding the world order, and here we can recall M. Kaplan's typology of types of international systems, where three of the five systems are associated with the principle of polycentrism. This conditionally "scientific" line can be continued with approaches to the problem of neorealism, liberalism, civilizational approach, etc.

The second line, conditionally "political", goes back to Russia's desire to get out of the western fairway, in which she had to follow after the collapse of the USSR until she got out of the crisis of the 90s. The concept showed the possibility of taking their rightful place in the world in the future.

Unfortunately, today these two lines are often intertwined. However, with the fact that the modern system of international relations is focused on the formation of a multipolar, or polycentric, world, it finds not only more and more followers, but also scientific confirmation of this position. Evidence of this is the discussion within the Russian International Affairs Council (RIAC) on the modern understanding of «multilateralism» and «multipolarity.»

Before offering our vision of building the pole of a multipolar world on the basis of the EAEU, let us clarify some initial provisions/conditions.

Based, among other things, on the discussion that unfolded within the framework of the RIAC, it seems that the main views on multipolarity and the pole itself among the countries are as follows [6]; they are presented in table 1.

Table 1.

Basic approaches to understanding multipolarity

China	Russia	USA (West)
Emphasis on material bipolarity (multipolarity). The international structure has a natural attribute. In any case, it reflects the existing asymmetry in the material potential of international actors. Two subjects - a bipolar system. There is no political connotation.	Definition of a pole on a political component. This foreign policy is aimed at demonstrating power with a shortage of material resources. This is the ability to concentrate on achieving specific foreign policy goals; resource mobilization. To maintain a consistent long-term strategy in the regions.	The emphasis is on value. The approach implies confrontation due to a mismatch of values. If there is no opposition of values, this is not a complete bipolarity.

Source: ttps://1prime.ru/world/20230418/840405080.html

One cannot but agree with the analysis presented by Zhao Huasheng and A. Kortunov. Under the circumstances, the pole in Russia is determined mainly on the basis of political significance; the possibility of political influence on international relations and, one might say, military power. In the current conditions, today, apparently, one cannot hope for «soft power».

In other words, it is obvious that without the formation of a «center of economic power» real multipolarity will not work.

The pole can be a state, a state-civilization, a region, and regional integration.

Recently, quite often the Russian (Eurasian) civilization is considered as the pole of a multipolar world [7,8].

In our opinion, a more productive approach is based on the region (regional integration) or the so-called «global region» [9]

As you know, the Russian president connects the formation of a multipolar world precisely with the development of integration. “Obviously, the union has every opportunity to become one of the powerful, independent, self-sufficient poles of the emerging multipolar world, to be a center of attraction for all independent states that share our values and seek cooperation with the EAEU,” emphasizes the President of Russia [3]. The integration structure is several states that may be different in their economic strength and have different types of economies.

Economic development, especially the steady increase in internal trade, is an important indicator of the success of integration. And in the EAEU, much attention is paid to this, especially in such areas as energy, transport, the chemical industry, mechanical engineering, and information technology. In other words, innovative areas and high value-added products. All these areas are included in

the Treaty on the EAEU developed before 2015. The EAEU began to function on January 1, 2015.

In our opinion, in the current situation, it is necessary to more accurately determine the directions and criteria for the formation of the economic component of the EAEU pole.

One of the possible and real options to form such a pole is to take into account the formation of a new technological order for the development strategy of the Eurasian Union in the context of the transformation of the world economic order.

As is known, the world economic structure is a system of international and leading national institutions that ensure the expanded reproduction of national economies and the world economy in the corresponding secular cycle of accumulation. The greatest importance here is given to the institutions of the leading country, which significantly affect world trade, economic and financial relations [10]. The process of changing the world economic structure is associated with a change in the technological structure; this is happening now.

The current change, a process that fits into the degradation of the liberal capitalist system, and attempts to preserve the existing hegemony of the United States. According to Sergei Glazyev, Academician of the Russian Academy of Sciences, today, following the American cycle, the center of economic development is shifting to Asia, where China and the countries of Southeast Asia are moving ahead. This leads and is accompanied by the escalation of the world hybrid war.

According to the academician of the Russian Academy of Sciences, these are also new "approaches to strategic planning, the functioning of public-private partnerships, an essential state component in the management of the banking system ... a model that is focused on the growth of social welfare."

In fact, these are well-known «institutions», but they need to be somewhat adapted; similar structures of Southeast Asia, and, first of all, China, can be models for this.

But so far, the Russian government has no plans in this direction.

All these problems were discussed at the RIAC round table on the sidelines of the Eurasian Congress in Sochi [11].

Thus, today, the results of the formation of the economic pole are considered in statistical data, including with the help of a system of integration indicators [12]. The formation of the pole, taking into account the concept of changing world economic structures, involves reformatting or creating institutions based on the use of the principles of non-discrimination, mutual respect for sovereignties and national interests, building equal and mutually beneficial relations with other states. The construction of the pole in this case can be considered a transition to the sixth technological order.

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FEATURES OF THE TREATMENT OF YOUNG CHILDREN IN THE PHASE OF ANURIA OF ACUTE RENAL FAILURE

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Abstract. *Based on the study of intensive care of 40 children with acute renal failure in the anuric phase at the age of 2 months to 3 years, a significantly significant increase in the activity of stress-protective, anti-inflammatory, antibacterial therapy was revealed, depending on the severity of the condition. A significantly significant inverse correlation was found between the volume of sedative and vasodilator therapy (-0.91), anesthesia and the volume of intravenous infusion (0.71), as well as sedative and diuretic therapy (0.8) in group 1. The need to strengthen anti-inflammatory therapy increased on days 17, 23.26 in group 2 and on days 4-13, on days 27-29 in children of group 3. The need to increase antibiotic therapy was identified on the 5-13th day of treatment in children of the 3rd group. There was a decrease in anticoagulant therapy with a decrease in TPR and a tendency to an increase in the introduction of an anticoagulant with a decrease in the CO in group 1. At a later date, in children of the 3rd group, it became necessary to compensate for the CBV deficiency by introducing washed erythrocytes with a daily diuresis of more than 500 ml.*

Keywords: *treatment of acute renal failure in children.*

Relevance. The most common causes of prerenal acute renal failure (ARF) in children are dehydration against the background of acute gastroenteritis, accompanied by fluid loss through the gastrointestinal tract (vomiting, diarrhea), exogenous (poisoning) and endogenous (sepsis) intoxications, and the so-called «losses in the third space» (with burns, nephrotic syndrome, liver diseases). Causes of renal acute renal failure in children include diseases of the renal parenchyma (glomerulonephritis, autoimmune and vascular damage to the kidney tissue), exposure to drugs (antibiotics and others), and nephrotoxins. Serious consequences are oliguria / anuria. The goal of intensive care for acute renal failure is to prevent potentially fatal complications and renal ischemia, such as pulmonary and cere-

bral edema, hypervolemia (volume overload), hyperkalemia, acidosis, and drug toxicity. Optimization of treatment is achieved by maintaining mean blood pressure at the level of 80-100 mm Hg, active treatment of hypoxia, ensuring zero or even negative balance for the prevention of pulmonary edema in anuria, monitoring the electrolyte composition of the blood, acid-base balance (ABB). The authors consider it unacceptable to add potassium to infusion solutions and the use of drugs that can increase potassium levels (angiotensin-converting enzyme inhibitors (ACE inhibitors)). The complex of intensive nephroprotection includes osmodiuretics (mannitol, 10-20-40% glucose solution, 7.5-10% sodium chloride solution), afferent arteriole dilators (dopamine at doses of 1-2 mcg / kg / min, eufillin 8-10 mg /kg per day), and then loop diuretics (furosemide), which should be administered as a 3 mg/kg bolus followed by a metered infusion at a rate of 0.5 mg/kg/h. The absence of a pronounced diuretic effect from the therapy, a decrease in the glomerular filtration rate, as well as an increase in creatinine or urea during the day by more than 1.5 times are indications for renal replacement therapy. Early initiation of extracorporeal detoxification helps to prevent the development of multiple organ failure. A perfusionist who provides hemodialysis in a child first of all faces the problem of hemohydrobalance disturbance and its correction. Numerous studies have confirmed the concept that antihypertensive therapy slows down the rate of progression of CKD [1-4]. However, there is not enough data on the monitoring of complex intensive care during the period of anuria in young children, which served as the basis for this study.

Goal of the work. To study the features of intensive care in children with acute renal failure in the period of anuria at an early age.

Material and research methods. The data of intensive care monitoring of 40 children with acute renal failure admitted to the ICU of RSCEM with anuria from 1 to 5 days at the age of 10 months to 3 years 4 months from the ICU of regional children's hospitals and branches of RSCEM were studied. Prior to admission to the clinic, all patients received anti-inflammatory therapy aimed at the treatment of ARI-2, pneumonia 26, glomerulonephritis - 9, AII-3 patients. According to the indications, due to severe progressive respiratory failure, patients were provided with invasive mechanical respiratory support from the first day. All patients underwent hemodialysis, 4 patients underwent hemodialysis in combination with plasmapheresis under the control of hemodynamics, acid-base status (ABS), respiratory system, maintenance, antibacterial, anti-inflammatory, syndromic corrective intensive therapy according to the recommendations in the literature. A favorable outcome with the restoration of full functional activity of the kidneys and discharge from the hospital was observed in 30 children (groups 1 and 2), an unfavorable outcome in 10 children (group 3). The first group consisted of patients who received intensive care in the ICU for up to 10 days (15), the second - children (15) with a favorable outcome after intensive care for 11-65 days.

As shown in Table 1, the duration of intensive care in children of groups 2 and 3 significantly exceeded the duration of treatment in the ICU in group 1 by 20 or more days ($p<0.05$, respectively). In group 2, the duration of mechanical respiratory support (MRS) was 18.6 ± 8 days, in group 3, a longer MRS, unfortunately, did not improve the outcome of the disease.

Table 1.

Characteristics of patients

Groups	Age, month.	Start of IVL, days	Duration of MCI, days	In ICU, days
1	29±2,8	0	0	7,8±1,5
2	19±7,7	4,3±3,5	18,6±7,6	27,8±4,3*
3	30,5±6,5	5,5±0,5	25,5±6,7	30,7±6,8*

* - the difference is significant relative to the indicator in group 1.

Results and its discussion.

The assessment of the volume of complex drug therapy consisted of counting the frequency of administration during the day in standard doses of painkillers, including sedatives, anti-inflammatory drugs (dexamethasone), antibacterial drugs, heparin (under the control of the hemocoagulation system by laboratory methods), vasodilators: calcium channel blockers, antispasmodics, eufillin, novocaine, administered in combinations according to indications, blood products (hypo / dysproteinemia - albumin 10% -20%, coagulopathy - FFP, severe anemia - erythrocyte mass), the drug of choice for diuretic therapy was mainly saluretic furosemide. The introduction of carbohydrates (hypertonic glucose) was carried out only during hemodialysis with clinical signs of an increased risk of heart failure due to an energy-deficient state due to hypoglycemia.

Table 1.

Average values of drug load in the acute period of acute renal failure by severity

Drugs, frequency of administration per day	1 group	2 group	3 group
Calories (glucose 10%-20%)	11,6±9,8	12,8±8,0	25,6±11,2
Painkillers	0,6±0,2	1,6±0,5*	1,7±0,7*
Anti-inflammatory	0,7±0,2	1,4±0,3*	1,8±0,5*
Antibiotics	2,0±0,2	3,1±0,4*	3,2±0,5*
Heparin	2,6±0,5	1,6±0,6	2,4±0,8
Vasodilators	4,8±0,8	3,1±0,8	4,0±0,5
Blood products, ml/day	34,5±11,1	24,1±17,0	57,2±50,8
Diuretics	0,4±0,3	0,2±0,2	0,1±0,02

* - deviation is significant relative to the indicator in group 1

There was a tendency to increase the administration of glucose according to the severity of the condition in group 3 almost twice as much as in groups 1 and 2. A relatively more massive analgesic supplemented with sedatives, in isolated cases barbiturates, anticonvulsants, relaxants in groups 2 and 3 was more than three times due to the need to relieve convulsive syndrome, mechanical respiratory support (MRP) due to acute respiratory failure (ARF). At the same time, the introduction of dexamethasone was 100% more in group 2, 150% in group 3 than in children of group 1. Antibacterial therapy was also more actively carried out in groups 2 and 3 by 30% ($p<0.05$), respectively). There were no significant differences in the volume of anticoagulant, vasodilator, blood replacement drugs, as well as diuretic therapy, depending on the severity of the condition. Thus, a significantly significant increase in the severity of the condition was found in more active sedative, anti-inflammatory, antibacterial therapy.

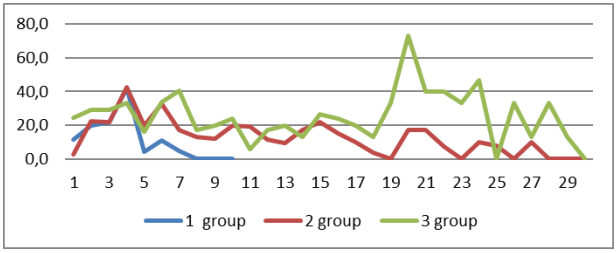

Figure 1. *Calories Administered During Hemodialysis*

The need to increase energy support during hemodialysis was identified on the 20-24th day of treatment in group 3 (Fig. 1).

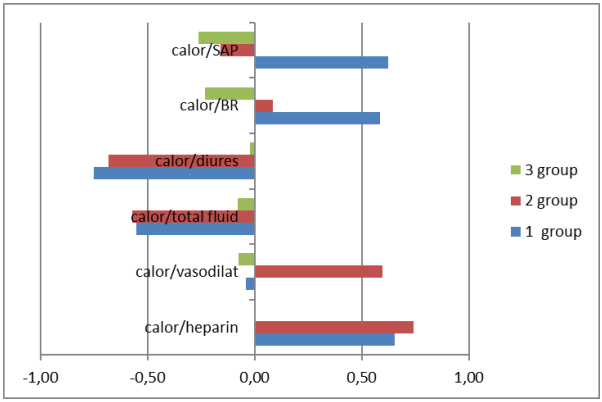

Figure 2. *Correlations of energy maintenance during hemodialysis*

There was a tendency for a direct relationship between calories and the administration of heparin (mainly during hemodialysis) (0.74) and vasodilators (0.6). Noteworthy is the inverse correlation between the administration of glucose and the amount of diuresis in groups 2 and 1 (-0.68 and -0.7).

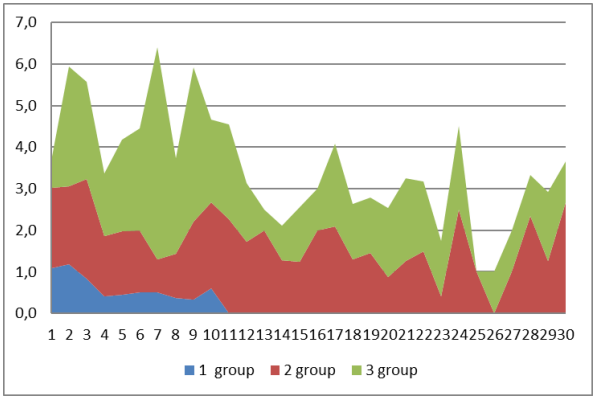

Figure 3. *Stress-protective therapy*

The most massive stress-protective therapy was carried out in the 3rd group of children.

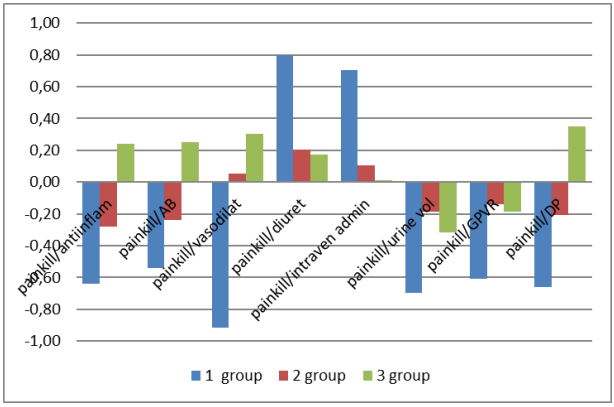

Figure 4. *Correlations of sedative + analgesic therapy*

A significant inverse correlation was found between the volume of sedative and vasodilator therapy (-0.91) and the volume of intravenous infusion (0.71) and diuretic therapy (0.8) in group 1 (Fig. 4).

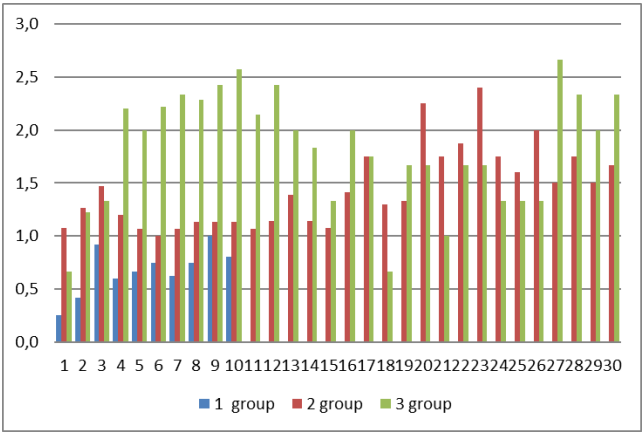

Figure 5. *Anti-inflammatory therapy.*

The need to strengthen anti-inflammatory therapy increased on days 17, 23.26 in group 2 and on days 4-13 and on days 27-29 in children of group 3 (Fig. 5).

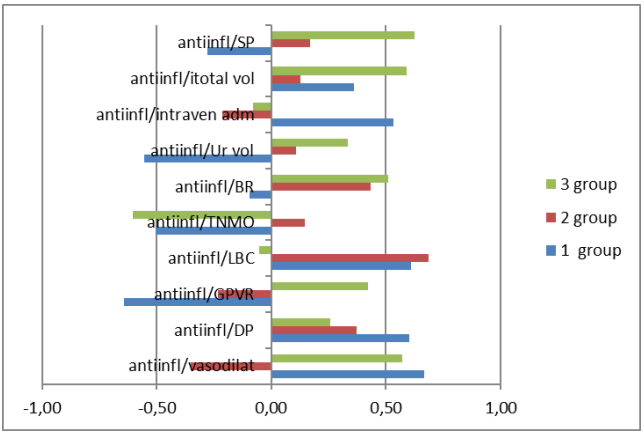

Figure 6. *Hormone therapy correlations*

A direct relationship between the administration of dexamethasone and vasodilators (0.67), as well as the daily volume of water administered (0.6), and the TPR (0.53) was revealed in group 1. The feedback of dexamethasone administration was noted with the amount of intravenous fluid administration (-0.64), with the CO indicator (-0.56) indicating the possibility of reducing the volume of infusion and reducing the CO during hormonal therapy (Fig. 6) in group 1.

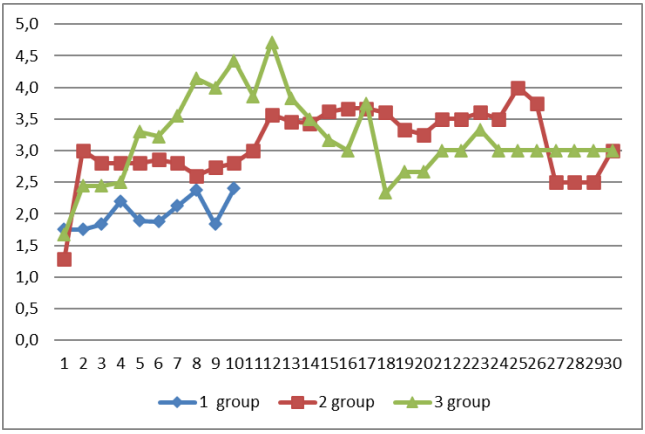

Figure 7. *Antibacterial therapy*

The need to increase antibiotic therapy was identified on days 5-13 of treatment in children of the 3rd group (Fig. 7).

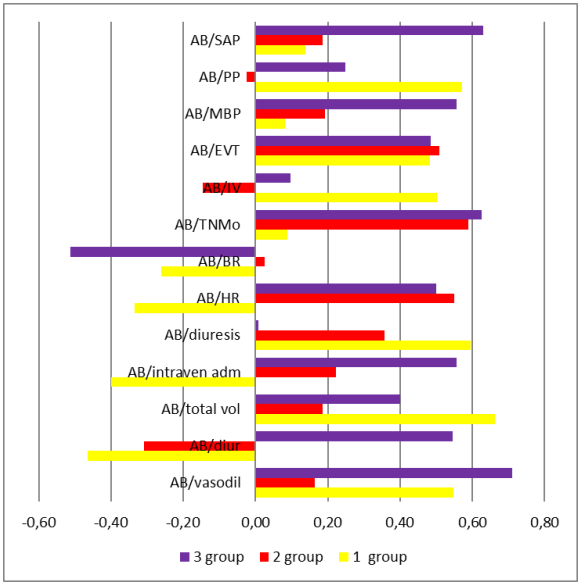

Figure 8. *Correlations of antibiotic therapy*

In the absence of significant differences between groups in the amount of vas-

odilator therapy (Table 2), there was a significantly significant direct correlation between vasodilator therapy and DBP (0.7), TPR (0.8), and inverse with diuretics (-0.8), the amount of intravenous infusion (-0.7), CO (-0.6). The revealed relationships characterize the effectiveness of the ongoing vasodilator with an increase in the effectiveness of the treatment of acute renal failure in group 1. While in children of groups 2 and 3, these connections were significantly weakened or disappeared completely (Fig. 9).

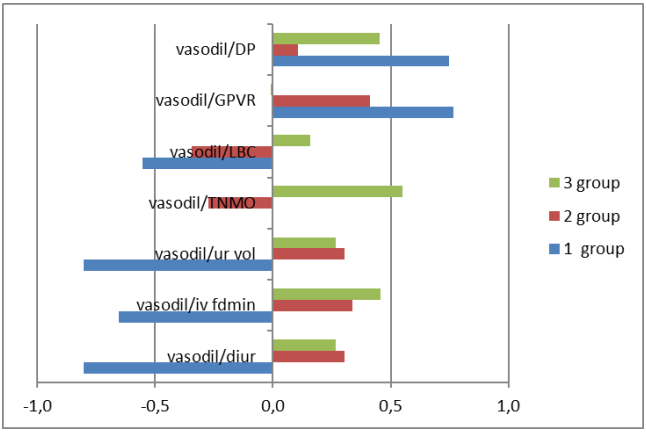

Figure 9. *Correlations of vasodilatory correction.*

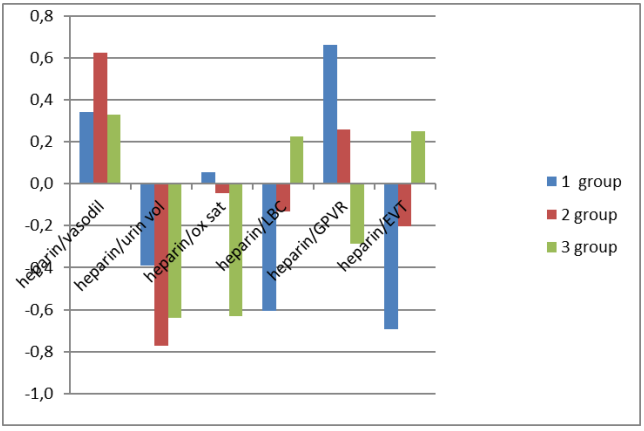

Figure 10. *Correlations of heparin administration.*

In the absence of significant differences in the frequency of anticoagulant therapy by groups, a direct correlation was found between the administration of hep-

arin and TPR (0.7) and the inverse correlation with the CO (-0.6) and AVT (-0.7) in children of the 1st group. While in groups 2 and 3, the negative relationship between the administration of an anticoagulant and the amount of urine excreted per day increased (-0.8; -0.6, respectively). The revealed characterizes a decrease in anticoagulant therapy with a decrease in TPR and a tendency to an increase in the introduction of an anticoagulant with a decrease in the CO in group 1 (Fig. 10). On the first day, a relatively greater administration of saluretics was noted in groups 1 and 2, which, already during the first three days, proved to be effective, as evidenced by the appearance of daily diuresis in group 1, an average of 32 ml, in group 2, 10 ml, while in group 3, anuria lasted for three days (Fig. 11). A trend towards an increase in the introduction of diuretics was noted in group 2 on the 10th, 20-21 days, in group 3 - on days 8,13,16.

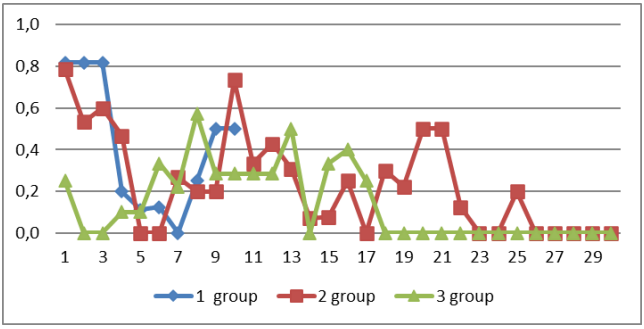

Figure 11. *Diuretics (frequency of administration).*

On the 23rd and 25th days in children of the 3rd group, it became necessary to compensate for the CBV deficiency by introducing washed erythrocytes (Fig. 12).

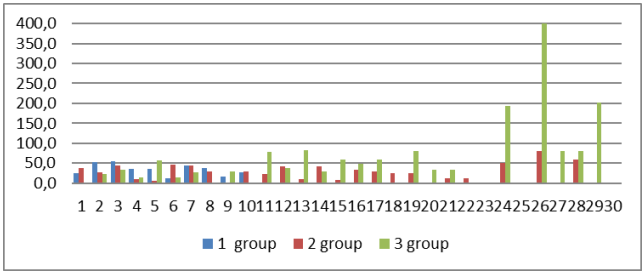

Figure 12. *The volume of administration of blood products*

There were no significant correlations between the administration of blood products and hemodynamic parameters.

Conclusion. A significantly significant increase in the activity of stress-protective, anti-inflammatory, antibacterial therapy was revealed depending on the severity of the condition. A significantly significant inverse correlation was found between the volume of sedative and vasodilator therapy (-0.91), anesthesia and the volume of intravenous infusion (0.71), as well as sedative and diuretic therapy (0.8) in group 1. The need to strengthen anti-inflammatory therapy increased on days 17, 23.26 in group 2 and on days 4-13, on days 27-29 in children of group 3. The need to increase antibiotic therapy was identified on the 5-13th day of treatment in children of the 3rd group. There was a decrease in anticoagulant therapy with a decrease in TPR and a tendency to an increase in the introduction of an anticoagulant with a decrease in the CO in group 1. At a later date, in children of the 3rd group, it became necessary to compensate for the CBV deficiency by introducing washed erythrocytes with a daily diuresis of more than 500 ml.

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FEATURES OF COMORBIDITY AND THE COURSE OF SEPSIS IN ONCOHEMATOLOGICAL PATIENTS

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Abstract. *The constant revision of the definitions of sepsis, the criteria for its diagnosis, on the one hand, reflects the growing understanding of the molecular pathophysiology of this process, on the other hand, the continuing failures in its treatment, since the mortality rate in sepsis reaches 70%. All this determines the constant search for sepsis biomarkers, which may be of the greatest importance for its diagnosis, prognosis, and treatment. In order to study the features of comorbidity and the nature of the course of sepsis in oncohematological patients, a comparative analysis of clinical observation data of 25 patients with lymphoproliferative diseases (myeloma, lymphomas) was carried out. Patients who received cytostatic therapy with and without complications of sepsis constituted the first and third groups, respectively; patients with autologous hematopoietic stem cell transplantation after a course of cytostatic therapy, also with and without complication of sepsis, made up the second and fourth groups of observations, respectively. In the statistical analysis of the obtained data, nonparametric tests were used - the Mann-Whitney test, the $\chi 2$ test, and Fisher's exact test, at $p<0.05$. Only in groups with complications of sepsis, including those with lethal outcomes, there were pronounced stages of chronic cardiovascular pathology, confirming the importance of vascular lesions in the development, course and outcomes of sepsis as a background disease. In the study of biomarkers reflecting the activity of inflammation and cellular damage, statistically significant differences were obtained in the level of C-reactive protein in both groups with sepsis when compared with groups without sepsis, in the level of lactate dehydrogenase - between the first and corresponding comparison groups (group 3). In both groups with transplantation of autologous hematopoietic stem cells, both with complication (group 2) and without complication of sepsis (group 4), a sharp*

increase in the level of LDH was detected, consistent with the literature data and associated with an increase in the level of cell lysis after transplants; there were no statistically significant differences in the level of thrombocytopenia (traditionally having a marker value) between groups with sepsis and groups without sepsis. The search for markers of risk and severe course of sepsis requires further research.

Keywords: *sepsis, oncohematology, comorbidity, markers of inflammation and cellular damage.*

Introduction

Currently, sepsis is defined as a pathological condition caused by the invasion of the pathogen and the subsequent unregulated reaction of the macroorganism, life-threatening as a result of the development of multiple organ failure [1, 2]. The last 30 years are characterized by a constant revision of the definitions of sepsis, criteria for its diagnosis, which, on the one hand, reflects a growing understanding of the physiological and pathological mechanisms of its development, the molecular pathophysiology of this process, and, on the other hand, continuing failures in the treatment of sepsis [1-4], lethality in which reaches 70% [5, 6]. Despite a growing number of studies exploring an even wider range of targeted therapies, no significant clinical progress has been achieved over the past decade [7].

Today it becomes clear that sepsis is a very complex process, in which not only a wide variety of pathological reactions take place (manifestations of inflammation, various metabolic disorders, reactions of the nervous, immune systems, hemostasis systems), but also their simultaneous development, or coexistence, when the outcome of the process as a whole is determined by the balance, in particular between inflammatory and anti-inflammatory reactions, as well as various cells of the immune system with the development of immunosuppression or its overcoming [4].

All this determines the constant search for biomarkers of sepsis, which may be of the greatest importance for its diagnosis, prognosis, and treatment [3].

Ceteris paribus, in patients, one of the reasons for the unfavorable course of sepsis may be a comorbid background [8].

This work is devoted to the first results of a comparative assessment of the features of comorbidity and the nature of the course of sepsis in patients with lymphoproliferative diseases, in whom sepsis complication occurred during therapy.

Aim of the work is to identify the features of comorbidity and the nature of the course of sepsis in oncohematological patients.

Materials and methods

A comparative analysis of the data of clinical examination and observation of 25 patients (19 men and 6 women aged 49 to 68 years) with lymphoproliferative diseases - lymphomas (7) and multiple myeloma (18), who were treated in the

hematology department and department of anesthesiology and resuscitation of the Surgut Regional Clinical Hospital in 2021-2023. Of these, patients who received a course of cytostatic therapy (CST) complicated and not by the development of sepsis constituted the group 1 and group 3, respectively, patients with autologous hematopoietic stem cell transplantation (HSCT) after CST also with and without complications of sepsis constituted the group 2 and group 4 of observations, respectively. The studied groups were comparable in terms of the age of the patients. Among patients with sepsis, positive blood cultures were obtained in three patients of the group 1 (*Staphylococcus epidermidis* (2), *Enterococcus faecium* and *Enterococcus faecalis* (1) *Escherichia coli* (1)) and in all eight patients of the group 2 (*Staphylococcus epidermidis* (5), *Staphylococcus hominis* (1), *Streptococcus mitis* (1), *Corynebacterium sp* (1)). According to a large meta-analysis, there were no significant differences in mortality from all causes, including the need for mechanical ventilation, renal replacement therapy in patients with positive or negative blood cultures (the latter are observed in 28-49% of cases), there was only a significant difference in the length of stay of patients in the intensive care unit [6]. The course of sepsis with the development of septic shock occurred in two patients of the first and one of the second group, all three had the development of multiple organ failure syndrome and death.

All patients underwent dynamic studies of clinical and biochemical blood tests (data were analyzed on the day preceding the development of symptoms of sepsis and/or transplantation of autologous hematopoietic stem cells and on the following 3rd, 5th, 7th, 9th and 11th day of observation in the hospital), as well as the necessary instrumental research methods (ultrasound, X-ray research methods, ECG, and others).

According to the principle of group formation, the study is retrospective. The criterion for inclusion of patients in the study was the presence of a lymphoproliferative disease (lymphoma or multiple myeloma) complicated by sepsis (groups 1 and 2) or its absence (groups 3 and 4) during CST in all groups and transplantation of autologous hematopoietic stem cells in patients of the 2nd and 4th groups. The exclusion criterion for all groups was the presence of a confirmed coronavirus or HIV infection. Voluntary informed consent was obtained from all patients for the use of the results of their examination in the clinic, as well as permission from the ethical committee of the Surgut State University (protocol № 34 dated March 29, 2023).

Comparative statistical analysis was performed using the Statistica 10.0 program and Microsoft Excel 2010. After determining the type of distribution of the obtained data using the Shapiro-Wilk method, the results were compared using the nonparametric Mann-Whitney test with the determination of the median (Me), the first (Q_1) and the third (Q_3) quartiles. For a comparative analysis of qualitative

indicators (the frequency of various manifestations of the process or symptoms) presented as a proportion (%) of the number of observations in each group, the $\chi 2$ test was used, including the Yates correction and Fisher's exact test. The critical level of significance in testing statistical hypotheses was taken equal to 0.05.

Results and discussion. An analysis of the nature and frequency of comorbidity showed (Table 1) that, while the frequency of diseases of the cardiovascular system was comparable in groups with and without complications of sepsis, the compared groups differed in the nature of the pathology and the stage of severity of the process. Thus, coronary artery disease, stage III hypertension (AH), and chronic heart failure were noted only in patients of the 1st group (two of whom had a lethal outcome). At the same time, in groups with autologous HSCT (i.e., the second and fourth groups), stage II hypertension prevailed among cardiovascular diseases, and in group 4, stage III hypertension was present in two cases. If diseases of the endocrine system were noted in the first, second and fourth groups, then diabetes mellitus occurred only in patients with sepsis, two of them had a fatal outcome; the frequency of overweight and obesity prevailed among patients of the 2nd group; in the 4th group, obesity of the 1st degree was noted in two. The frequency of diseases of the gastrointestinal tract, liver and biliary tract also prevailed in patients of the comparison groups. The data obtained may indicate, in our opinion, that vascular pathology of various genesis as a background disease can be of great importance in the development, course, and outcomes of sepsis, initially determining tissue perfusion deficiency, which, theoretically, progresses faster in conditions of additional vascular damage in cytokine storm. The presence of chronic organ pathology with its characteristic restructuring of the tissue substrate (death of structural elements of the tissue with an increase in fibrosis and a decrease in organ function) predetermines a decrease in compensatory-adaptive reactions in pathology, as well as a decrease in local immunity [8].

Table 1

Character and frequency of concomitant pathology (n, %)

Accompanying diseases	**Group 1 (CST, sepsis+) n=5**	**Group 2 (CST+HSCT, sepsis+), n=8**	**Group 3 (CST, sepsis-) n=3**	**Group 4 (CST + HSCT, sepsis-), n=9**
Diseases of the cardiovascular system, including:	4 (80,0)	8 (100,0)	2 (66,7)	(66,7)
ischemic heart disease	2 (40,0)	0 (0,0)	0 (0,0)	0 (0,0)
HD, including:	4 (80,0)	7 (87,5)	2 (66,7)	6 (66,7)
HD II-III stages	4 (80,0)	6 (75,0)	1 (33,3)	5 (55,6)
Chronic heart failure	3 (60,0)	0 (0,0)	0 (0,0)	1 (11,1)

Diseases of the endocrine system, including:	2 (40,0)	3 (37,5)	0 (0,0)	3 (33,3)
- diabetes mellitus	2 (40,0)	1 (12,5)	0 (0,0)	0 (0,0)
- obesity I-III degree	0 (0,0)	3 (37,5)	0 (0,0)	2 (22,2)
- hypothyroidism	0 (0,0)	0 (0,0)	0 (0,0)	1 (11,1)
Diseases of the gastrointestinal tract	4 (80,0)	5 (62,5)	2 (66,7)	6 (66,7)
Presence of DCT stigmas	3 (60,0)	7 (87,5)	3 (100,0)	8 (88,9)

Note: HD - hypertonic disease; DCT - dysplasia of connective tissue.

It is interesting that in all groups there was a high proportion of patients with visceral signs of dysplasia of connective tissue (DCT), primarily signs of disorders of the connective tissue of the cardiovascular system (aneurysm of the interventricular septum, mitral valve prolapse, additional chords of the left ventricular myocardium), which attract attention both in the aspect of hemato-mesenchymal dysplasia, and those numerous syndromes that are associated with DCT and the changing nature of epithelial-stromal relations with it [9, 10]. The concept of hemato-mesenchymal dysplasia, formulated in the eighties of the last century by Z. S. Barkagan, is based on a high frequency (20-79%) of the combination of DCT with various hemostasis disorders, or hemostatic disorders [9]. Later, coagulopathy in patients with CTD was proposed to be considered as mesenchymal cytopathy [11]. It is possible that the presence of DCT also predetermines unfavorable pre-existing or background changes during the development of sepsis.

It is difficult to classify developing complications (except for sepsis) in the analyzed groups of patients due to the combined existence of various mechanisms of their development - connection with the pathogenetic mechanisms of the underlying (basic) disease, ongoing therapy, in particular cytostatic and antibacterial, the development of sepsis as the most important complication of the underlying disease, and, again, - ongoing therapy; it is also difficult to interpret whether the syndrome is a complication or a manifestation of the underlying disease and the complication following it (Table 2).

Table 2

Structure and frequency of complications of the underlying disease (n, %)

The nature of the complications	**Group 1 (CST, sepsis+) n=5**	**Group 2 (CST+HSCT, sepsis+), n=8**	**Group 3 (CST, sepsis-) n=3**	**Group 4 (CST + HSCT, sepsis-), n=9**
Sepsis, including:	5 (100,0)	8 (100,0)	0 (0,0)	0 (0,0)

- with established bacteremia	3 (60,0)	8 (100,0)	0 (0,0)	0 (0,0)
- with the development of septic shock	2 (40,0)	1 (12,5)	0 (0,0)	0 (0,0)
- with the development of the organ dysfunction	3 (60,0)	1 (12,5)	0 (0,0)	0 (0,0)
Hemostasis system, including:	4 (80,0)	8 (100,0)	0 (0,0)	9 (100,0)
- secondary thrombocytopenia	2 (40,0)	8 (100,0)	0 (0,0)	9 (100,0)
secondary coagulopathy	2 (40,0)	0 (0,0)	0 (0,0)	0 (0,0)
- thrombosis pulmonary artery	1 (20,0)	0 (0,0)	0 (0,0)	0 (0,0)
- anemia of various genesis	4 (80,0)	2 (25,0)	2 (66,7)	3 (33,3)
Respiratory system, including:	4 (80,0)	0 (0,0)	1 (33,3)	1 (11,1)
- bilateral focal pneumonia	3 (60,0)	0 (0,0)	0 (0,0)	1 (11,1)
- spontaneous pneumothorax	0 (0,0)	0 (0,0)	1 (33,3)	0 (0,0)

In fact, in each patient, against the background of the underlying disease and ongoing therapy, a complex symptom complex is formed that determines the severity of the condition and the outcome in each specific case. At the same time, the qualitative characteristics, in particular, disturbances in the hemostasis system, are different in groups with sepsis and their corresponding comparison groups. So, secondary coagulopathy, pulmonary artery thrombosis occurred only in patients of the group 1 (in comparison with the group 3), they also have a higher frequency of anemia of various origins, but with HSCT (groups 2 and 4) disorders in the hemostasis system were noted in both groups, which may be due to the nature of chemotherapy (suppression of all bone marrow sprouts before transplantation) and the effects of the transplant itself.

Comparison of the study groups for a number of biomarkers (Table 3), reflecting the activity of inflammation and cellular damage, showed that the most marker indicators of the severe course of sepsis, including in three cases with a fatal outcome, were the level of lactate dehydrogenase (LDH) and C-reactive protein (CRP). Statistically significant differences in the level of LDH were obtained between the first group with complication of sepsis and the corresponding comparison group, or the 3rd group. At the same time, in both groups with HSCT, both with sepsis complication (group 2) and without complication (group 4), a sharp increase in LDH levels ($p>0.05$) was detected, which is consistent with the liter-

ature data and is associated with an increase in the level of cell lysis [12, 13]. An increase in serum LDH levels is the result of cell lysis occurring ex vivo, correlates with the number of apheresis procedures required to collect a sufficient amount of hematopoietic stem cells (HSC), may be the result of an increase in erythrocyte contamination with a large number of apheresis and, as a consequence - their hemolysis, which explains the negative correlation of the total dose of administered HSCs with the maximum percentage change in LDH. Cell lysis in response to transplantation of autologous hematopoietic stem cells is observed in 99% of patients, usually in the period from 1 to 5 days after transplantation [12].

Table 3

Comparative characteristics of the level of activity biomarkers inflammation and cellular damage (me (q25; q75))

Marker	Group 1 (CST, sepsis+) n=5	Group 2 (CST+HSCT, sepsis+), n=8	Group 3 (CST, sepsis-) n=3	Group 4 (CST + HSCT, sepsis-), n=9	p
LDH	534,0 (355,75; 830,75)	279,5; (135,0; 111,0)	279,5 (205,25; 336,5)	201,0 (99,0; 590,0)	p_{1-3}<0,01 p_{2-4}>0,05
CRP	34,75 (18,78; 87,18)	27,05 (4,53; 86,65)	8,1 (3,93; 27,03)	8,4 (2,20; 17,60)	p_{1-3}<0,01 p_{2-4}<0,01
Thrombo-cytopenia	132,5 (79,25; 230,75)	55,0 (34,0; 124,0)	126,0 (86,75; 194,25)	80,0 (40,0; 135,80)	p_{1-3}>0,05 p_{2-4}>0,05

Statistically significant differences were also found in the level of CRP in both groups with sepsis (groups 1 and 2) when compared with the corresponding comparison groups without sepsis (groups 3 and 4), differences in the level of thrombocytopenia (traditionally considered as a marker of an unfavorable outcome) was not revealed in the groups compared in the work.

Evaluation of the effectiveness of the search for sepsis biomarkers over the past 10 years indicates a still ongoing increase in the number of markers identified in sepsis, albeit at a slower pace than in the past. In most studies, the role of procalcitonin (PCT) and CRP, as well as interleukin (IL)-6, presepsin, and CD64 membrane glycoprotein, is more often studied. Although sepsis biomarkers can complement the clinical assessment of the process, in particular the effectiveness of ongoing therapy, real progress in the identification of biomarkers of clinical importance is negligible, and in the consensus on the definition of sepsis-3, the role of biomarkers in its diagnosis remains uncertain [3].

Conclusion

In general, patients with sepsis among oncohematological patients represent a very heterogeneous population. A simple calculation of the number of chronic

diseases is considered as an oversimplified approach in assessing the impact of comorbidity, since the combination of some diseases can trigger superadditive interactions [14].

Although it is recognized that biomarkers need to be assessed in a significant number of patients in order to achieve a random distribution of risk factors (age, organ dysfunction, nature of comorbidities) that may affect the results of the study, it is very difficult to establish the specific physiological role of individual markers, since most of they "play several roles" [3]. CRP and PCT are currently the most studied and widely used biomarkers. At the same time, the study of the dynamics of CRP can be useful for assessing the patient's individual response to therapy, in particular, changes in the level of CRP in the first 48 hours after the start of antibiotic therapy can help in assessing the response to it, the study of PCT is similarly evaluated [3] . The obtained results and literature data indicate the need to continue research.

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THE INFLUENCE OF THE DURATION OF NIGHT SLEEP ON THE PHYSICAL PERFORMANCE OF STUDENTS

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Abstract. *The article presents the results of studying the effect of the duration of night sleep on the physical performance of young men studying in specialized universities in the city of Tyumen, who have the sports qualification of a master of sports of the Russian Federation, a candidate for a master of sports and the first sports category. It is shown that the duration of night sleep has a significant effect on physical performance and is higher in young men whose sleep duration is 9 hours. The higher the athlete's qualification, the higher the level of physical performance, independent of the duration of night sleep.*

Keywords: *night sleep, students, physical performance.*

Who knows the secret of sleep, knows the secret of the brain.
M. Jouvet.

Relevance. The problem of night sleep in people of different ages and gender and its impact on the human body has always attracted the attention of specialists

in various fields [2, 3, 4, 7, 10, 11, 12, 13, 19, 20, 21]. Academician I.P. Pavlov, an outstanding Russian physiologist, considered the study of the problem of the nature of sleep to be one of the key ones in the study of higher nervous activity of a person, defining sleep as "a process of diffuse cortical inhibition" [9].

The International Association of Sleep Medicine reports that about 35% of adults of working age do not consider their sleep to be sufficient [19].

Assessment of the level of physical performance (PP) is a priority area of sports medicine, for which various methods are used [1, 3, 6, 8, 14, 15].

At present, it has been convincingly proven that FR and maximum oxygen consumption (MOC) are an integral indicator of human functional capabilities [16, 17, 18].

Purpose: to assess the PP in young men of specialized universities in the city of Tyumen, depending on the duration of night sleep.

Organization, material and research methods. The assessment of the level of FR was carried out according to the step test PWC 170 V.L. Karpman in 36 young men aged 18.47 ± 0.93 years, who are students of three specialized universities in Tyumen, who have a sports qualification of the first sports category (21), a candidate for master of sports (9) and a master of sports of the Russian Federation (6), specializing in skiing racing, biathlon, martial arts, kettlebell lifting and athletics. The duration of night sleep in 7 young men was 9 hours, in 10 - 8 hours, in 8 - 7 hours, in 6 - 6 hours and in 5 students - 4-5 hours.

The principles of voluntariness, the rights and freedoms of the individual, guaranteed by articles 21.2 and 22.1 of the Constitution of the Russian Federation, as well as the Order of the Ministry of Health and Social Development of Russia No. 774n dated August 31, 2010 "On the Council on Ethics" were observed. The study was conducted in compliance with the ethical standards set forth in the Declaration of Helsinki and the Directives of the European Community (8/609EC) and with the oral consent of the students.

Results and discussion. In young men, whose duration of night sleep was 9 hours, the RF was equal to 1287.4±19.7 kgm/min; 8 hours - 1258.1±21.1 kgm/min; 7 hours - 1224.6 ± 22.3 kgm / min; 6 hours - 1189.5±22.0 kgm/min; less than 6 hours - 1108.3±24.7 kgm/min.

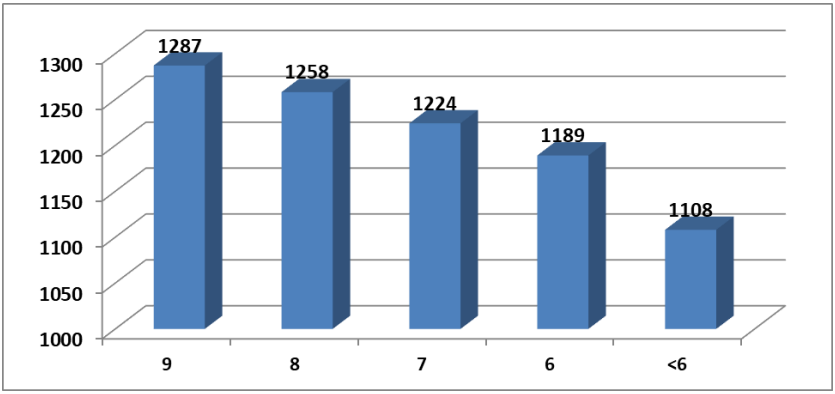

Figure 1. *Indicator of physical performance of young students of universities in Tyumen, depending on the duration of night sleep.*

Therefore, RF is highly dependent on the length of night sleep. Thus, the difference in the FR values between young men, whose night sleep duration was 9 hours, and their peers, whose night sleep duration was 8 hours, in absolute values is 29.3 kgm/min. However, as the duration of night sleep decreased, the PP of young men decreased. So, in absolute terms, the FR index in young men, whose night sleep duration was 9 hours, in comparison with young men, whose night sleep duration was 6 hours, was 97.9 kgm/min, which is statistically significant ($p<0.05$).

The minimum FR values were found in young men whose night sleep duration was less than 6 hours, while the difference in absolute values was 179.1 kgm/min, which is statistically significant ($p<0.05$).

We concluded that the higher the athlete's qualification, the less dependence of his PR on the duration of night sleep. The results of the study showed that the masters of sports of the Russian Federation have a significantly ($p>0.05$) higher FR, in comparison with young men who have the qualification of the first sports category (Fig. 2). The PP of the young men of the MS RF was 1279.8±18.6 kgm/min, the young men of the Candidate Master of Sports - 1238.6±19.3 kgm/min, the young men of the 1st sports category - 1198.1±17.9 kgm/min,

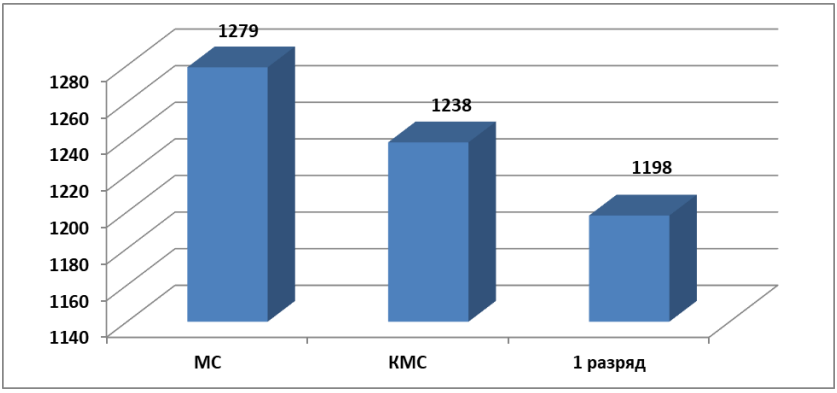

Figure 2. *Indicator of physical performance of young students of universities in Tyumen, depending on sports qualifications.*

We should agree with the opinion that when the duration of night sleep is less than 8 hours for a long time, the restoring, positive effect of sleep on the body begins to decrease [5].

Conclusion. The duration of night sleep favorably affects the FR of young men involved in sports, which is caused by a number of cumulative factors, one of which is the physiologically determined process of restoring the activity of functional systems in a state of relatively long-term functional rest. It should be taken into account that the higher the qualification of an athlete, the more resistant his body to lack of sleep, which does not affect the FR. At the same time, we consider it premature to make a long-term forecast on the possibility of maintaining a high level of risk factors and we plan to conduct a dynamic study.

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EEG FEATURES IN CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER

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Abstract. *The paper presents the importance of electroencephalographic (EEG) examination in the diagnosis of attention deficit hyperactivity disorder (ADHD) in children, taking into account the complexity of differential diagnosis. The most common features of the bioelectrical activity of the brain (BEA) of the brain in children associated with the clinical manifestations of ADHD, compared with healthy peers, are considered. The relationship between ADHD and epilepsy has been shown, including benign epileptiform patterns of childhood and subclinical manifestation of epileptiform activity on the EEG. EEG features typical for children with ADHD: decreased activity of interfrontal relations and increased level of intrahemispheric connections, functional manifestations of immaturity of the frontal-thalamic structures, signs of a deficit of nonspecific activation from the reticular formation of the brainstem, signs of hypersynchrony of rhythmic electrical activity.*

Keywords: *electroencephalography, attention deficit hyperactivity disorder, children.*

Attention deficit hyperactivity disorder (ADHD), F90.0 according to ICD-10, 6A05 according to ICD-11, is a widespread disorder in the pediatric population. In Russia, according to various estimates, from 4 to 18% of children suffer from ADHD. In other countries, similar trends are observed: for example, the preva-

lence in the USA in children is 4-20%, in the UK - 1-3%, in Italy - 3-10%, in China - 1-13%, in Australia - 7-10 %. [1]

There are the following main causes of ADHD: damage to the central nervous system (CNS) during pregnancy or childbirth; genetic predisposition; family factors; biochemical factors - a violation of the metabolism of dopamine and norepinephrine [2]. The first signs of ADHD appear before the age of 5, in boys 4-5 times more often than in girls. At early school age, more pronounced manifestations can be observed due to the fact that the child begins education in an educational institution, where it is necessary to adapt to a new daily routine and new social requirements.

The main method for diagnosing ADHD is the clinical method, i.e., the presence of symptoms of impaired attention, hyperactivity and impulsivity. Attention deficit is characterized by the following manifestations: difficulty with prolonged concentration of attention during the game or when performing tasks; inability to complete the task to the end, a quick transition from one unfinished business to another; inability to concentrate on details for a long time; the manifestation of aggression when performing tasks in which it is necessary to show concentration; distraction in ordinary situations at school and at home, forgetfulness of items necessary for completing tasks. Hyperactivity is characterized by increased motor activity: the child runs, spins, is in constant motion; makes chaotic movements of the limbs; overly talkative. Impulsivity is manifested by the fact that the child answers questions without thinking; makes shouts during a lesson at school; interferes with other children by getting into conversation and games; often fights [3].

But the use of only a clinical approach to diagnosis can lead to overdiagnosis of ADHD. The most acceptable is a comprehensive diagnostic approach, using neurophysiological diagnostic methods, namely electroencephalography. EEG diagnostics makes it possible to reveal the qualitative characteristics of disorders in the neuropsychic functions of the child's brain and to describe the nature of the disorders [4]. From the point of view of neurophysiology, there is an opinion that the hyperactivity syndrome is a compensatory reaction of the body to eliminate the disruption in the interaction of the caudate nucleus and the frontal cortex, which arise due to an imbalance of dopamine and norepinephrine. Increased hyperactivity serves as a protective mechanism for the normal interaction of brain structures with each other.

Based on the analysis of the EEG in children with ADHD, it was found that the background EEG recording corresponds to the age norm, but the results of cross-correlation analysis in the range of recorded rhythms reflect the almost complete absence of connections between the frontal and other brain structures. During hyperventilation in children with ADHD, generalized, slow-wave activity with a frequency of 3-5 Hz is recorded from the first minute of hyperventilation, throughout

the entire test, in cycles of 10-15 seconds. During the recording of slow-wave activity, according to the results of cross-correlation analysis, restoration of connections between the frontal and other structures is recorded [5].

Also, in children with ADHD, the EEG shows a decrease in interfrontal relations and an increase in communication levels in the right hemisphere in the frequency of the dominant alpha rhythm. The immaturity of the frontal-thalamic structures is revealed. The following patterns are characteristic: a decrease in the activity of interfrontal relations ($p<0.05$) and an increase in intrahemispheric connections in the right hemisphere at the frequency of the dominant alpha rhythm; high-amplitude, pointed alpha rhythm and / or a group of high-amplitude bilaterally synchronous waves of the alpha range (they are signs of hypersynchronous electrical activity of the occipital and parietal zones). In children with ADHD, EEG signs of functional immaturity of the frontal-thalamic structures, signs of a deficit of nonspecific activation from the reticular formation of the trunk, signs of hypersynchrony of the rhythmic electrical activity of the occipital and parietal zones in the form of a high-amplitude pointed alpha rhythm were revealed. The localization of changes suggests that for the children of the examined group, disturbances of not alpha rhythms, but sensorimotor rhythms, are decisive, since the main changes are manifested in the central frontal cortical zones. By analogy with the alpha rhythm, which reflects the state of functional inhibition in the visual sphere, it can be assumed that sensorimotor rhythms reflect the process of functional deactivation in the somatosensory system. Consequently, a decrease in the power characteristics of sensorimotor rhythms in the alpha range in the fronto-central cortical zones may reflect an increased activation of the sensorimotor cortex due to a deficit in inhibition in the sensorimotor system. The revealed changes in quantitative characteristics of the EEG in children with ADHD can be explained by impaired inhibition processes both at the level of cortical structures and at the level of subcortical formations [6].

Visual analysis of the EEG of children with ADHD found that the EEG typology does not differ significantly from that of healthy children. In the group of children with ADHD, as in the norm, no pathological EEG types were detected, which include EEG types 2 and 5 according to the classification of E.A. Zhirmunskaya, 1991. When analyzing individual characteristics of the EEG, a number of signs were established that indicate the existence of a certain delay in the formation of bioelectrical activity (BEA) of the brain in ADHD. The high prevalence (up to 45%) in all age periods of a pronounced and massive reaction to a test with hyperventilation can be regarded as an indication of an insufficient level of maturity of the system of interconnections between the cortex and deep structures of the brain in ADHD. Also, visual assessment of the EEG of children with ADHD reveals signs that may indirectly indicate some delay in the formation of cortical rhythms.

With ADHD in children, various pathological forms of activity are often found: an increased level of diffuse slow-wave activity, an increase in slow-wave activity, an increase in beta activity, and nonspecific paroxysmal activity. These violations of brain BEA are nonspecific, and may be the result of an organic lesion of the central nervous system in the early stages of ontogenesis, leading to microstructural damage in different parts of the brain, including the cortex itself. Such violations of the cortical rhythm may indicate dysfunction of the regulatory structures of the brain (both meso-diencephalic and lower brainstem), as well as subcortical nuclei.[7]

The most common EEG features in children with ADHD were disturbances in sensorimotor rhythms (Gorbachevskaya NL et al., 1996, 1998). These works describe a slow sensorimotor rhythm, the frequency of which lies within the theta range, and its increase in childhood hyperactivity of various origins, in particular, in fragile X syndrome, in ADHD, as well as in Rett's syndrome, which is accompanied by excessive motor activity. in the form of stereotypical movements. This type of electrical activity in the brain may be a sign of dysfunction of the motor cortex. Gorbachevskaya N.L. et al. consider a slow sensorimotor rhythm as an indicator of a violation of the inhibitory control of motor activity by the frontal parts of the brain (that is, as a sign of frontal dysfunction).

Quantitative analysis of the EEG reveals a decrease in the total power index (TPI) of the EEG in the frequency range of 0-32 Hz in all age periods, in all clinical forms and pathogenetic variants of ADHD. The most pronounced differences from the norm in the EEG power parameters of children with ADHD, identified by spectral analysis, are localized in the fronto-central and parietal regions of the brain.

There are certain areas of the brain in which differences from the norm in the quantitative characteristics of the EEG in children with ADHD are most pronounced in all age periods. Such areas are zones of representation of sensorimotor rhythms, namely the fronto-central and parietal areas of the brain [8].

According to Yu.S. Shevchenko, we can assume several cerebral mechanisms leading to the appearance of a hyperactive syndrome with impaired attention: a decrease in the level of the functional state of the cerebral cortex and a decrease in regulatory (inhibitory) influences from the cortex on subcortical structures; reduction of nonspecific activating influences from the reticular formation of the medulla oblongata and midbrain; dysfunction of the frontal-thalamic associative system; combined disorders [9].

ADHD in children is often combined with epilepsy. In general, the prevalence of epilepsy among children with ADHD is higher than in the general population. The frequency of detection of epileptiform disorders on the EEG in children with ADHD is higher than in the general population (5.6-30.1% vs. 3.5%). ADHD often occurs before the onset of epilepsy. ADHD can be combined with both a focal

form of epilepsy and a generalized one. But more often in children with a mixed form of ADHD, generalized forms were encountered, and in children with ADHD with a predominance of inattention, focal forms of epilepsy were found. In children with ADHD, the EEG (up to 40% of cases) showed rolandic spikes, which are a benign epileptiform pattern of childhood. Children with epilepsy are more likely to have symptoms of attention deficit (30-40%) than symptoms of hyperactivity. Signs of ADHD can be manifested on the EEG by subclinical epileptiform discharges (discharges of epiactivity without clinical manifestations). Studies have been conducted that have identified a link between epileptiform discharges and cognitive dysfunctions. In general, there is evidence that ADHD symptoms, especially attention deficits, may result from subclinical EEG epileptiform discharges. When subclinical epileptiform manifestations were detected on the EEG in children with ADHD, antiepileptic therapy was performed, which proved to be effective against both ADHD symptoms and epileptiform changes on the EEG [10].

Conclusion. Thus, for early, high-quality differential diagnosis of attention deficit hyperactivity disorder, it is necessary to use objective examination methods, such as electroencephalography. EEG patterns characteristic of children with attention deficit hyperactivity disorder are a decrease in the activity of interfrontal relations and an increase in the level of intrahemispheric connections, functional manifestations of immaturity of the frontal-thalamic structures, signs of a deficit of nonspecific activation from the reticular formation of the trunk, signs of hypersynchrony of rhythmic electrical activity. EEG examination is a fairly effective method in diagnosing attention deficit hyperactivity disorder, since 70-80% of children with ADHD have characteristic changes on the EEG, and epileptiform activity is detected in 5-30% of children

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ON THE ISSUE OF FINDING ALTERNATIVE METHODS OF SOIL IMPROVEMENT, GROWTH STIMULATION AND PLANT PROTECTION

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Abstract. *The article presents materials devoted to the search for new, non-reagent methods of soil improvement, growth stimulation and plant protection based on the information properties of silicon dioxide (SiO2) and the use of the effect of macroscopic quantum nonlocality. As a result of the studies, data were obtained confirming high biological activity (SiO2) with a non-contact (distant-address) method of exposure. On the example of urban soils, a significant change in the number of microorganisms in the main group of soil microbiocenosis was established. An increase in the bioproductivity of urban technozems was registered, using the example of a cucumber of the Mamluk F-1 variety, which was confirmed also on closed soils in a greenhouse, while the time for plants to reach technical maturity was reduced. The results of cytophotometric analysis of seedlings by phases of the cell cycle of cereal crops in the synthesis phase and the post-synthetic phase are higher than control samples, which explains the increase in the yield of this crop, while the infection of plants with brown rust (Puccinia recondita) decreased significantly, the "harmful turtle" bug (Eurygaster integriceps) disappeared from the experimental plots.*

Keywords: *silicon dioxide, informational properties of minerals, soil microbiocenosis, soil fertility, macroscopic quantum nonlocality in biosystems.*

As is known, the interaction of sciences forms interdisciplinary research, the share of which increases with the development of science. One of the theories under discussion postulates that all crystalline and biological systems, from protein macromolecules to the biosphere, are oscillatory systems. The fluctuation of a biosystem means that such a system is in constant expectation of a variety of ex-

ternal influences and in constant readiness, one way or another, to respond to these influences. Consequently, the biosystem, as it were, chooses possible options for interaction with the outside world and options for its possible responses. External random influences turn out to be something like a starting impulse, starting from which the biosystem can choose one change from the entire spectrum of possible, including super-weak influences at the electron level[1].

The chemical and physical properties of natural minerals determine their importance for agriculture, the production of mineral fertilizers, and the remediation of contaminated areas. Currently, interest in natural minerals is also growing due to their informational properties [2, 3]. Silicon dioxide (α-quartz) exhibits some electromagnetic properties in an electromagnetic field. When exposed to an electromagnetic field, it can exhibit effects such as polarization and dispersion. Polarization means that atoms and molecules create an electric dipole moment, and dispersion is associated with a change in the speed of propagation of electromagnetic waves in biosystems depending on their frequency. The proposed approach is based on the informational properties of silicon dioxide (SiO2) - the programmability of its frequency characteristics (superweak forces at the electron level) and the transmission of information to the target.

The purpose of this work was to study the effect of silicon dioxide, processed according to the Alfa-Quartz frequency program, on soil microbiocenosis, plant growth and development.

Materials and methods. The study of the effect of SiO2 “Alfa-Quartz” - an analogue of a low-intensity laser emitter with a controlled set of frequencies, was carried out on urbanized soils within a metropolis. The connection between the mineral and the object was established through the information matrix of the object, the distance between the agent and the recipient was 80 meters; control area - no impact. The size of the plots is 2x2 m, the distance between the plots is 15 m. Sample preparation of soil samples was carried out in accordance with GOST 17.4.4.02–84. The indicator of soil bioproductivity was cucumber seedlings of the Mamluk F-1 variety, grown in the greenhouse farm of “SelectCenter Gavrish-Slobodsky” LLC, which were monitored for 60 days. In the experiment, quantitative changes were evaluated in the main group of soil microbiocenosis. The number of bacteria, fungi, and actinomycetes was counted according to the standard method [4]. Previous studies have been carried out to study the non-local effect of SiO2 on various crops, the agent-recipient distance ranged from 25 to 50 km.

Results and discussion. As a result of the research, data were obtained confirming the high biological activity of Alfa-Quartz silicon dioxide. It has been established that the number of microorganisms in the main group of soil microbiocenosis has changed significantly. The action of the mineral led to the inhibition of bacteria and fungi and to the stimulation of actinomycetes. At the same time,

the number of bacteria in the experimental area decreased by 32%, fungi by 67%, compared with the control. The indicators of actinomycetes increased by 88.9%. The yield of cucumbers in the experimental plot averaged 880 g per plant, in the control plot there were no fruits and ovaries. Actinomycetes have gained a dominant development, displacing bacterial and fungal flora from the ecological niche, which indicates the final phase of bacterial succession and nitrogen balance. It is known that actinomycetes participate in the accumulation of biologically active substances in the soil and the formation of nitrogen balance, convert nitrogen and phosphorus contained in the soil into an easily digestible form, thereby increasing soil productivity, and, in addition, are destructurants of hydrocarbons. During the month (July), the non-local action of the mineral in the greenhouse farm of "SelectCenter Gavrish-Slobodsky" LLC led to an increase in yield by 17% (1039.4 g / plant in the experiment, 885.1 in control), while the time to reach plants of technical maturity decreased by 1 month. The distance between the mineral-greenhouse was 50 km.

Studies were also carried out on tomatoes and cereals in laboratory (together with the All-Russian Research Institute of Agricultural Biotechnology, Moscow c.) and field conditions (together with the State Sort Commission, Zakharovo, Odintsovo District, Moscow Oblast) at various distances.

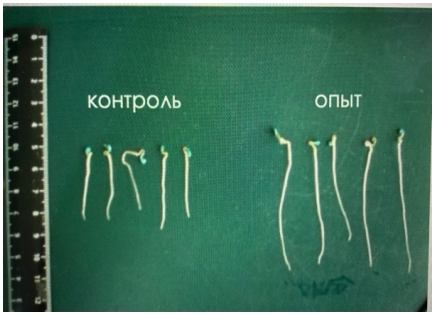

Figure 1. *Effect of SiO2 on seedlings of fumigated tomato seeds of the Baskak variety. Distance agent-recipient 25 km, exposure time 14 days.*

It has been established that the length of the root of germinated seeds of tomato variety "Baskak" under the influence of "Alfa-Quartz" is 42% more than control samples (Fig. 1), the length of the stem of seedlings of spring wheat "Zlata" under the influence of "Alpha-Quartz" increased by 30 % compared to control (Fig. 2). The results of cytophotometric analysis (Fig. 3) for the phases of the cell cycle of spring wheat "Zlata" showed an increase in cells in the synthesis phase and post-synthetic phase by 11%, which explains the subsequent increase in yield by 50%,

in addition, in the experimental fields (distance agent-recipient 40 km) recorded a 30% reduction in leaf rust (*Puccinia recondite*) infestation. (Minutes No. 1 to Contract No. 19 dated May 26, 2016, FSBI "Gossortkomissiya", Zakharovo village, Odintsovo district).

Figure 2. *Influence of SiO2 on seedlings of spring wheat "Zlata". Distance agent-recipient 25 km, exposure time 14 days.*

Figure 3. *Cytophotometric analysis. Distance agent-recipient 25 km, exposure time 14 days.*

The observed phenomena of information transfer from a mineral to a biological object at any distance belong to the field of macroscopic quantum nonlocality, a complete theory of which is currently absent. However, it is known that biomolecules (DNA, amino acids, proteins) consisting of elementary particles participate in biochemical reactions according to the laws of quantum physics [5]. The ques-

tion of the presence and use of macroscopic quantum nonlocality in biosystems is still open and refers to phenomena that cannot be described by classical laws, but the fact that this phenomenon exists has already been proven by the studies of many scientists [2, 6]. In the present work, experiments were carried out that make it possible to use quantum effects at the macroscopic level in living systems.

Conclusion. As a result of the analysis of quantitative characteristics in the main group of soil microbiocenosis, the dynamics of growth and development of vegetable and cereal crops, under the non-local action of silicon dioxide treated according to the "Alfa-Quartz" frequency program, the possibility of increasing productivity and protecting plants from adverse environmental factors was shown. Further research in this area is necessary for a deeper understanding of superweak interactions in biosystems, for solving problems of environmental protection and rational nature management based on new physical principles.

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THE RELATIONSHIP AND INTERDEPENDENCE OF THE CONCEPTS OF PULSE AND HEALTH IN TRADITIONAL CHINESE MEDICINE AND MODERN MEDICINE

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Abstract. *This article talks about six positions where wrist pulses are palpated. By palpating the pulses of these organs, it is possible to learn about the functional activity of various systems of the body as well as "secondary" formations. Thus, lungs influence and are related to skin, nose, hair and voice; spleen (pancreas) influences digestion process, blood, muscles; heart controls blood vessels, tongue and is related to thinking functions; kidneys are related to ear, anus, sexual organs. The brain, bone marrow, bone system, uterus and ovaries depend on their activities; the liver affects the musculoskeletal system, genitourinary organs, eyes and nails. The Cube Model is formulated to explain the relationship and interdependence between the arterial pulse and the eight elements of pulse status at six points on the right and left hands, and between the eight elements at six points and health status in TCM.*

Keywords: *blood, blood cells, pulse wave, blood velocity, pulse parameters, hypertension.*

Introduction

Pulse diagnosis has been known since before our era. The greatest number of extant literary sources are of ancient Chinese and Tibetan origin.

Among the traditional ancient Chinese sources are fundamental works such as Bin-hu Mo-shue [1], Xiang-lei-shi, Zhu-bin-shi, Nan-jin, and sections in the treatises Jia-i-jing, Huang-di Nei-jin [2], Su-wen Lin-shu, etc.

One of the greatest connoisseurs of pulse diagnosis is considered to be Bian Que, the Chinese physician (V-IV centuries B.C.). There are amazing legends

about him. According to some sources, in those days strange men were forbidden to see women. And because most doctors were men and for this reason could not examine sick women, various methods were developed to examine their pulse. For example, a thin string or ribbon was tied to a woman's wrist, the other end of which was led to a doctor behind a curtain. The doctor would determine the patient's pulse by the movement of the ribbon. Legend has it that Bian Que not only possessed a similar diagnostic method, but also surprised his contemporaries by determining the presence of life in patients thought to be dead.

Subsequently, his follower Tai Tsangun (267-215 BC) developed and refined the teachings of the pulse.

Bian-Cho, in his book "Nei-Ting" published in the Qing dynasty (221-207 B.C.), wrote that every process in the organism and every organ has its "concentration" point (cunkou) on the radial artery of the hand.

Detailed explanations of how, by examining the pulse, one can identify disease and even predict its outcome, are contained in the writings of one of the leading physicians of the Han era, Chun Yu-yi (215-177 BC).

Considerable attention to the issues of pulse diagnosis is given in 18-volume classic canon of Chinese medicine – "Huang-di nei-jing"[2] ("Book of Nature and Life" – beginning of III century BC), written in the form of dialogue of the Yellow Emperor with the court physicians.

Already in our era belongs to the Confucianist Huang Tu-yi (215-282 A.D.)'s Jia-Yi Jing, which consists of 12 volumes. The fourth volume is devoted to the doctrine of the pulse.

However, more complete information is thought to have been gathered in the "Science of the Pulse" ("Mo-jing") attributed to the physician Wang Shu-hae (3rd-4th centuries A.D.). He suggested that the pulse varies in different parts of the body. For example, if the pulse in common places breaks and even "disappears" - on radial artery, in the points of **cun** and **guan**, it may persist in the points of **Chi**. In such cases, he believes that the pulse is "rooted" and the prognosis remains more favourable. If, on the other hand, the pulse is not detected at the points where the "root pulse" is usually palpable, even if it persists at the **cun** and **guan** points, the pulse is unfavourable in terms of the prognosis of the disease.

Wang Shu-hae's book had a great influence on the state of medicine in neighbouring countries. For example, of the 48 methods for studying the pulse subsequently known in Arabia, 35 were borrowed from his book "The Science of the Pulse".

Later, the teachings of the pulse became increasingly important in diagnostics. Depending on the nature of the disease, constitution of the patient, time of year, hour of the day and many other factors, hundreds of types of pulse were distinguished. A large number of studies have been written about it.

Shi Fa (1241) in his book "Cha-shin Ji-nan" on diagnostics of diseases distinguished 33 kinds of pulse and gave their graphic representation in the table. Great material on pulses was collected in the book "Shan-han-lai sudi" by K-yun-bo, which was issued during Manchu dynasty of Qing (1644-1911).

Nowadays, many specialists use the collection of basic pulse information with explanations in five editions, compiled from materials of the above books and called "Tiao-cheng-tu-tzu Nan-tin-mei-tsue" ("Explanations and corrections of some explanations for books on secret pulse knowledge"). And also, a summary of the Bin-hou Mo-shue[1] (Ming era) pulse manual in a book by the staff of the Beijing Institute of Chinese Medicine (1960).

In "Zhud-shi" [4] which is basic treatise of Tibetan medicine (XII century) consisting of four volumes, the separate chapter contains information about the pulse (Ch. 1, Part 4). In the treatise it is said that the study of the pulsating vessel in the diagnosis gives the doctor data similar to a ray signal. Diagnosis by pulse was considered important in Tibetan medicine: "A doctor who does not know the pulse is like a fowlman who cannot set off a catching bird...".

The greatest scientist of Central Asia, Abu Ali Ibn Sina (980-1037 AD) described about 40 types of pulse, dedicating a special chapter to it in "Canon" [3].

Ibn Sina considered Galen one of his teachers and in the "Canon" quotes his statement: "For some time I constantly missed [the period of] contraction then began to repeat palpation, until I felt its signs, and then, not long after, [perceived it completely]. After that the gate [of knowledge] of the pulse opened before me, and [anyone] who will be as diligent [to feel it] as I was, will comprehend what I have comprehended. On this statement, however, Ibn Sina observes that in most cases the contraction of the pulse is difficult to feel.

He himself distinguishes features of pulse as smooth and irregular, wavy and spindle-shaped ("gazelle"), two-beat, long, trembling ("fading tail"), short, small, slow, ant-like ("mouse tail"), soft, tense, nervous, low, saw-like, full, empty, etc. According to his observations, the pulse rate varies according to the seasons, in women during pregnancy, in various painful sensations. The frequency is influenced by the terrain and the age of the person. Ibn Sina notes the change in the pulse in bathing, people experiencing mental turmoil, etc.

All these remarks and notes indicate that Ibn Sina, based on the experience of predecessors and extensive personal observations, thoughtfully approached the study of the pulse and made a great contribution to the development of this important area of medical science.

Pulse diagnosis also developed in the West. However, there is scant information about the earliest researchers of the pulse.

Aristotle (IV century B.C.) considered that pulse is the startle of heart as a result of feeding into it through large blood vessels.

Ancient Greek philosopher **Democritus** (VI-V centuries B.C.), who also paid much attention to medicine, had written about pulse, inflammation, rabies.

In Ancient Greece, the doctrine of the pulse was created by **Herophilus** of the Alexandrian school. This doctrine was further developed in the medicine of ancient Rome, especially in the writings of **Galen**.

Later, English physician William Garvey (1578-1657 A.D.) in his book "Anatomical study of the motion of heart and blood in animals", published in 1628, refuted Galen's ideas about "pulsating power" of arteries and proved that pulsation of arteries follows the heartbeat and is a direct consequence of heart contraction. He explained the true meaning of systole and diastole, which were misunderstood and thus created the basis for pulse diagnosis in Western medicine.

Nowadays, the role of ancient Oriental pulse diagnosis is becoming more and more important, because since the last decades of the 20th century, scientists and medical practitioners in many countries of the world have become more and more interested in a corresponding traditional method of treatment - acupuncture[5].

Wrist pulses

According to ancient oriental medicine, any illness, physical or mental, that has a physiological effect is reflected directly in pulses and usually even before symptoms appear in the human body. As a consequence, pulse diagnosis is the cornerstone of Chinese medicine.

Experienced doctor while assessing the pulse can determine not only presence of excess or lack of energy, but also location, severity, type, duration and even cause of the disease.

It should be remembered that the pulse examination is only one of the four basic elements of diagnosis and should certainly be combined with others to make a definitive diagnosis.

The place where the carpal pulses are palpated is the pulse concentration point, which is divided into three segments or three positions.

There are a total of six positions on both wrists at which the pulse is examined – three on each hand **(Figure 1).**

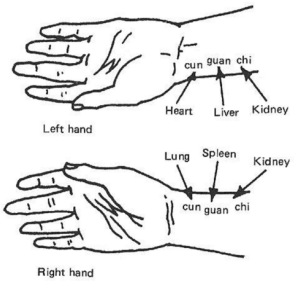

Figure 1. *Distribution of organs at the wrist pulse*

I position (Kun) corresponds to proximal skin fold of wrist;

II position (Guan) corresponds to the protrusion of the distal head of the radial joint;

III position (CHI) is proximal to the head of the radial joint along the radial artery.

In turn, each position is subdivided into a superficial layer and an inner layer, and in positions II and III of the right wrist there is also a middle layer. By palpating the superficial, internal and medial pulses, the energy status of the organs corresponding to these layers can be determined (**Table 1**).

Table 1.

The energetic state of the organs corresponding to the layers.

Position	Layer	Left wrist	Position	Layer	Right wrist
I	Superficial	Small intestine	I	Superficial	Large intestine
	Inner	Heart		Inner	Lungs
II	Superficial	Gall bladder	II	Superficial	Abdomen
	Inner	Liver		Middle	Pancreas
				Inner	Spleen
III	Superficial	Bladder	III	Superficial	Three parts of the torso
	Inner	Kidneys		Middle	Sexuality
				Inner	Blood circulation

Initially, a set of carpal pulses are examined to clarify the general situation, then each wrist area (three positions) separately to clarify the energy status of the five organs and the six hollow organs. In both cases, three pulse waves are attempted: superficial, which is investigated by placing the finger lightly on the skin; middle, by applying light pressure; and deep, by applying strong pressure.

Pressing with the finger on the superficial pulse harder, then even harder, until it registers in depth, the doctor determines the strength of resistance under the finger. He then eases the pressure until the surface pulse is felt and then examines it under the finger.

Pressure is applied deeply to determine the energy of the organs and relieved pressure to investigate the energy of the hollow organs.

Deep pulses are much more important than superficial pulses. In Chinese medicine deep pulses correspond to the five main organs: **Lungs**, **Spleen** (pancreas), **Heart**, **Kidneys**, **Liver**.

By palpating these organs, it is possible to get information about functional activity of different systems of organism as well as "secondary" formations. Thus, **lungs** influence and are connected to skin, nose, hair and voice; **spleen** (pancreas) influences digestion process, blood and muscles; **heart** controls blood vessels, tongue and is connected to thinking functions; **kidneys** are connected to ear, anus and sexual organs. Their activity affects the brain, bone marrow, bone system, uterus and ovaries; the **liver** affects the musculoskeletal system, genitourinary organs, eyes and nails.

In women, the pulses on the right hand are more important than on the left. In men the opposite is true. Therefore, it is preferable to start studying deep pulses in women from the right wrist, and in men from the left wrist.

Midline pulses are palpated in positions II and III on the right wrist [5].

Distribution of organs in six positions

The heart, liver and kidneys are assessed by the left Kung, Guan and Qi, while the lungs, spleen and kidneys are assessed by the right Kung, Guan and Qi. Both left and right Qi may be used to assess the kidneys: ***the left Qi indicates the health of the kidneys, while the right Qi represents their physiological function***, which is called the gate of life. **The gate of life** is the place where the transformation of Qi originates, and it is the root of life [7].

Several studies have been carried out to examine the difference in arterial pulse in six places. Chang[6] conducted a six-point arterial pulse study in patients with left ventricular failure and found that left ventricular ejection fraction correlated positively with $\mathbf{h_1}$**at** of right Kung at floating level and right Guan at mid-level and correlated negatively with $\mathbf{h_1}$**at** of left Qi at mid-level and right Qi at sunken level. Cardiac output was positively correlated with $\mathbf{h_1}$ at left Guan at floating level and left Qi at mid-level and negatively correlated with $\mathbf{h_1}$ at right Guan at mid-level and right Qi at submerged level. Yang et al[8] found that patients with congestive heart failure had significantly different blood pressure waveforms on the left side of the heart from those in healthy subjects with different pressures at six sites. These studies demonstrated that the arterial pulse at the six sites differed according to health status.

Huang [9] postulated that the radial artery at the six sites had a different number of neuroreceptors and that the thresholds of these neuroreceptors, which respond to nerve signals sent by the autonomic nervous system, would vary under different pathophysiological conditions. However, no studies have been carried out to test this hypothesis.

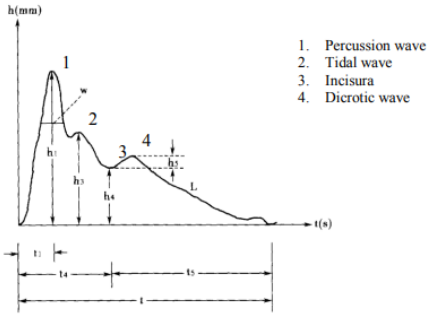

Figure 2. *Typical blood pressure waveform (adapted from Fei, 2003, p.163)* [12]

The relationship and interdependence of the concepts of pulse and health in TCM and modern medicine.

In the work of Tang C.Y. [10] the Cube Model was formulated to explain the relationship and interdependence between arterial pulse and the eight elements of pulse status at six points on the right and left hands, as well as between the eight elements at six points and health status in TCM. This scheme serves as the basis for quantifying the six-point pulse status in patients with hypertension.

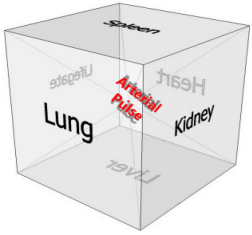

Figure 3. *Cube's model*

The Cube model consists of two levels. The first level includes the arterial pulse and the eight six-point elements, while the second level covers the eight six-point elements and the state of health in TCM. More specifically, the first level deals with the sensation of the arterial pulse as perceived by the TCM practitioner, while the second level interprets the eight elements in the six points to determine the state of health. The two concepts are interrelated.

This article reveals the symbolic meaning of Cube in relation to the arterial pulse and health status in TCM, and describes the dependent and independent variables at the two levels.

Arterial pulse and the eight elements at six points

The eight elements are assumed to be influenced by the arterial pulse at six points (left and right Kun, Guan and Qi).

The arterial pulse at the six points is the independent variable.

An independent variable is a condition, intervention or characteristic that predicts or causes a particular outcome [11]. There are two types of independent variables: active variables and attributive variables.

An active variable is a variable that the researcher manipulates so that subjects are attributed to a particular level of that variable, while **an attributive variable** is a variable that the researcher cannot attribute to the subjects but must observe naturally.

The six-point arterial pulse is an attributive variable and is operationalized as a six-point arterial pressure waveform.

The dependent variable is the response or effect that is assumed to change depending on the independent variable [11].

Depth, frequency, regularity, width, length, smoothness, stiffness and strength are the eight elements of pulse condition at six points. The intensity of each element is determined by the feeling of the arterial pulse as perceived by the TCM practitioner. Thus, the eight elements in the six points are dependent variables and are operationalized as an assessment along a continuum whose extremes are Yin and Yang.

In particular, **depth** is operationalized as the vertical position of the arterial pulse and assessed on a continuum: the deepest is Yin and the most fluctuating is Yang.

Frequency - the number of beats per minute, with Yin being the slowest and Yang the fastest.

Regularity - the rhythm of the arterial pulse, which is classified as regular or irregular.

Width - the intensity of the arterial pulse, the lowest is Yin and the highest is Yang.

Length - the range of arterial pulse that can be felt by kun, guan and qi, with the shortest length being Yin and the largest being Yang.

Smoothness - the elasticity of the arterial pulse, where the coarsest is Yin and the smoothest is Yang.

Stiffness - elasticity of the radial artery, where the least rigid is Yin and the most rigid is Yang.

Finally, **strength** - the strength of the arterial pulse in relation to the change in pressure exerted by the TCM practitioner, where the least strength is Yin and the greatest is Yang.

The eight elements at six points and the state of health

In TCM pulse diagnosis, the state of health is determined by the state of the pulse at six points, with each point reflecting the state of health of a particular organ.

The **left** kun, guan and qi reflect the health of the **heart**, **liver** and **kidneys** (**left**) and the **right** kun, guan and qi reflect the health of the **lungs**, **spleen** and **kidneys** (right, gate of life). The eight elements are the criteria for assessing the health of the organs. Thus, the eight elements in six places are independent variables in the second level of the Cube Model.

Health status is the final measure of the pulse diagnosis of TCM and is a composite measure of organ health status. Health status is the dependent variable in the second level of the model and is operationalised as a hypertension or normotension designation.

The Cube model

The Cube Model uses an intertwined and cascading relationship between arterial pulse, the eight elements in six locations, and health status to embody it (**Figure 3**).

The Cube model is formulated under three assumptions. The first is that the eight elements have equal weight in assessing overall heart rate status.

Secondly, the middle point of the continuum indicates the balance of Yin and Yang.

Thirdly, the six points have the same weight in determining the state of health.

The Cube model is analogous to the concept of health in TCM. Health is perceived as a balance of Yin and Yang, which in turn depends on the individual functioning and interaction of organs. Thus, six pyramids, of which Cube consists, are analogy of organs located in six places on left and right hands.

The inside of the Cube represents blood flow in the organs, the combination of which makes up the arterial pulse. Consequently, **any change in blood flow in any of the organs is reflected in the arterial pulse**. By assessing the six pyramids one can determine the health of the organs and therefore the general state of health.

Location of the six organs

The six pyramids inside the Cube represent the six places where the TCM physician assesses the pulse. The lungs and heart, liver and spleen, kidneys (left) and right (gate of life) are arranged in opposite pyramids according to their role in overall health. This arrangement is based on the notion that the left kun, guan and qi evaluate blood, which is Yin in nature, while the right kun, guan and qi evaluate qi, which is Yang in nature. Thus, the arrangement of the organs on the cubes is in accordance with the Yin-Yang theory.

Eight elements

Each pyramid consists of eight elements. The enlarged square of the Cube side (**Figure 4**) shows the relationship between the eight elements. Each element

represents complementary pair Yin-Yang. According to Yin-Yang theory, Yin always represents internal and Yang always represents external. Therefore, the dark square in the center, indicating the Yin nature of the elements, is the core of the pyramid, and the white square, indicating their Yang nature, is the outer part of the pyramid.

The intensity of the eight elements depends on the arterial pulse. Thus, the cumulative intensity of the eight elements indicates the health status of the organ designated by the pyramid in question.

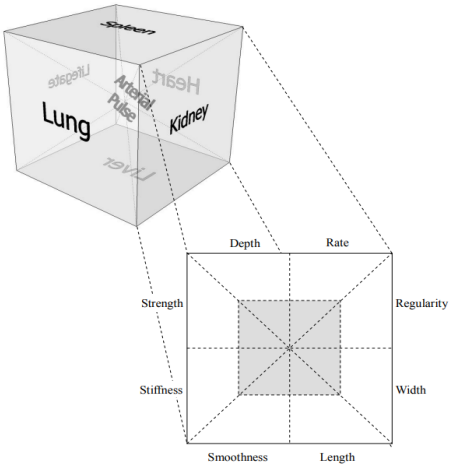

Figure 4. *Diagram of an eight-element pyramid*

Interconnectedness in the Cube Model

The Cube model for TCM pulse diagnosis is inspired by the Tai Chi symbol. The dotted line connecting the six pyramids together symbolises the alternation and dynamic relationship between the organs. In the Yin and Yang model of each element, the eight elements in each pyramid and the six pyramids of the Cube are connected by dotted lines, which means that they are composites of Yin and Yang and **constantly alternate**, **and balance each other**. The solid outline of the Cube represents the absolute of health, just as the circle of Tai Chi represents peace.

Health cannot be expanded or diminished: only the state of health, which is determined by the interaction of Yin and Yang in the body, can be changed.

The analogy between the throwing of the Cube as a dice and the state of health.

Figure 5. *Cube, dice*

In a balanced Cube Model, when rolled as a dice, the probability of each pyramid falling out is equal, as the areas and weights of the pyramids are the same.

Thus, ***a balanced Cube Model is analogous to a state of health in which blood flow in the organs is normal, wave reflection and wave resonance occur properly, the intensity of the eight elements is near the middle of the continuum and forms a regular shape in the center of the pyramid, and the six pyramids are equal and balanced. Yin and Yang are balanced and harmony is achieved***.

However, if the area or weight of any of the pyramids is deliberately altered, the Cube is no longer balanced and may be called unbalanced. In an imbalanced Cube the probability of each pyramid being thrown is unequal and depends on the area and weight of the pyramids. The unbalanced Cube is an analogue of an unhealthy condition at which abnormal functioning of any of organs influences reflection of waves and wave resonance in system of blood circulation, blood flow changes, and hence, weight of pyramid representing this organ changes. The arterial pulse changes according to the health of the organ, which means that the intensity of the eight elements also changes. The pyramid formed by the eight elements is no longer regular, but smaller or larger and skewed. Thus, there is imbalance in the six pyramids, Yin and Yang are unbalanced and health is disturbed.

The significance of the Cube Model (dice).

The relationships between the arterial pulse and the eight elements in the six points are considered in order to provide a modern scientific explanation of the eight elements.

The relationships established are then used to develop an objective standard for the eight elements, and the differentiation of blood pressure status using the eight elements at six points is investigated. The resulting differentiation model can be used as an outcome measure for blood pressure in TCM.

Conclusion.

This article has presented the Cube Model, which illustrates the relationship and interdependence of the concepts of pulse and health in TCM and modern medicine.

The two levels of the model have been described, and the dependent and independent variables at each level have been identified and operationalized. The intertwined and cascading relationships between the arterial pulse, the eight elements, the six points and health have been depicted and explained.

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REVIEW OF CONDUCTED STUDIES OF PHYSIOLOGICAL ADAPTATION TO COLD EXPOSURE

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Introduction

Human adaptation to cold is an evolutionarily developed mechanism by which the human body signals a problem to the central control organs, which, in turn, try to solve the current problem by increasing metabolism, constricting peripheral vessels and changing human behavior. Activation of stress systems requires high metabolic costs and can be harmful to health and survival if they are excessively active, but at the same time, adaptation suggests that with the constant activation of stress systems, mechanisms are formed that allow switching to less energy-consuming reactions that do no harm.

The purpose of this work is: to present evidence of adaptive reactions of the body, to conduct an up-to-date critical analysis of past research.

Mechanisms of adaptation to cold

Primary adaptation mechanisms include: 1) hypermetabolic 2) insulating 3) behavioral responses. Hypermetabolic reactions are directly related to an increase in metabolism, which produces more heat in response to cold exposure. This type of reaction is divided into two subcategories: thermogenesis associated with frequent muscle contraction, or muscle tremors, and non-trembling thermogenesis. The insulating adaptation mechanism is associated with changes in the hemodynamics of the human body, the most common variant of this effect is vasoconstriction, which in turn reduces the heat transfer from the skin, thus conserving the body's resources. Separately, there is a type of adaptation associated with our behavior, when in cold weather people try to dress warmer or stay in a warm room.

In the future, with constant exposure to cold, the degree of influence of the primary mechanisms of adaptation decreases. For example, a decrease in vasoconstriction and even in some situations exposure to cold can, on the contrary, lead to dilation of the blood vessels of the skin, but only in the case of constant local cold exposure. The rate of metabolic reactions changes, so the researchers found that with constant general cooling, the amount of brown adipose tissue increases

to replace the already existing white adipose tissue, which provides increased thermogenesis in cold conditions. Such a metabolic response contributes to a decrease in the severity of shivering thermogenesis, which is not "economical" with prolonged cold exposure.

The blunting of primary thermoeffector reactions occurs through a change in the activity of peripheral thermoreceptors and a change in the central processing of afferent signals. The activity of peripheral thermoreceptors is regulated by two mechanisms, the first is a decrease in the number of thermoreceptors and the second is a decrease in their activity. Central mechanisms play a leading role in long-term adaptation to cold exposure, so studies have been conducted in which local or general cooling was applied to one part or half of the body, respectively, but measured the response from the opposite side, which did not experience discomfort. All these studies concluded that adaptation to cold exposure is a consequence of changes in the activity of central mechanisms and is weakly dependent on peripheral stimulation.

Physiological reactions when exposed to cold air

Adaptation of the human body to cold air occurs only with repeated exposure to the cold component. Such effects can be observed in residents living in cold climates and therefore constantly exposed to the environment. Laboratory conditions of a cold climate are created in specialized chambers, where there is a control of temperature, relative humidity and air velocity.

The natural effects of cold air have also been studied in indigenous people living in cold regions of the world. These studies show a reduction in metabolic responses to cold air exposure compared to controls. Indigenous people also had higher blood flow in their upper extremities, and their finger temperatures were higher.

In addition to these studies, surveys were conducted of the indigenous people of Africa, living in a relatively temperate climate, but lacking warm clothing and shelter, the results of these studies showed similar results to the above works.

A separate group of scientists conducted studies on minimally dressed volunteers to short-term exposure to cold environmental air for 1 hour over 14 days. The same study examined soldiers who trained and slept in cold air for 10 days. In more than half of the observations, according to the results of the experiment, a decrease in the hypermetabolic response was observed with a delay in tremulous thermogenesis.

Similar studies were conducted on athletes exercising outdoors in the winter, compared with a control group of students who were exposed to cold air only during short walks. In accordance with the adaptation mechanisms, the group of athletes demonstrated a weakened metabolic response and a decrease in temperature sensitivity.

A laboratory study of the adaptive capabilities of a person was carried out in a specialized climatic chamber, lasting from several days to several months. The results of the conducted studies showed similar dynamics of processes in the form of a decrease in tremulous thermogenesis, a decrease in body temperature and a decrease in blood pressure. It is interesting to note the fact that people acclimatized to cold did not show a decrease in metabolic heat production, while those who were minimally acclimatized to environmental conditions showed an increase in heat production at the beginning of the experiment, and their complete acclimatization to cold occurred by the 31st day of the study.

Physiological reactions when exposed to cold water

Adaptive mechanisms that are included in the work in the human body have a more diverse specificity. This is due to the fact that water has a much higher electrical conductivity and heat transfer from the skin to water is more intense, in comparison with the same conditions in air.

Studies conducted on fishermen who are constantly in contact with cold water only in the area of the hands showed that with local exposure to cold water on the hands, there is an increase in blood flow in these sections and, as a result, a local increase in temperature. This manifestation suggests that with prolonged, constantly repeated local cold exposure, the effect of vasoconstriction is replaced by the effect of vasodilation. From subsequent studies conducted on volunteers, the hands, which were programmatically immersed in cold water, showed that, when exposed to local cold, the temperature sensitivity of the area under study decreases. From this it can be assumed that the mechanism of adaptation associated with vasodilation helps to protect the hands from prolonged exposure to cold water, since with prolonged vasoconstriction in the distal parts of the hands, necrosis of the distal parts of the fingers may occur.

A study of professional divers of the last century who used cotton bathing suits showed a decrease in the rate of onset of shivering thermogenesis, and the divers' metabolic rate increased by 30%. Also in this study, for the first time, the theory of a countercurrent mechanism was put forward, as a result of which the blood entering the skin was pre-cooled, thereby maintaining internal heat in the body.

Laboratory conditions were also used, in which volunteers were immersed in cold water. During long-term immersions in water, the researchers concluded that the general cooling with water leads to a decrease in the temperature of the skin, an increase in metabolism, and an increase in the threshold for the onset of thermogenesis, in contrast to short-term ones, where the main role of primary adaptation is played by tremulous thermogenesis and peripheral vasoconstriction.

Conclusion

Thus, to the existing studies, as a result of which scientists were able to make and create an appropriate classification of adaptive reactions, new information

related to vasodilation was added, and information about the course of metabolic processes was also updated. The conducted study summarized the accumulated research material in the field of adaptive capabilities under cold exposure, which provides a certain basis for future research. As for example, the study of the time frame of human adaptation to the cold.

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MICROBIOMICS AND GENETICS: LOOKING AT THE INTERACTION OF MICROORGANISMS AND GENOMIC FEATURES

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Abstract. *In this blog post, we explore the fascinating interplay between microbiomics and genetics. Microbiomics refers to the study of micro-organisms and their collective genetic material in a particular environment, while genetics is the study of genes, their functions, and how they are inherited. Recent studies have shown that the human microbiome, which is the collection of micro-organisms that live on and inside the human body, has a significant impact on human health. The microbiome can influence a wide range of physiological processes, including metabolism, immune function, and behavior. Moreover, genetics plays a crucial role in shaping the composition of the microbiome. Certain genetic mutations are linked to an increased risk of developing inflammatory bowel disease, which is thought to be related to changes in the gut microbiome. Conversely, the microbiome can also influence genetic expression. For instance, gut bacteria can produce short-chain fatty acids that can affect the expression of certain genes in the host. We also discuss how researchers can study the relationship between microbiomics and genetics, using approaches such as metagenomics and genome-wide association studies. By understanding the complex and dynamic interplay between micro-organisms and genomic features, we can gain insights into how to promote and maintain human health.*

Keywords: *microbiomics, genetics, microbiome, metagenomics, genome-wide association studies, human health, gene expression.*

Introduction

General information about the microbiome and genetics

The microbiome is the totality of all microorganisms, including bacteria, viruses, fungi, and other microorganisms, that inhabit a particular environment or organism. Primarily, the human microbiome consists of bacteria that predominantly inhabit the gut, but are also present in other parts of the body, including the skin and oral cavities. The microbiome is considered an "organ within the body" and plays an important role in maintaining human health.

Genetics, on the other hand, studies heredity and the genomes of organisms. The genome is the complete set of genetic information encoded in an organism's DNA. Genetics studies how genes determine the features and functions of an organism, including its phenotype (observable characteristics).

There is a strong connection between the microbiome and genetics. For example, genetic factors can influence the development and diversity of the human microbiome. Different people may have differences in the composition of the microbiome, which may be related to their genetic traits. Certain genes can influence interactions with microbes and regulate immune responses to their presence.

On the other hand, the microbiome can also influence genetics. Some microorganisms can affect gene expression, modify DNA or affect the functioning of body cells. This opens up opportunities to investigate the role of the microbiome in various genetic diseases and conditions[1].

Purpose and relevance of the study

The purpose and relevance of the study: consideration of interaction between microorganisms and genomic features" is to study the interaction of microorganisms living inside our body (microbiome) with genetic features of the host. This research is highly relevant because the microbiome is a complex ecosystem consisting of bacteria, viruses, fungi and other microorganisms that have a significant impact on our health and the development of various diseases.

Understanding microbial and genetic interactions can help us better understand the mechanisms involved in disease development, individual susceptibility to disease, and treatment efficacy. This research may also lead to the development of new approaches to the diagnosis, prevention and treatment of various diseases based on microbiome data and genetic information.

1. Basics of Microbiomics

1.1 The concept of the microbiome

The microbiome concept refers to the complex community of microorganisms that coexist with humans, plants, and animals in a mutually symbiotic relationship.

The microbiome includes bacteria, viruses, fungi, and protozoa, and their genetic material. The microbiome is present in many parts of the human body, including the skin, oral cavity, respiratory tract, gastrointestinal tract, and reproductive system [1]. Microbes have coexisted with humans throughout history and have evolved mutually beneficent relationships. They play a crucial role in various processes such as digestion, vitamin synthesis, and immune system modulation [2]. The diversity of the microbiome has a significant impact on health and disease outcomes. Imbalances in the microbiome, also known as dysbiosis, can lead to various health complications, ranging from inflammatory bowel disease to cardiovascular disease. Therefore, understanding the microbiome and its functions is important in developing new treatments and therapies aimed at restoring and maintaining a healthy microbiome [3]. Recent advances in sequencing technology are facilitating the exploration of the microbiome's role in human health and disease. Using metagenomics, researchers can study the genetic material of the entire microbial community in a given sample. As a result, a vast amount of data has been generated, giving a better understanding of the composition and function of the microbiome.

Multiple factors influence the composition of the microbiome, including diet, genetics, environmental factors, antibiotics, and other medications. Several studies have shown that changes in diet can have a profound effect on the composition of the microbiome. For example, diets high in fiber have been associated with a more diverse and stable microbiome.

1.2 Composition of the microbiome

The composition of the microbiome can vary widely depending on the individual, as well as environmental factors, such as diet, exposure to antibiotics, and hygiene practices. Generally, however, the following microorganisms are common in the different regions of the body:

Skin Microbiome:

The skin contains many different types of microorganisms, including bacteria, fungi, and viruses. The bacterial composition typically includes species such as Propionibacterium, Staphylococcus, and Streptococcus, among others. These bacteria can play a critical role in protecting the skin from infection, as well as promoting wound healing.

Oral Microbiome:

The oral microbiome includes a wide range of bacteria, fungi, and viruses, many of which are critical for maintaining oral health. These microorganisms can include species such as Streptococcus, Prevotella, and Porphyromonas, among others. Imbalances in the oral microbiome have been linked to a variety of oral health issues, including cavities, gum disease, and bad breath.

Gut Microbiome:

The gut microbiome is perhaps the most well-studied microbiome in the body, and plays a critical role in digestion, immune function, and overall health. The gut microbiome is dominated by bacteria, with the most abundant species including Bacteroidetes, Firmicutes, and Actinobacteria. These bacteria can perform a variety of functions in the gut, including breaking down complex carbohydrates, synthesizing vitamins, and regulating immune function.

Reproductive Tract Microbiome:

Finally, the reproductive tract contains its own unique microbiome, although this area is still relatively understudied. The vaginal microbiome, in particular, can include a wide range of microorganisms, including Lactobacillus, Gardnerella, and Fusobacterium, among others. Imbalances in the vaginal microbiome can lead to a range of reproductive health issues, including bacterial vaginosis and urinary tract infections.

Overall, the microbiome is a complex and dynamic system that plays a critical role in regulating our health and well-being. Further research is needed to understand the precise composition of the microbiome in different parts of the body, as well as how these microorganisms interact with each other and with our own cells [5].

Table 1

The major types of microorganisms found in the different regions of the human microbiome.

Region	Microorganisms
Skin	Bacteria, fungi, viruses
Oral	Bacteria, fungi, viruses
Gut	Bacteria, viruses
Reproductive Tract	Bacteria, fungi

According to the Human Microbiome Project Consortium, "the human microbiome consists of the genomes of the microorganisms that reside in and on the human body, as well as the environmental conditions that influence them." This includes bacteria, viruses, fungi, and archaea, which can be found in various parts of the body including the skin, mouth, gut, and genital tract. Li et al. (2013) found that the microbial communities in the human microbiome are relatively stable over time, and that there are core taxonomic memberships of bacteria that are consistently present across different individuals. These include species from the genera Bacteroides, Faecalibacterium, Ruminococcus, and Prevotella, among others. The microbiome is important for many functions in the body, such as digestion, immune system regulation, and protection against harmful pathogens. Disruptions

to the microbiome, such as through the use of antibiotics or changes in diet, have been linked to various health problems including obesity, inflammatory bowel disease, and even mental health disorders.

1.3 Different methods of microbiome analysis

The field of microbiome analysis has seen a tremendous advancement in recent years due to the advent of new powerful technologies that have made it possible to investigate the microbial communities that inhabit complex ecosystems. A microbiome is defined as the entire genetic content of all the microorganisms that live in or on a host, and their collective metabolic pathways and interactions, as well as the host's response to them. The different methods of microbiome analysis can be broadly classified into two main categories, namely culture-dependent and culture-independent methods.

Culture-dependent methods involve isolating bacterial species from the microbiome by growing them on selective media in the lab. This method was the most commonly used approach for identifying bacterial species before the advent of modern molecular techniques. It involves culturing bacteria under a defined set of conditions so that only specific bacterial species can grow. The advantage of this method is that it allows for the isolation, characterization, and identification of bacterial species in a pure culture. However, culturing can lead to bias because some bacterial species may be difficult to culture, or conversely, only those that can grow under specific culture conditions can be identified. Nevertheless, this method is still valuable for understanding the physiology and genetics of individual microbial species, and it remains the gold standard for bacterial isolation and characterization.

Culture-independent methods are designed to overcome the limitations of culture-dependent methods by not relying on the growth of microorganisms. Instead, these methods harness the power of molecular techniques to analyze the entire microbiome in a single assay. Some of the most common culture-independent methods include:

16S rRNA gene sequencing: This method is based on the extraction of the 16S ribosomal RNA gene, which is present in all bacteria, and using it to identify bacterial species present in a sample. This method is high throughput and can detect a wide range of bacterial species in a single assay. It is also relatively inexpensive and can be used for both qualitative and quantitative analysis of the microbiome. The main limitation of this method is that it only allows for the identification of bacterial species and not other microbial groups such as fungi and viruses [4].

Metagenomics: This method involves sequencing the entire genetic content of the microbiome, including bacteria, fungi, viruses, and other microorganisms. Metagenomics enables the identification of novel microorganisms and unculturable species that are not detectable by traditional methods. It can also provide infor-

mation about the metabolic pathways and functional processes of the microbiome, which are critical for understanding host-microbe interactions. However, the cost and complexity of this technique make it less accessible to many researchers [6].

Metatranscriptomics: This method involves sequencing the entire microbial transcriptome, which is the collection of all RNA molecules in the microbiome. This approach allows for the identification of active microbial populations and the functional processes that are occurring in the microbiome. Metatranscriptomics can provide information on key microbial functions such as metabolism and virulence but may miss transient or low-level transcripts.

Metaproteomics: This method involves analyzing the entire protein content of the microbiome and identifying the proteins present. This approach provides information on the functional activity of microbial species and can be used to detect virulence factors and other important proteins. However, it is more challenging than other methods and requires a high level of expertise [7].

2. Basics of genetics

2.1 General terms and concepts

The concept of genetics is the study of how traits are passed on from one generation to the next. It is the study of genes, their structure, function, and the way they are passed on from parents to offspring. Genetics helps to understand the heredity of organisms, human health conditions and create genetically modified organisms (GMOs) that can withstand harsh environmental conditions [7]. The study of genetics begins with the study of DNA, which is divided into multiple genes on long strands of chromosomes. Each gene consists of a long sequence of nucleotides that form the genetic code. The genetic code of an organism is determined by the sequence of nucleotides in its DNA. There are 4 types of nucleotides that make up the genetic code: Adenine (A), Guanine (G), Cytosine (C), and Thymine (T) [8]. The DNA strands of a gene are transcribed into RNA, which is then translated into proteins. Proteins are the building blocks of life, and they determine the structure and function of an organism. The DNA code is used to create specific sequences of amino acids that make up the proteins. Genetic variation occurs due to the random mutations that occur during DNA replication. Some mutations are beneficial, while others may be harmful [9]. Through natural selection, organisms that possess beneficial mutations are more likely to survive and reproduce, leading to the evolution of new species. Inheritance patterns of genes are dependent on several factors, including whether the gene is on an autosome or a sex chromosome, dominant or recessive, and whether the gene is linked or unlinked. Human inheritance patterns are also influenced by factors such as genetic imprinting, incomplete dominance, and multiple alleles. The field of genetics has led to many advancements in healthcare, including the identification of genetic disorders and the development of diagnostic tests and therapies. Genetic

testing can reveal potential health risks and help doctors make more informed decisions about treatment. Genetic engineering has allowed scientists to create GMOs that can withstand harsh environmental conditions and provide more food for the growing population [9].

The concept of genetics is essential in understanding heredity, evolution, and biological diversity. It is a rapidly advancing field that has the potential to revolutionize healthcare, agriculture, and environmental conservation.

2.2 The role of genetic mechanisms in the life activity of microorganisms

Genetic mechanisms in microorganisms consist of DNA replication, transcription, and translation, which form the basis of gene expression and regulation [8]. These mechanisms contribute to microbial growth, adaptation to environmental conditions, and virulence. In addition, microorganisms possess genetic elements like plasmids, transposons, and bacteriophages that enable genetic diversity and transfer of genes within microbial populations [9].

The process of DNA replication in microorganisms is an essential component of their life cycle. Replication is the basis for their growth and reproduction, allowing them to create genetic copies of themselves. During the replication process, the semiconservative nature of DNA allows each strand to serve as a template for the synthesis of a new complementary strand. This results in two identical DNA molecules, each consisting of one original strand and one newly synthesized strand [10]. Transcription is an essential process in which the genetic information in DNA is transcribed into RNA by the enzyme RNA polymerase. The RNA molecule carries the genetic information from the DNA to the ribosomes, where it is translated into proteins. This process is crucial in microbial growth and metabolism [11]. The process of translation involves the conversion of genetic information from RNA into proteins. In microorganisms, this process involves the assembly of ribosomes, the recruitment of amino acids, and peptide bond formation. Proteins synthesized in this manner play essential roles in cellular processes, metabolism, and regulation of gene expression [12]. Genetic diversity is a crucial aspect of microorganism life activity, conferred by genetic elements such as plasmids, transposons, bacteriophages, and mobile genetic elements. These elements play a central role in the horizontal transfer of genes between bacterial populations, leading to rapid adaptation to changing environmental conditions and acquisition of virulence genes. In addition, they provide the foundation for the development of biotechnological applications such as recombinant DNA technology [9].

Genetic mechanisms play an essential role in the life activity of microorganisms. DNA replication, transcription, and translation are fundamental processes, leading to gene expression and regulation. Genetic diversity confers microorganisms appropriate adaptive tools that enable them to survive in various habitats, including extreme conditions.

3. Interactions between Genetic Mechanisms and the Microbiome

Have you ever wondered how your genes and the bacteria in your gut interact? It may seem like they have nothing to do with each other, but the truth is that they have a complex relationship that impacts your health and well-being in ways you may not even realize. In this article, we will explore the intricate interactions between genetic mechanisms and the microbiome, including the role of the microbiome in gene expression, the impact of genetic anomalies on the microbiome, and the genomic diversity of the microbiome [6].

3.1 The Role of the Microbiome in Gene Expression

The microbiome is the collection of microorganisms that live in and on our bodies, including bacteria, viruses, fungi, and other microbes. These tiny organisms play a crucial role in our health, influencing everything from our immune system to our mood. But did you know that they also play a role in gene expression?

Research has shown that the microbiome can interact with our genes in several ways. First, the microbiome can produce metabolites that can alter gene expression. For example, the microbiome can produce short-chain fatty acids that can affect the expression of genes related to inflammation and metabolism [9].

Second, the microbiome can interact with our immune system, which can in turn impact gene expression. For example, when the immune system detects a threat from an invading microbe, it produces cytokines that can trigger changes in gene expression to help fight off the infection.

Finally, the microbiome can directly influence the expression of our genes by interacting with our epigenome. The epigenome is the set of chemical modifications to our DNA that can turn genes on or off. Research has shown that the microbiome can influence these modifications, which can impact gene expression.

3.2 Impact of Genetic Anomalies on the Microbiome

Just as the microbiome can impact gene expression, genetic anomalies can also impact the microbiome. For example, mutations in genes that code for proteins involved in the immune system can impact the composition of the microbiome. This is because the immune system plays a crucial role in shaping the microbiome, by helping to keep harmful bacteria in check and promoting the growth of beneficial bacteria.

In addition, genetic anomalies can impact the ability of the microbiome to perform its functions. For example, mutations in genes involved in the breakdown of dietary fiber can impact the ability of the microbiome to produce short-chain fatty acids, which as we mentioned earlier can impact gene expression [16].

3.3 Genomic Diversity of the Microbiome

Finally, let's talk about the genomic diversity of the microbiome. The microbiome is incredibly diverse, with thousands of different species of bacteria, viruses,

and fungi. This diversity is important because it helps to ensure that the microbiome can perform its many functions, from helping to digest our food to protecting us from harmful pathogens.

However, this diversity can also make it challenging to study the microbiome. Each person's microbiome is unique, and even small variations in the composition of the microbiome can have a big impact on health. This is why researchers are working to better understand the genomic diversity of the microbiome, so that we can develop more personalized approaches to healthcare that take into account the unique needs of each individual [14].

In conclusion, the interactions between genetic mechanisms and the microbiome are complex and multifaceted. The microbiome plays a crucial role in gene expression, while genetic anomalies can impact the composition and function of the microbiome. And with the incredible genomic diversity of the microbiome, there is still much to be learned about this fascinating and important area of research.

4. Exploring the Complexity of the Relationship between Biodiversity and Microbiomics

The relationship between biodiversity and microbiomics is a complex and fascinating topic that has garnered a lot of attention in recent years. Both are essential components of our ecosystems, and their interactions are critical to maintaining the balance of nature. In this article, we will delve deeper into the complexity of the relationship between biodiversity and microbiomics, exploring the various factors that influence this relationship.

4.1 The Role of Biodiversity in Microbiomics

Biodiversity is the variety of living organisms that exist in an ecosystem. It encompasses the diversity of species, their genetic makeup, and the diversity of their habitats. Microbiomics, on the other hand, is the study of the microbial communities that inhabit different ecosystems. These communities are composed of bacteria, fungi, viruses, and other microorganisms that play a vital role in maintaining the health of the ecosystem.

The relationship between biodiversity and microbiomics is symbiotic. Biodiversity provides a foundation for microbial diversity by creating a variety of habitats and food sources for microorganisms. In turn, microbial diversity contributes to the overall biodiversity of an ecosystem by playing a critical role in nutrient cycling, decomposition, and other essential ecological processes.

4.2 The Interactions between the Microbiome and Biodiversity

The microbiome refers to the microorganisms that live within and on the bodies of plants, animals, and other living organisms. These microorganisms play a critical role in maintaining the health of their host and the ecosystem as a whole. For example, the gut microbiome of animals and humans plays a vital role in digestion, immunity, and even mental health.

The diversity of the microbiome is directly linked to the biodiversity of the ecosystem [12]. The more diverse the ecosystem, the more diverse the microbiome. This diversity is essential for maintaining the stability of the ecosystem and protecting it from environmental stressors such as pollution, climate change, and habitat loss.

4.3 The Complexity of the Relationship between Biodiversity and Microbiomics

The relationship between biodiversity and microbiomics is not linear. Instead, it is influenced by a range of factors, including environmental conditions, nutrient availability, and the presence of other microorganisms. For example, studies have shown that changes in temperature and pH levels can affect the composition of microbial communities, leading to changes in the overall biodiversity of the ecosystem [10].

Furthermore, the relationship between biodiversity and microbiomics can be influenced by human activities such as land use changes and pollution. These activities can lead to the loss of biodiversity and changes in the microbial communities, which can have significant effects on the health and stability of the ecosystem.

The Importance of Understanding the Relationship between Biodiversity and Microbiomics

Understanding the relationship between biodiversity and microbiomics is crucial for maintaining the health and stability of our ecosystems. By recognizing the complexity of this relationship, we can better protect and preserve our natural world. This includes taking steps to reduce our impact on the environment, such as reducing pollution and protecting biodiversity hotspots [1].

The Effects of Human Activities on Biodiversity and Microbiomics

Human activities such as deforestation, habitat destruction, and pollution have a significant impact on biodiversity and microbiomics. These activities can lead to the loss of habitat and resources for both macro and microorganisms, ultimately leading to a decline in biodiversity.

Furthermore, pollution can directly affect the composition of microbial communities, leading to changes in the overall biodiversity of the ecosystem. For example, the use of pesticides and other chemicals can kill off beneficial microorganisms, leading to a decline in microbial diversity [2].

5. Applications of Microbiomics and Genetics in Medicine

Microbiomics and genetics play an important role in modern medicine and have a wide range of applications. The role of microbiomics in the diagnosis and treatment of disease is becoming more and more recognized and is being actively researched.

1. Microbiome Identification: The microbiome is the community of microorganisms that inhabit the human body, especially the digestive and reproductive

systems. Studying the microbiome can help determine the connection between microorganisms and various diseases, such as obesity, chronic inflammatory diseases, autoimmune diseases and even mental disorders.

2. Personalized medicine: Genetic research can analyze a patient's individual genetic code and identify genetic mutations associated with inherited diseases. This allows the development of personalized approaches to the diagnosis, treatment and prevention of diseases based on each patient's unique genetic characteristics.

3. Pharmacogenomics: Genetic studies can help determine how individual patients respond to certain drugs. This allows dosages and medications to be more closely matched to achieve the best possible treatment effect and reduce the risk of unwanted side effects.

4. Gene Therapy: Genetic research allows the development and application of gene therapy to treat inherited diseases. Gene therapy involves the introduction or editing of genetic material into the cells of the body in order to correct a genetic defect and restore normal organ and tissue function.

5. Prenatal diagnosis: Genetic tests can be performed during pregnancy to detect hereditary diseases and abnormalities in the fetus [11].

5.1 Genetic approaches in the treatment of microbiome diseases

Genetic approaches to treating microbiome diseases are based on manipulating the genetic material of the microorganisms that inhabit our bodies. Some of these approaches include:

Fecal mass transplantation (fecal microbiotherapy): This is a procedure in which fecal mass from a healthy donor is transferred into the gut of a patient suffering from a microbiome imbalance. Such a transfer restores the normal microbiome and can be effective in treating Clostridium difficile infections and other diseases associated with microbiome imbalances.

Probiotics: Probiotics are live microorganisms that can be added to the body in order to restore normal microbiome composition. These can be bacteria such as Lactobacillus and Bifidobacterium, or yeasts such as Saccharomyces boulardii. Probiotics can be used to treat a variety of conditions related to the microbiome, including irritable bowel syndrome and inflammatory bowel disease.

Prebiotics: Prebiotics are food substances that promote the growth and activity of beneficial microorganisms in the gut. They are dietary fiber and other insoluble substances that serve as a food source for microbes. Prebiotics can be used to stimulate the growth of beneficial bacteria and improve the composition of the microbiome.

Microbiome Engineering: This is a new area of research that seeks to change the composition and function of the microbiome by modifying the genetic material of microorganisms. For example, using genetic engineering, microbes can be

modified to produce certain bioactive substances or have specific functions that can be.

The use of microbiomics and genetics in pharmacology opens new perspectives in the development of individualized and more effective drugs.

Some of the approaches include:

Pharmacogenomics: Pharmacogenomics studies the interaction of genetic variants in patients with response to drug therapy. The study of genetic markers can help predict the efficacy and safety of certain medications in a particular patient. This allows personalization of treatment and avoidance of unwanted side effects [5].

5.2 Use of Microbiomics and Genetics in Pharmacology

Microbiome Pharmacology: The study of the microbiome can help determine how microbes can affect the effectiveness and metabolism of drugs. Microbes can metabolize or modify the effects of drugs, which can affect their effectiveness and safety. Microbiome studies help develop strategies to optimize drug therapy and predict individual drug response.

Probiotics in Pharmacology: Probiotics, which are living microorganisms, can be used as therapeutic agents. They can help restore or modify the composition of the microbiome for health benefits and improve response to drug therapy. Probiotics can also be used to reduce the side effects of medications.

Microbial Metabolites: Microbes in our bodies can produce metabolites that can affect the effects of medications. Studying these microbial metabolites and their interaction with drugs can help to optimize the dosage and effectiveness of drug therapy.

Gene therapy and gene editing: Genetic technologies such as gene therapy and gene editing can be used to modify the genetic material of microorganisms in order to improve drug efficacy or synthesize specific molecules for therapeutic purposes.

Conclusion

In conclusion of this article, we can conclude that microbiomics and genetics are important and interrelated fields of scientific research. The study of the composition and interaction of microorganisms in the microbiome allows us to shed light on many processes occurring in living organisms, and the application of genetic methods allows us to deepen our understanding of the mechanisms of these processes. Microbiomics and genetics play a significant role in medicine; the application of these fields of science in the diagnosis and treatment of diseases can improve the treatment process and increase its effectiveness. In addition, the study of the interaction between the microbiome and biodiversity can not only help to understand ecosystem processes but can also lead to the development of more effective methods to conserve and enhance biodiversity in nature. Overall, the

joint study of microbiomics and genetics represents a potentially important tool for gaining new and in-depth knowledge about the functioning of living organisms and microorganisms, which may lead to the development of more effective methods of disease control and environmental conservation.

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DRILLING RESULTS OF THE KOLA ULTRA-DEEP WELL SG-3 ARE THE KEY TO SOLVING THE PROBLEMS OF MODERN ULTRA-DEEP DRILLING PROGRAMS

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Abstract. *The history of the implementation of the drilling project in the Early Precambrian rocks of the Baltic Shield of the Kola vertical superdeep well, which reached a record depth of 12,262 m in 1990, is considered, and the main scientific and technical achievements obtained during the implementation of this project are characterized. SG-3 fully completed all the tasks assigned to it. Thousands of linear meters of core were brought to the surface and examined in detail, including from a record depth. Unique information was obtained on the structure and composition of the deep horizons of the earth's crust, which significantly changed the data of previous deep geological and geophysical studies. New information was obtained on the chemical and mineral composition of deep rocks, the presence of ore mineralization and metal-bearing hydrothermal systems in them was proved. It has been proved that the most ancient Early Precambrian metasedimentary rocks were formed with the active participation of biological processes. The SG-3 project and the colossal scientific and technical information obtained during its implementation were forgotten for many years. The development of modern ultra-deep drilling programs related to the search for hydrocarbon and metal raw materials at depth made it necessary to analyze, reinterpret and digitize all the half-forgotten information on this problem.*

Keywords: *superdeep drilling, Kola superdeep well SG-3, Baltic Shield, Archean, Early Proterozoic, crystalline rocks, gneisses, granites, amphibolites.*

Introduction. Half a century before our days, on May 24, 1970, on the day of the centennial anniversary of the birth of V.I. Lenin, an event happened in the USSR that many thousands of geologists of our planet - petrographers, mineralogists, geophysicists, mine geologists, etc., had been impatiently waiting for many

years to reach a depth of 15 km. When comparing the achievements of space research with the results of studying the deep horizons of the earth's crust, their sharp discrepancy is striking. If space has been studied by a variety of methods thousands of kilometers from the surface of the Earth, then the depth of penetration into the bowels of the planet was limited to only a few kilometers at wells drilled in the search for mineral deposits. When describing the composition of the deep layers of the earth's crust, geologists had to operate with indirect data, studying volcanic ejections of deep material, or trust hypothetical depth profiles and sections in the constructions of geophysicists.

The scientific foundations of the ultra-deep drilling program were developed in the USSR in the early 1960s. The program itself was approved in 1962 by N.S. Khrushchev on the basis of the decision of the Council of Ministers of the USSR. To conduct research under this program, in 1963, an Interdepartmental Scientific Council was established on the problem of «Study of the Earth's interior and super-deep drilling», which included hundreds of qualified geologists from various research centers. The research program for the 70-80s included: the development and scientific justification of a model of the structure of the earth's crust and upper mantle, as well as the development of scientifically based methods for predicting mineral deposits, with quantitative and qualitative assessments of mineral resources. Unlike boreholes used in the search for hydrocarbons, the task of SG-3 was to obtain reliable scientific information about the structure and composition of the deep horizons of the earth's crust, in particular, the transition zone between the earth's crust and mantle (Mohorovichich boundary).

In addition to SG-3, the program provided for the creation in 1970-90 in the most important ore areas of the core network of ultra-deep (deeper than 7 km) boreholes. First of all, it was planned to drill the Saatli well in Azerbaijan with a depth of 8.3 km.

The work program was classified, and the country first learned about this project only in 1975, when an article by the Minister of Geology A.V. Sidorenko. In 1984, the first monograph about this project was published [4], and in 1998, a monograph about the scientific achievements of researchers [5]. The grandiose project has become a symbol of the scientific and industrial achievements of the country. In 1987, a special postage stamp dedicated to the Kola Superdeep was even issued.

An impressive collection of rock samples from the borehole core has been examined by a wide variety of methods. Many thousands of manufactured sections and polished sections from the borehole section were studied in detail. As a result, a reliable characterization of the geological and geochemical features of the rocks of the well, their chemical and mineral composition was obtained [6, 7, 8]. The results of measurements of the absolute age of many hundreds of rock samples were also obtained [12].

Implementation of the Kola Superdeep Borehole project.

Place of laying SG-3, on the recommendation of A.V. Sidorenko, was chosen in 1968 in the Pechenga ore district. The well is located 10 km southwest of the mining village of Zapolyarny (69°23′46″ N, 30° 36′ 31″ E), from which an asphalt highway was laid to the drilling site. Drilling operations were carried out by a specially formed Kola GSE, numbering about 3 thousand people. More than 60 large enterprises of the country participated in the work, and 19 research institutes conducted scientific research. All equipment and materials were of domestic production [5].

In the deserted tundra, a powerful modern enterprise was erected with a whole complex of buildings and structures, with industrial and residential premises and a canteen for 320 visitors. (Fig. 1). The production complex of the well was a unique high-tech structure, with a powerful foundation, on which a sectional tower 74 m high was erected, with developed equipment for drilling, for lowering and raising the drill string and stabilizing the entire pipe string, as if on weight (during tripping operations) , and during drilling [4]. Powerful power and pumping units and drilling control and monitoring systems were placed inside the tower. Modern compact telemetry and electronic sensors, which measured a wide variety of physical parameters of deep rocks while drilling, instead of the inefficient traditional logging cable, moved directly in the flow of mud mud, forwarding the measurement results to the surface.

Until 1975, the drilling of the well was carried out by the Uralmash-4E serial rig. Starting from a depth of 7263 m and up to a record mark, the drilling was carried out by a specially designed drilling rig «Uralmash-15000», weighing more than 15,000 tons, with a winch capacity of 400 tons

The Kola well was a multi-kilometer telescopic system [5]. The wellhead had an initial diameter of 92 cm and a final diameter of 21.5 cm. The first technical string (stationary casing) with a footage of 2000 m had a diameter of 324 mm. The second technical string (removable casing) had a length of 8770 m with a diameter of 245 mm. The columns were marked with magnetic marks, which made it possible to carry out accurate measurements of the depth parameters of the rocks. Radioactive marks on the last downhole pipe made it possible to measure the bottom hole temperature. Deeper than the second technical string, the rocks compacted with depth ensured full stability of the uncased wellbore, which made it possible to drill with an open hole, up to a record mark.

Figure 1. *Kola superdeep borehole (SG-3).*

On June 6, 1979, the bottom hole reached a depth of 9584 m, which exceeded the record depth of 9583 m, which belonged to the Bertha Rogers oil well in the United States. With further drilling, the record depth of penetration increased. Drilling conditions became more difficult with depth, and drillers constantly had to overcome difficult emergency situations. The temperature at a depth of 12 km reached 220°C, causing damage to devices and mechanisms. The drill core sample delivered to the surface disintegrated into fine grit as a result of decompaction and increased gas release due to a sharp change in pressure. A dense core sample could be obtained only with a slow rise of the drilling core sampler, when the gradual deconsolidation of the rocks occurred.

Emergencies during tripping operations were often accompanied by breaks in the drill string and the loss of drilling equipment. At the moment of separation of the drilling projectile from the bottom, the entire twelve-kilometer column was held on weight by a winch, and despite the loss of part of the weight in the weighted mud according to the Archimedes law, it began to stretch like rubber. As a result, the column became 40 meters longer.

Figure 2. *View of the ruins of the Kola super-deep well SG-3.*

The broken kilometer sections of the drill string were cemented, and the vertical sinking of the shaft continued, with the drill string deflected at the place of the break. As a result, five parallel bypass shafts were drilled below the base depth of 7 km, so that in a three-dimensional projection the structure of the borehole took the form of an inverted tree crown with numerous branches. One of these forks in 1990 reached a record high of 12,262 meters [11].

Figure 3. *Welded hole in the wellbore SG-3.*

The drilling team prepared for drilling to a depth of 13-14 km, but the drilling tool broke again, and by decision of the Yeltsin government, drilling work was stopped. In 1991, the Kola Superdeep Well received the status of the Research and Production Center «Kola Superdeep». In 1995-2007 The RPC conducted research already in the status of the Kola deep geolaboratory. In the geolaboratory for international projects of UNESCO and the International Geological Union, scientists from more than 20 countries carried out unique studies. The lack of funding eventually led to the closure of the Kola deep geolaboratory, although the research projects prepared by scientists at relatively low costs could bring the country multimillion-dollar profits. By the time of closing, the budget of the Kola Deep Geolaboratory was only 3 million rubles. in year. In 2008, the SG-3 building was mothballed, the equipment was stolen for scrap. Gradually, the magnificent building turned into ruins (Fig. 2, 3).

The Kola superdeep well is still the deepest well in the world. A number of wells abroad, drilled at an acute angle to the surface, are longer than SG-3. In 2008, the Maersk Oil BD-04A well was drilled in the Al-Shaheen oil field, with a length of 12,290 m. the length of the well Z-42 of the Chayvinskoye field was 12,700 m.

However, the given examples of ultra-deep drilling operations cannot claim to overcome the record achievement of the Kola super-deep well. It is possible to drill at an acute angle in pliable sedimentary rocks of gas and oil fields up to 15

km. And well SG-3 in monolithic crystalline rocks actually delivered a working industrial drilling tool to a depth of 12262 m. No one and nowhere abroad could surpass this result.

Together with geologists of the Kola superdeep well (chief geologist Yakovlev Yu.N., geologist Smirnov Yu.P.) and the Geological Institute of the KSC RAS (Vetrin V.R., Gorbatsevich F.F. and others), the author for many years (1999 -2021) was directly involved in the study of the geology of the Early Precambrian rocks of the well, and the studies concerned the gneiss-granites of the Archean basement [17], but mainly the supracrustal rocks of the Pechenga complex (Fig. 4), the full section of which was discovered by SG-3 in the interval 0-6842.0 m [7,9]. In addition, the rocks of auxiliary structural wells IX (depth 1300 m) and Kh (depth 1100 m) were studied in detail, which made it possible to trace the rocks from section SG-3 along the rise [9].

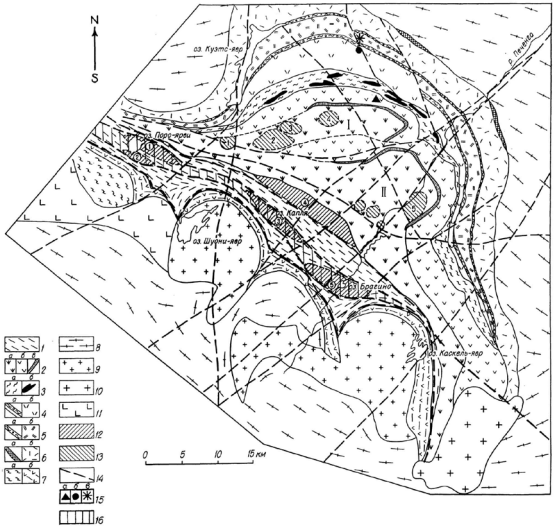

Figure 4. *Scheme of the geological structure of the Pechenga structure [7]: 1 – South Pechenga complex; 2-6: Pechenga complex.: 2 - IV BS: a, b, c - subformations; 3 - IV OS: a - metasediments; b - intrusions; (4) rocks III OS (a) and III BS (b); 5, rocks II OS(a) and II BS(b); 6 – rocks I OS (a) and I BS (b); 7: a – gneiss-schists, b – amphibolites; 8 – gneiss-granites of the Archean basement; 9 – plagiogranites (1940 Ma); 10 – microcline granites (1762 Ma); 11 - gabbro; 12 - volcanic centers in the South Pechenga zone; 13 - volcanic centers in the North Pechenga zone; 14 - faults; 15 – position of SG-3 (a) and structural wells IX (b) and Kh (c); 16 – Poroyarvinsky fault trough.*

Results of the Kola Superdeep Well Project implementation.

SG-3 fully completed all the tasks assigned to it, both in technical and scientific terms. In the process of research, a number of important information about the deep horizons of the earth's crust was obtained. In many ways, the results were unexpected and not fully appreciated by the scientific community.

First of all, a high permeability for fluids and hydrothermal solutions of the abyssal zones of the Earth's crust has been established. Previously, it was believed that with depth, the solidity of rocks should increase, which will lead to a decrease in their permeability, as well as porosity and fracturing. However, the actual density of cracks and high porosity of rocks at great depths, contrary to forecasts, persisted, and even increased in some areas. Under high pressure, fluids and hot solutions circulate in these zones.

In the 70-80s of the last century, projects were developed to get rid of liquid radioactive waste and toxic substances by pumping them into the sedentary deep layers of the earth's crust. The results of drilling SG-3 forced humanity to abandon such projects - fluid flows in a matter of years would carry radioactivity and toxic compounds to the entire thousand-kilometer surrounding space, and as a result, the deep zones of the earth's crust of the largest European states would be poisoned.

As a result of sinking the Kola well, unique data on the structure and temperature characteristics, physical properties and geochemical features of deep rocks were obtained, the presence of ore mineralization and metal-bearing hydrothermal systems in the deep zones of the earth's crust was proved. Completely unexpected results were recorded when measuring the temperatures of rocks at great depths. Previously, it was assumed that in the strata of crystalline rocks of the basement of the Baltic Shield, the temperature increases slightly with depth (by about 8-10°C per 1 km). Instead of the expected 120°C, the measured temperature in the Kola well reached 180°C at a depth of about 10 km, and 212°C at a depth of 12 km. It is possible that the increase in temperature is due to increased tectonic activity in the abyssal zones of the earth's crust. The drilling results completely refuted the previously existing ideas about the structure of the earth's crust both in the area where the well was laid, and within the entire Baltic Shield. The most experienced geophysicist, an employee of the Geological Institute KolNSC RAS, N.V. Sharov, who had been working on the Baltic Shield for decades, rated the results of seismogeological studies of his colleagues on the planet's crystalline shields extremely low [10]: "During deep drilling, direct data were obtained on the composition and structure of the earth's crust to a depth of 12 km, which showed that we know nothing about the continental crust. The drilling results showed that the heterogeneities recorded by geophysical data in the upper part of the crystalline crust are due to changes not only in the composition of deep rocks, but also in their physical state. Therefore, the determination of even the approximate composition of rocks

by the values of only the velocity of propagation of elastic waves cannot be unambiguous." The design section of the earth's crust in the drilling area, compiled according to seismic data, predicted that at a depth of 4 km, the drilling tool would leave the Early Proterozoic rocks and enter the crystalline rocks of the Archean basement [5]. Further, according to the project, having passed a three-kilometer layer of granite-gneisses and a thin layer of amphibolites of the basalt layer, the well was supposed to reach the ultrabasic rocks of the upper mantle. However, in reality, drilling up to a depth of 6842 m proceeded through the Middle Proterozoic rocks of the Pechenga Complex and only then through the Archean granite-gneisses of the crystalline basement. Amphibolites of the basalt layer were not found at all - to the very record depth, the drilling projectile made its way through the Archean granite-gneisses. Compacted due to increased PT conditions, crystalline rocks significantly changed their physical properties and were perceived by geophysicists in seismological studies as denser than conventional granite-gneiss. These ideas formed the basis for the design section of the Kola well. As a result, instead of the supposed "Conrad surface" (the roof of the basalt layer) at a depth of seven kilometers, only a kind of deconsolidation zone was actually established - a "crustal waveguide", along which powerful subhorizontal movements of tectonic blocks occurred. Similar deconsolidation zones were established throughout the entire depth section of the well [6]. The result of the movement of tectonic blocks in these zones was the scaly-thrust structure of the entire Lapland-Pechenga megablock. For the first time, the existence of significant accumulations of underground highly mineralized waters at abyssal depths in the basement of the Baltic Shield has been proven. The largest inflows of mineralized waters are found at great depths (6.5-11.5 km and more), in zones of tectonic movements with increased permeability. In zones of intensive circulation of groundwater, the formation of low-temperature hydrothermal mineralization (copper, lead-zinc, nickel) took place. This allows us to conclude that it is fundamentally possible for large deposits of low- and high-temperature metal ores to appear in the deep horizons of the earth's crust, which is an important factor in the development of metallogenic forecasts for the search for ore deposits at great depths. In addition, hydrocarbon gases, including methane in significant concentrations, were found in the Archean gneiss-granites of the basement. This is another argument in favor of the inorganic origin of hydrocarbons. The conducted studies on the well showed that deep crystalline rocks were formed with the active participation of biological processes. At the same time, the isotopic composition of carbon in the analyzed samples indicates two sources of their origin: one of them is of mantle origin, the second is biogenic, with biogenic carbon predominantly concentrated in Proterozoic metasedimentary rocks. Also, in the Proterozoic metasediments, the remains of microorganisms were found, the absolute age of which is more

than 2 billion years. These facts confirm the fruitfulness of V.I. Vernadsky about the existence of early Precambrian biospheres on Earth. The gamma ray logging conducted at the Kola superdeep borehole made it possible to establish the vertical zonality of the distribution of uranium, thorium and potassium concentrations. This discovery, along with other geophysical methods, made it possible to formulate a general thermal model for the formation of the most ancient earth's crust in the Archean-Proterozoic. The geophysicists of the Kola Superdeep, using also the results of measurements of geophysical parameters at other superdeep wells in the country, could track in three-dimensional space the features of changes in these parameters and, on this basis, build three-dimensional models of the stress states of the earth's interior over vast territories, as well as predict subsequent changes in these states. The developed bases for volumetric modeling of deep crustal stresses could help to make reliable forecasts of earthquakes and catastrophic movements of abyssal sections of the earth's crust many thousands of kilometers from SG-3.

Japan, along with other developed countries of the world located in seismically unfavorable areas, allocates tens of billions of dollars for research work related to the prediction of catastrophic earthquakes, powerful impulsive tectonic movements of the earth's crust blocks and other natural hazards associated with explosive discharges of stresses in the earth's interior . Short-sightedly stopped half a century before the present day, global geophysical research on the SG-3 would significantly bring the population of the planet closer to solving the problem of human safety in seismically hazardous zones. The resumption of international geophysical research would also help solve a number of other important scientific problems related to tracking patterns with the peculiarities of changes in geophysical parameters in the deep zones of the planet's lithosphere and oceanic hydrosphere, up to tracking the movement of submarines in the ocean depths. The continuation of large-scale research on ultra-deep drilling projects would also bring humanity closer to successfully solving the main mystery of deep geophysics - establishing the details of the structure of the most important interface between the mantle and the lower horizons of the earth's crust (the Mohorovichic surface), and even more so from establishing the nature and structural features of the mantle itself. Taking into account the most important scientific and technical problems that could have been solved in due time with the continuation of work at SG-3, it can be stated that the closure of the Kola super-deep well is an extremely reckless and ill-considered action.

Possibilities of resuming drilling operations on the remaining SG-3 shafts. Expert estimate of the cost of restoring the Kola superdeep wellbore - about 100 million rubles. To a depth of 4 km, a working borehole with a diameter of 20 cm has been preserved, and deeper, to a depth of 8 km, a working borehole with a diameter of 10 cm has been preserved. Further penetration to a depth of more than

12 km, taking into account the need to overcome crystalline monolithic rocks of the highest category XII in terms of drillability, in modern conditions is comparable in terms of costs to the implementation of a large space project. The Soviet country, when implementing the prestigious project of the Kola superdeep well, was not associated with the problem of saving financial costs. As a result, the SG-3 project cost the state half a billion rubles. Currently, vertical drilling in crystalline rocks to a depth of 13-15 km will require fantastic efforts and financial costs of several billion dollars. However, the onset of a global crisis associated with an acute shortage of explored and predicted mineral resources, in particular hydrocarbon raw materials and metal ores, requires an early mobilization of efforts to develop international ultra-deep drilling projects, as well as boosting research aimed at revolutionary improvement of deep drilling technology and technology. The deepening crisis, which is alarming for developed countries, has forced a number of major states, and primarily China, to re-concentrate efforts to solve this problem.

In 2016, the China Geological Survey developed the Deep Geological Survey Project, which focuses on the national energy strategy. Experts from the Geological Survey of China believe: «Deep drilling is a way to understand the material composition, structure and dynamic process of the Earth's inner spheres» [15]. Much more specifically, this problem is considered by practitioners - Chinese geologists-engineers: "Deep drilling is becoming the direct and most effective means of exploiting deep mineral resources. To determine the limit of drilling depth in the earth's crust, we for the first time, using a three-axis server system, conducted tests for the case of well deformation under high P-T conditions" [16]. Chinese drilling geologists have focused their attention on deep drilling in China's oil basins. However, it should be noted that all over the world, the reserves of metal ores are associated primarily with shields - areas of platforms on which the Archean basement comes to the surface. There are no large shield structures in China, but significant exposures of the ancient basement are known on the Liaodong and Shandong Peninsulas and on the South China Platform. China will certainly, given its financial resources, begin deep vertical drilling in the Early Precambrian crystalline rocks in these areas. This is where the experience of the Kola Superdeep is useful to Chinese geologists. It is characteristic that while dozens of publications on these issues appeared in the press during the drilling of a well and during the processing of the obtained materials, in stagnant years, rare publications usually dealt with technical problems, for example, neutron tomography of individual samples of the SG-3 section [17], or the use of simulation analysis to compensate for deviations of the wellbore during deep drilling [16]. Some of the published publications deal with the problems of reinterpretation of previously published materials in the light of new hypotheses and ideas [1, 2, 3]. Currently, dozens of

research centers in Russia and abroad are showing interest in the revival of the SG-3. The very symbol-brand of the Kola super-deep well penetrates deep into the minds of Russians. Feature and documentary films about the Kola Superdeep are filmed on Murman, though often with mystical fantasies about the underworld awakened during drilling. Deputy Governor Olga Kuznetsova at a briefing in May 2020 announced that the regional government had decided to restore SG-3, with its subsequent transfer to federal ownership in the status of a tourist site. Certain shifts in this direction are already taking place, with Russia acting as the initiator of the initiative to resume ultra-deep drilling. On April 6, 2018, Director General of Rosgeology Roman Sergeevich Panov said in an interview with a correspondent of the weekly Argumenty Nedeli (htpp://www.mstu,edu.ru) that a project has been developed for drilling four ultra-deep wells up to 7 km deep, the first of which will be drilled at North Caucasus to test the hypothesis of large deposits of hydrocarbons at depth. Efforts to restore the scientific significance of the Kola ultra-deep well and the real possibility of continuing vertical deep drilling using the remaining working holes will play a significant role in the international process of implementing ultra-deep drilling projects. In the future, large international projects for studying the deep layers of the lithosphere will make it possible to build three-dimensional geophysical models of the movement of giant blocks of the earth's crust, which will facilitate the development of reliable and timely forecasts of catastrophic earthquakes and powerful tectonic shifts of abyssal geological blocks, and will also allow solving a number of important scientific problems. It is to be hoped that the Kola Superdeep Borehole has not yet had its last word.

Conclusion. It should be noted that the project of ultra-deep drilling «Kola borehole SG-3» was completed at a fairly high level. The main task facing the creators of the project - knowledge of the structure of the deep bowels of the planet - was successfully solved. The prerequisites for the development of the fundamental foundations of the theory of the formation of the earth's crust in the early Precambrian have been created. In the process of research, a number of important information about the structure of the earth's interior was obtained. The results were largely unexpected and not yet sufficiently systematized. A number of issues, due to objective reasons, need further study, in particular, knowledge of the essence of the most important interface between the mantle and the lower horizons of the earth's crust - the Mohorovichic surface, and even more clear understanding of the nature and features of the mantle itself. Attempting a successful solution to this problem directly depends on the continuation of large-scale deep drilling work. The purpose of the publication is to once again draw the attention of the scientific community to an important problem - the resumption of deep drilling on a global scale, which will help solve the cardinal task of geology - the creation of a real model of the structure of the earth's crust and upper mantle. Within

the framework of this model, geologists will be able to study the features of the material composition and physical characteristics of deep rocks, develop modern models of equipment and apparatus for research and determine the best directions for further work. In the future, the solution of these problems will significantly strengthen Russia's position as a leading power in future international programs for ultra-deep drilling. Detailed scientific studies of the lower horizons of the planet's crust using ultra-deep drilling is a unique opportunity to obtain reliable information about the material composition and physical properties of deep rocks, to establish the presence of complex natural processes in the depths of the planet, to reliably provide resources for future industry, and to create guarantees for the successful economic and social development of society . A deep study of the earth's interior is due not only to the desire of mankind for knowledge, but also to ensure real positive achievements in economic and social development. It is generally accepted that with the successful drilling of the Kola superdeep well, a new period in the study of the continental earth's crust of our planet began. Ultra-deep drilling on the continents and in the oceans will eventually grow into a new branch of science and technology, which will combine the latest achievements of scientific and technological progress in general and geological sciences in particular. The possibility of studying the earth's interior will open up for geologists new, yet unknown patterns of the Earth's development, which will make it possible to find out the features of geological processes at great depths, including the processes of formation of unique deposits of mineral raw materials.

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ANALYSIS OF THE FOREST RESOURCE POTENTIAL IN ZABAIKALSKY MOUNTAIN-PERMAFROST FOREST AREA

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Abstract. *The total area of forests included in the Zabaikalsky mountain-frozen forest region is 27,682.5 thousand hectares, of which 17,287.0 thousand hectares (62.4% of the total forest area) are commercial forests. The main timber reserves are concentrated in Mogochinsky (13%), Tungokochensky (14%), Charsky (11%) forestries of the Trans-Baikal krai and Muisky (11%) forestries of the Republic of Buryatia. The actual harvesting of wood from all types of cuttings, in general, in the forest area amounted to 614.52 thousand m3 of marketable wood or 11.12% of the total annual allowable cut (5524.07 thousand m3). The largest percentage of the use of the total allowable cutting area in the forest area under study was when cutting forest plantations in forest areas intended for the construction, reconstruction and operation of forest facilities, timber processing infrastructure and facilities not related to the creation of forest infrastructure - 15.27%.*

The purpose of the study is to analyze and assess the quantitative and qualitative state of forests, the level of use of the allowable cut in the Trans-Baikal mountain-frozen forest region.

Keywords: *forest fund, Republic of Buryatia, Trans-Baikal krai, use of forest types, rated wood cutting, timber harvesting*

Introduction

The territory of the state forest fund of the Zabaikalsky mountain-frozen region is divided into 5 forestries of the Transbaikal Territory (Mogochinskoye, Nerchinskoye, Tungokochenskoye, Charskoye, Shilkinskoye) and 5 forestries of the Republic of Buryatia (Vitimskoye, Eravninskoye, Kondinskoye, Muyskoye, Romanovskoye). Forest areas are divided into 52 local forest areas. The distribution of the total area of the forest fund and the number of forestries in the territory are presented in table 1.

Table 1

Distribution of the area of the forest fund of the Zabaikalsky mountain-frozen region

Forestry	District forestries	Area, ha	Note
The Republic of Buryatia			
Vitimskoye	Bagdarinskoye	585400	The forestry office is located in the village of Bagdarin, located 594 km from the city of Ulan-Ude and 330 km from the nearest railway station Chita of the Trans-Baikal Railway
	Bauntovskoye	807975	
	Varvarinskoye	379711	
	Mongoyskoye	678506	
	Nizhnetsipskoye	1869990	
	Uakitskoye	977235	
Eravninskoye	Gundinskoye	123815	The department for organizing and ensuring the activities of the Eravninsky forestry is located in the village of Sosnovo-Ozerskoye, located 296 km from Ulan-Ude and 100 km from the nearest railway station - Mogzon
	Eravninskoye	94925	
	Eravninskoye (rural)	219455	
	Zazinskoye	315307	
	Mozhayskoye	76007	
	Sosnovo-Ozerskoye	102395	
	Tuzhinskoye	128693	
Kondinskoe	Isinginskoye	178073	The forestry is located “Eravninsky district”, the village of Sosnovo-Ozerskoye
	Kondinskoye	311226	
	Santyrinskoye	217559	
Muyskoe	Bambuiskoye	662162	The forestry is located in the north-east of the Republic of Buryatia on the territory of the municipality “Muisky district”, the center of which is the village of Taksimo
	Vitimskoye	104971	
	Muyskoe	278677	
	Muyakanskoye	260931	
	Paramskoye	154990	
	Severomuyskoye	470185	
	Taksimovskoe	171562	
	Ulan-Makitskoye	176210	
Romanovskoe	Vitimskoye	300789	The department for organizing and ensuring the activities of the Romanovsky forestry is located in the village of Romanovka, Ulan-Ude c.
	Dzhilindinskoye	485508	
	Kydzhimitskoye	356954	
	Romanovskoye	159339	
Transbaikal krai			
Mogochin-skoe	Amazarskoye	729021	The forestry is located in the north-eastern part of the Trans-Baikal krai on the territory of the municipalities “Mogochinsky District” and “Tungiro-Olekminsky District”
	Davendinskoe	268924	
	Ksenievskoe	339365	
	Mogochinskoe	376053	
	Sbeginskoye	171030	
	Semiozernoye	568763	

	Tungiro-Olekminskoye	4276932	
Nerchinskoe	Znamenskoye	56485	The forestry is located on territories "Nerchinsky district" and "Tungokochensky district"
	Zyulzinskoye	164259	
	Kalinovskoye	50162	
	Peshkovskoye	52892	
Tungokochenskoe	Vershino-Darasunskoye	100766	The forestry is located on the territory of the municipal formation "Tungokochensky district"
	Kalakanskoye	959358	
	Levoberezhnoye	884042	
	Tungokochenskoye	1794080	
	Usuglinskoye	399038	
Charskoe	Naminginskoye	1560115	The forestry is located in the northern part of the Trans-Baikal Territory on the territory of the municipal formation "Kalarsky Municipal District"
	Nelyatinskoye	1194430	
	Sredne-Kalarskaya dacha	989172	
	Udokanskoye	1261061	
	Charskoye	514922	
Shilkinskoye	Upper Khilinskoye	97181	Forestry in «Shilkinsky district» and «Tungokochensky district»
	Zubarevskoye	75890	
	Shilkinskoye	150000	

The Transbaikalian mountain-permafrost region is characterized by a complex structure of the surface. A characteristic feature is a large number of mares - hummocky pushets-sedge swampy slopes with dwarf birch, separate low-growing larches on frozen marsh soils. Plantations of low quality (IV-Va), mostly low-density (0.3-0.5), average timber reserves per 1 ha range from 40 to 120 m3 [1-2].

Material and methods

The study used various methods of comparative analysis and evaluation, graphic-analytical, information-analytical. The initial data for the study were taxation descriptions, forest plans of the subjects of the Far Eastern Federal District, forestry regulations of forestries [3-12], materials of the state forest registry (GLR-8) [13], form 6-OIP "Information on the use of forest plots leased, permanent (perpetual and gratuitous use) [14]", form 12-OIP "Information on the allocation of logging sites and felling of forest plantations" [15].

Results and discussion

The total area of forest lands on the territory of the Zabaikalsky mountain-frozen region as of 01/01/2020 is 23452.1 thousand hectares or 84.7% of the total area of the region (Table 2).

Table 2

Characteristics of forest and non-forest lands in the Zabaikalsky mountain-frozen forest region

Forestries	Land categories								
	Total area	Forest lands		Lands covered with forest vegetation		Land not covered by forest vegetation		Non-forest lands	
	ha	ha	%	ha	%	ha	%	ha	%
Transbaikal krai									
Mogochinskoye	6730088	6086881	90,44	5899766	87,66	187115	2,78	643207	9,56
Nerchinskoye	323798	308814	95,37	304947	94,18	3867	1,19	14984	4,63
Tungokochenskoye	4137284	3907182	94,44	3769473	91,11	137709	3,33	230102	5,56
Charskoye	5519700	3995002	72,38	3680737	66,68	314265	5,69	1524698	27,62
Shilkinskoye	323071	293631	90,89	279234	86,43	14397	4,46	29440	9,11
Total for forestries	17033941	14591510		13934157		657353		2442431	
The Republic of Buryatia									
Vitimskoye	5298817	4666692	88,07	4437829	83,75	228863	4,32	632125	11,93
Eravninskoye	1060597	967902	91,26	945878	89,18	22024	2,08	92695	8,74
Kondinskoye	706858	619760	87,68	613412	86,78	6348	0,90	87098	12,32
Muyskoye	2279688	1429093	62,69	1343569	58,94	85524	3,75	850595	37,31
Romanovskoye	1302590	1177129	90,37	1172221	89,99	4908	0,38	125461	9,63
Total for forestries	10648550	8860576		8512909		347667		1787974	
Total district	27682491	23452086	84,72	22447066	81,09	1005020	3,63	4230405	15,28

Protective forests occupy 7.8% of the total area of the district, operational forests - 62.4%, the rest of the area is occupied by reserve forests (Table 3) .

Table 3

Distribution of forests by purpose in the forest areas of the Trans-Baikal krai and the Republic of Buryatia

Forestries	Total forest area, ha	Protective forests		Operational forests		Reserve forests	
		ha	%	ha	%	ha	%
Transbaikal krai							
Mogochinskoye	6730088	457070	6,8	4290205	63,7	1982813	29,5
Nerchinskoye	323798	43501	13,4	280297	86,6	0	0,0
Tungokochenskoye	4137284	233834	5,652	3085755	74,584	817695	19,764
Charskoye	5519700	228849	4,15	4694121	85,04	596730	10,81
Shilkinskoye	323071	23877	7,4	299194	92,6	0	0,0
The Republic of Buryatia							
Vitimskoye	5298817	739417	14,0	1230445	23,2	3328955	62,8
Eravninskoye	1060597	116837	11,0	943760	89,0	0	0,0

Kondinskoye	706858	26876	3,8	679982	96,2	0	0,0
Muyskoye	2279688	176282	7,73	593561	26,04	1509845	66,23
Romanovskoye	1302590	112870	8,7	1189720	91,3	0	0,0
Total for the region	27682491	2159413	7,8	17287040	62,4	8236038	29,7

The average forest cover in the Trans-Baikal mountain-frozen forest region as of January 1, 2020 is 80% (Republic of Buryatia (Vitimskoye 89.6%; Eravninskoye 64.1%; Kondinskoye 89.1%; Romanovskoye 67.8%; Muiskoye 58.6%; Trans-Baikal Territory: Mogochinskoe 87.7%; Nerchinskoe 91.1%; Charskoe 66.7 5; Tungokochenskoe 91.1%; Shilkinskoe -86.4%).

The forests of the Trans-Baikal mountain-frozen region are assigned to the South Siberian mountain zone.

Coniferous plantations make up 466732 ha (young stands 17% (1484671 ha; middle-aged 28% 2406037 ha; maturing 9% 772681 ha; ripe and overmature 46% 3989273), softwood - 18229 ha (young stands 31%; medium-aged vegetable 53%; 7%, mature and overmature 9%).) forestries of the Trans-Baikal krai and Muisky (11%) forestries of the Republic of Buryatia (Figure 1).

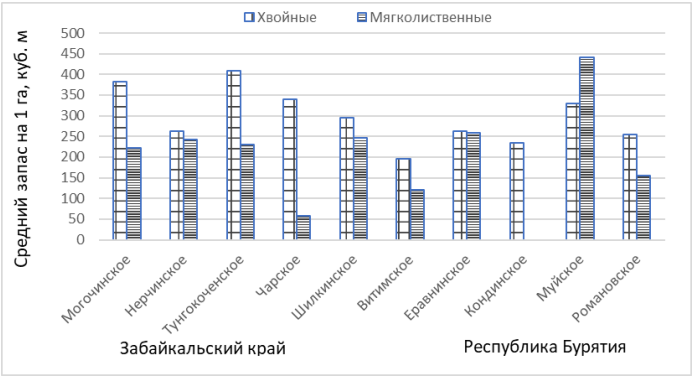

Figure 1. *Average stock per 1 hectare of operational fund in Zabaikalsky mountain-frozen forest area, m³*

As of 2021, 195 lease agreements for forest plots for various types of forest use are in force on the territory of the Zabaikalsky mountain-frozen forest region on an area of 381.14 thousand hectares (13.8% of the total forest fund area).

On the lands of the forest fund of the study area, the following types of forest use are carried out: timber harvesting, harvesting and collection of non-timber forest resources (brushwood), hunting, agriculture (reindeer and antler herding, hay mowing, grazing of farm animals); research and educational; recreational;

geological study of subsoil, development of mineral deposits; construction and operation of reservoirs and other artificial water bodies; construction, reconstruction, operation of linear facilities. In terms of area, the lease of the forest fund for the implementation of the geological study of the subsoil, exploration and extraction of minerals is absolutely dominant 43%, timber harvesting 16% (Figure 2).

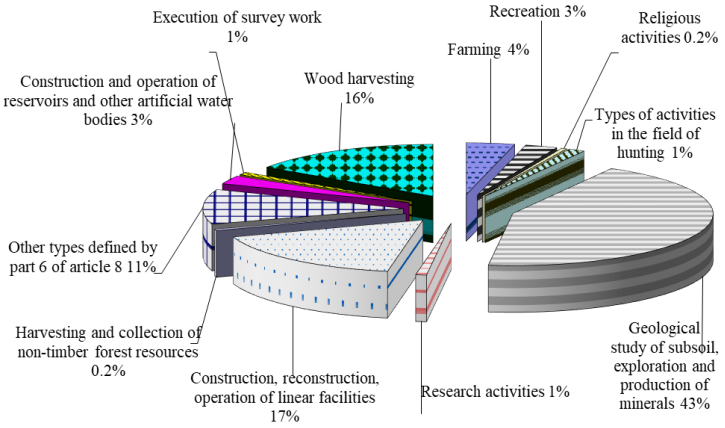

Figure 2. *Use of forest plots provided for rent in the Zabaikalsky mountain-frozen forest region*

The actual harvesting of wood from all types of cuttings, in general, in the forest region amounted to 614.52 thousand m^3 of marketable wood or 11.12% of the total annual allowable cut (5524.07 thousand m^3). The highest percentage of the use of the total allowable cutting area in the forest area under study was when felling forest plantations in forest areas intended for the construction, reconstruction and operation of forest facilities, timber processing infrastructure and facilities not related to the creation of forest infrastructure - 15.27% (table 4).

Table 4

Dynamics for all types of felling of forest plantations by forest areas located in the Zabaikalsky mountain-frozen region, thousand m^3

Forestries	Indicators	When felling mature and overmature forest plantations	When felling forest plantations when caring for forests	When felling damaged and dead forest plantations	When felling forest plantations in forest areas intended for the construction, reconstruction and operation of facilities
Transbaikal krai					
Mogochinskoye	Rated wood cutting	2658,9	1,7	12,3	469
	Actual development	38,7	0	4	43,3
Nerchinskoye	Rated wood cutting	433,7	0,2	9,1	24,3
	Actual development	31,4	0	4,1	0
Tungokochenskoye	Rated wood cutting	1096,3	1,9	15,7	53
	Actual development	36,5	0	0,4	1,6
Charskoye	Rated wood cutting	445,6	0,6	0,44	120
	Actual development	17,4	0	0	16,3
Shilkinskoye	Rated wood cutting	179,6	0,3	39,1	24,3
	Actual development	51,3	0	5,55	0,35
The Republic of Buryatia					
Vitimskoye	Rated wood cutting	721	85,9	71,7	1,8
	Actual development	14,89	0	0	5,3
Eravninskoye	Rated wood cutting	924,1	90,8	37,15	2,2
	Actual development	288,25	3,9	1,3	31,4
Kondinskoye	Rated wood cutting	678,4	22,5	0	2
	Actual development	12,9	3,3	0	0
Muyskoye	Rated wood cutting	382,1	120,3	16,88	0,7
	Actual development	16,0	0,43	0,6	4
Romanovskoye	Rated wood cutting	920,8	84,8	0	6,3
	Actual development	14,8	2,7	0	5,2
Total for the region	Rated wood cutting	8440,5	409	202,37	703,6
	Actual development	522,14	10,33	15,95	107,45
	%	6,19	2,5	7,88	15,27

When cutting damaged and dead forest plantations, the percentage of use of the total allowable cutting area was 7.88%, while cutting mature and overmature forest plantations - 6.19%; when felling forest plantations when caring for forests - 2.5%.

In the Trans-Baikal mountain-frozen forest region, clear cuttings predominate, they account for more than 95% of the total number of all types of felling. Of the selective cuttings, which account for 1%, uniformly gradual cuttings are carried out.

The most significant volumes of actual timber harvesting are noted in the Eravninskoye forestry of the Republic of Buryatia 144676.8 m3; Charskoye for-

estry of the Trans-Baikal Territory - 4524 m3. The main loggers in the Republic of Buryatia are "BLK" CJSC (table 5).

Table 5

Harvesting of timber on leased plots in the Zabaikalsky mountain-frozen region in the Republic of Buryatia and the Trans-Baikal Territory as of 01.01.2022 in operational forests

Name of the forest user	Area, ha	Operational forests					
		Installed annual volume of wood harvesting, cubic meters			Actually harvested, cub. m.		
		Totally	including:		Totally	including:	
			clear felling	selective felling		clear felling	selective felling
Transbaikal krai							
Tungokochenskoye forestry							
IE Kharitonov V.M.	14100	1984	1984	-	1575	1575	-
«Prioritet» LLC	28521	19909	19909	-	1203	1203	-
Charskoye forestry							
IE Gavshin K.P.	2476	4800	4800	-	4524	4524	-
Shilkinskoye forestry							
IE Yeremin S.A.	3994	4400	4400	-	4183	4183	-
IE Yeremin S.A.	8464	6768	6768	-	5902	5902	-
IE Leonova L.V.	15118	4700	4700	-	3983	3983	-
The Republic of Buryatia							
Yeravninskoye forestry							
«LPK VOSTOK» LLC	23678	22700	22200	500	23100	22200	900
IE Tsyrenzhapov B.D.	3042	300	300	-	-	-	-
«BLK» CJSC	118925	126300	114900	11400	145310,8	144676,8	634
Kondinskoye forestry							
«BLK» CJSC	671641	361800	332100	29700	15628,5	11239,5	4389

Based on the analysis of the forest fund and forest infrastructure of the Zabaikalsky mountain-frozen forest region, the **conclusions** are as follows:

1. Plantations of the Trans-Baikal mountain-frozen forest region are characterized by the predominance of coniferous stands. Coniferous forests account for 90%. The main timber reserves are concentrated in Mogochinsky (13%), Tungokochensky (14%), Charsky (11%) forestries of the Trans-Baikal Krai and Muysky (11%) forestries of the Republic of Buryatia

2. The area is dominated by the lease of the forest fund for the implementation of geological study of the subsoil, exploration and mining - 43%. The actual harvesting of wood from all types of cuttings, in general, in the forest region

amounted to 614.52 thousand m3 of marketable wood or 11.12% of the total annual allowable cut (5524.07 thousand m3). The level of use of the allowable cutting area for felling mature and overmature forest plantations is 6.19%. On the territory of the Republic of Buryatia, which are part of the Zabaikalsky mountain-frozen region, logging is carried out by: "BLK" CJSC, "LPK VO-STOK" LLC, IE Tsyrenzhapov B.D.; Trans-Baikal krai - IE Leonova L.V., IE Eremin S.A., IP Gavshin K.P., IE Kharitonov V.M.

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13.Form No. 8 for GLR in the Far Eastern Federal District dated 01/01/2020.

14.Form No. 6 of the OIP "Information on the use of forest plots provided for lease, permanent (perpetual and free use) for 2021.

15.Form 12-OIP "Information on the allocation of cutting areas and felling of forest plantations" for 2021.

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MULTI-MASS THERMODYNAMIC MODEL OF INDUCTION MOTOR

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Abstract. *The paper considers the development of computer 6-mass thermodynamic model of asynchronous motor with squirrel-cage rotor. Computer models of multi-mass thermodynamic models are an integral part of static and dynamic mathematical models, an intensively developing topical direction in the automated electric drive. The aim of the paper is to develop a mathematical and computer-based 6-mass thermodynamic model of an induction motor characterized by rational partitioning into thermal masses and heat generation and having a minimum of cross-links in the structural scheme. On the basis of previous papers of authors and analysis of papers of other authors the structural scheme of model is offered in which scientific novelty consists in calculation of heat transfer coefficients on the basis of variables of heat generation and steady-state temperatures of separated masses. The practical value of the article consists in formulas for calculation of heat capacity, heat transfer coefficients and time constants of isolated masses. Some heat transfer coefficients additionally depend on the engine rotation speed depending on the type of ventilation system. Theoretical research was carried out using the methods of thermodynamics and the theory of automatic control. The design software Matlab Simulink on the basis of the vector-matrix differential equation was used when calculating the thermal processes. The developed computer program in the article on the example of asynchronous motor*

4A90L4Y3 was used for the analysis of four different thermal processes in mode S1. The program can be used in the composition of static and dynamic models of an automated alternating current electric drive to calculate transients using tachograms and load diagrams with modes S1, S2, S3 and S6, as well as in the composition of models of load units for testing engines after overhaul.

Keywords: *thermodynamic mathematical model, heat generation, losses, induction motor, thermal parameters, computer model.*

INTRODUCTION

The choice of an electric motor is one of the key points when designing industrial plants. The performance, reliability and economy of the designed unit depend on the right choice of motor. In most cases, operating modes differ from the basic standard S1, S2 or S3 and therefore you have to overestimate the rated motor power, which leads to an increase in the cost of equipment, underutilization of the motor power.

To check motors by heating, it is preferable to use methods based on the construction and analysis of temperature load diagrams [1]. When selecting motors, the peculiarities imposed on electromechanical energy conversion processes by heating conditions must be carefully considered. Additionally, the nature of the internal heat generation depending on the drive system must be taken into account [2]. When controlling a squirrel-cage induction motor (SAC) from a transistor frequency converter based on an autonomous voltage inverter (VFD), the losses in the motor depend on the mechanical load (copper losses) and the speed of rotation (supply frequency), so a reliable thermodynamic model as part of a static or dynamic model of the electric drive that takes into account these features, is an integral part of the modern software package of the designer.

LITERATURE ANALYSIS ON ASYNCHRONOUS MOTOR THERMAL MODELS

Thermal models can be single-mass or multi-mass. Single-mass models do not meet modern requirements. Multi-mass models allow a fairly accurate calculation of the temperature of a selected element, and the calculation accuracy increases as the number of masses considered increases [3]. However, at the same time, the complexity of calculation also increases. 2,3,4,5,19,24 ADC mass thermal models are known [4–10], with the main direction of development being to reduce the number of masses, while maintaining temperature calculation accuracy. It was noted in sources [8, 11] that the number of Asynchronous motor elements considered, equal to 6 or 7, allows the temperature of engine components to be calculated with high accuracy. The complex finite-element model [12,13], which calculates simultaneously the electromagnetic, electromechanical, and thermal processes in the cross section of the Asynchronous motor raises doubts about the reliability of

the obtained array of results, since a scrupulous preparation of the array of initial parameters for this cross section is initially required, which is not always possible.

MAIN IDEA OF THE ARTICLE

Selection of quantity of thermal masses in thermal model should be based on typical design of ADC, availability of initial design data, uncomplicated methodology of initial parameters calculation with possibility of reliable measurements and experimental verification of obtained results. Three-phase asynchronous motors with phase or squirrel-cage rotor have a pronounced radial structure, in which the properties of materials differ little along the length, but significantly differentiate along the radius of the motor. The paper proposes 6mass thermodynamic radial model with separation of basic masses differing from each other by design, materials, heat capacity, nature of heat generation and heat transfer as a function of load and relative frequency f. Calculation of model parameters is based on motor design data (height and number of teeth, thickness and diameter of magnetic wire, etc.) [14], on experimental measurements and expert estimates of steady-state temperature.

DEVELOPMENT OF A THERMAL MATHEMATICAL MODEL

Assumptions accepted when developing a mathematical model of AD:

1. thermal masses are represented by concentric rings nested into each other and having different mass, specific heat capacity, and temperature;

2. heat exchange between bodies occurs as a result of contact thermal conduction and air convection due to temperature gradient in the first degree. Heat transfer by radiation is not considered.

3. Heat transfer coefficients from heat conduction and convection depend linearly on cooling air velocity and rotor rotation speed.

4. temperature of each thermal mass is constant across the cross section and varies as a function of internal heat generation, thermal conductivity and temperature of neighboring masses.

In accordance with this, thermal state of asynchronous motor is described by vector-matrix heat conduction equation

$$\frac{d\tau}{dt} = \frac{\Delta P}{C} = A \cdot \tau \qquad (1)$$

where: C – diagonal matrix of heat capacities, J/°C; τ – vector of temperature excess over the environment, °C; ΔP – heat generation vector (losses in the Asynchronous motor), W; A – diagonal matrix of thermal conductivities, J/c/°C.

The thermal mass breakdown of the engine elements adopted in the article (Table 1) minimizes cross-links, the heat capacity and thermal conductivity matrices become diagonal, and thermal calculations are simplified.

In Table 1 we summarize the initial formulas for calculating the thermal model: the breakdown of engine elements by heat masses; heat generation; heat capac-

ity; heat transfer: heat transfer; steady-state temperatures; transfer coefficients and heating time constants.В таблицу 1 введены следующие коэффициенты:

P_{1H} – rated electromagnetic power, W;

P_{2H} – rated mechanic power, W;

c_A, c_C, c_M – Specific heat capacity of aluminum, steel, and copper, respectively;

f – relative frequency of the drive supply voltage;

s – rotor slip.

Table 1

Initial formulas for calculating the thermal model

Name	1	2	3	4	5	6
Composition	Enclosure, casing, fan	Stator magnet wire without teeth tines	Stator teeth, winding, insulation	Rotor cogs, winding, insulation	Magnet wire of the rotor without teeth	Shaft, bearing. sewn
losses, W	dP_d	dP_{cc} [15]	dP_{mc}	dP_{mr}	dP_{cr}	dP_{mex}
Calculation	$0{,}005P_{2н} \cdot f$	$0{,}02P_{1н} \cdot f$	$3 \cdot I_1^2 \cdot R_1$	$3 \cdot I_2^2 \cdot R_2$	$s \cdot dP_{cc}$	$dP_{сумм} - dP_{1-5}$
Settled temperature, °C	50	75	100	130	110	60
Heat capacity C_i,J/°C	$M_1 \cdot c_a$	$M_c \cdot c_c$	$M_{3c} \cdot c_c + \cdot$ $+M_{3m} \cdot c_m$	$M_{4c} \cdot c_c +$ $M_{4a} \times\times c_a$	$M_5 \cdot c_c$	$M_6 \cdot c_c$
Heat transfer Aij, J/c/°C	$\frac{dP_{сумм}}{Q_1-1{,}1Q_0+0{,}1Q_6}$	$\frac{A_{10}(Q_1-Q_0)-dP_d}{Q_2-Q_1}$	$\frac{A_{21}(Q_2-Q_1)-dP_{cc}}{Q_3-Q_2}$	$\frac{A_{32}(Q_3-Q_2)-dP_{mc}}{Q_4-Q_3}$	$\frac{dP_{mr}-A_{43}(Q_4-Q_{30})}{Q_4-Q_5}$	$\frac{A_{54}(Q_4-Q_5)+dP_{cr}}{Q_5-Q_6}$
Coefficient Ki, c*°C/Дж	$\frac{1}{A_{10}+A_{21}+A_{60}}$	$\frac{1}{A_{21}+A_{32}}$	$\frac{1}{A_{32}+A_{34}}$	$\frac{1}{A_{34}+A_{54}}$	$\frac{1}{A_{54}+A_{65}}$	$\frac{1}{A_{65}+A_{60}}$
Time constant T, c	$K_1 \cdot C_1$	$K_2 \cdot C_2$	$K_3 \cdot C_3$	$K_4 \cdot C_4$	$K_5 \cdot C_5$	$K_6 \cdot C_6$

FUNCTIONAL DIAGRAM OF THE MATHEMATICAL MODEL

For a reliable description of the processes, a functional scheme of the mathematical model (Figure 1), showing the breakdown of engine elements by heat masses and the interaction between the heat fluxes of the allocated masses, was developed.

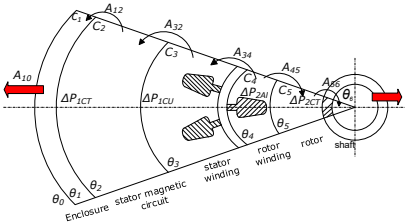

Figure 1. *Functional scheme of the asynchronous motor mathematical model*

Calculation of the 6-mass thermodynamic model begins with calculation of heat capacities and heat generation variables for the nominal long-run operation mode S1. Further, according to experimental data and on the basis of expert evaluation, the set temperatures of thermal masses are determined. The fourth thermal mass - rotor winding - is the hottest, because it has high heat generation and poor cooling conditions. According to the values of heat generation and temperatures of thermal masses determined by the heat transfer coefficient (Table 1), which calculated the numerical values of heat generation and heat transfer coefficients for the nominal mode of the electric motor 4A90L4Y3 2,2 kW 1500 rpm (Table 2).

Table 2

Numerical values of the model coefficients

mass number / Name	1	2	3	4	5	6
Heat capacity, C_i	4576.852	3775.667	2330.802	1595.866	783.356	275.209
Heat Generation, ΔP_i W	11	86.738	415.023	149.44	8.67	28.782
Heat generation at standstill, W	0	0	415	149.5	0	28.8
Heat transfer coefficients	A_{10}	A_{21}	A_{32}	A_{43}	A_{54}	A_{65}
Rated	20.356	23.987	25.6	9.79	2.576	1.755
When stopping and self-ventilating	6.785	23.987	25.6	3.26	2.576	1.755
At standstill and independent ventilation	20.356	23.987	25.6	3.26	2.576	1.755

The coefficient A_{60} is assumed an order of magnitude smaller than the coefficient A_{10}. The values of coefficients A_{10}, A_{34} and A_{60} depend on the speed of rotation of the engine, so their values at zero speed and self-ventilation are reduced by a factor of 3. Ambient temperature Θ_0 is equal to 20 °C

Simulation of thermal transients was performed using the engineering software package Matlab Simulink [16]. The structural diagram of the 6-mass thermodynamic model of the asynchronous motor is designed according to the vector-matrix equation (1) and includes integrators with heat capacity coefficients Ci, blocks with heat transfer coefficients $À_{ij}$, heat generation blocks ΔPi, speed mode control blocks and oscilloscope for monitoring transients (Figure 2). For integrators, the initial temperature of separated masses Θ_0

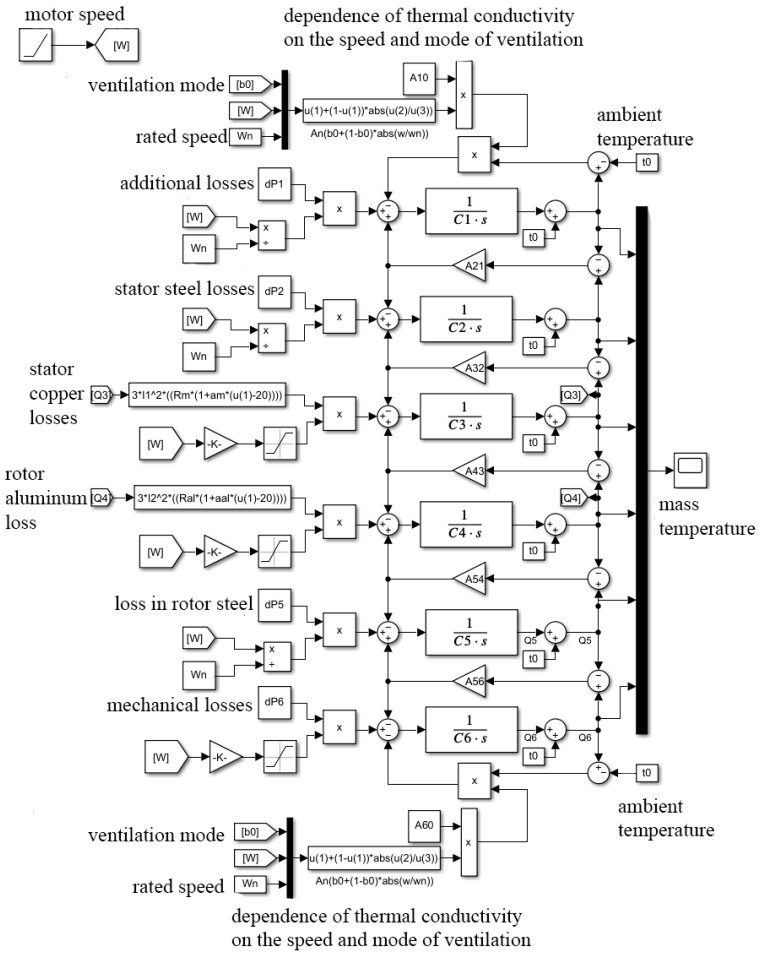

Figure 2. *Block diagram of the computer model*

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For each mode of operation heat generation values were set on the basis of the condition that in the IF-AD system the added losses and losses in steel depend proportionally on the frequency f, and the degree of ventilation for a self ventilated motor at zero speed decreases from 1 to 0.33. It is taken into account that the active resistances of stator and rotor windings depend on the corresponding temperatures [17].

Operation of thermodynamic model was investigated for four typical modes of operation (Figures 3-5).

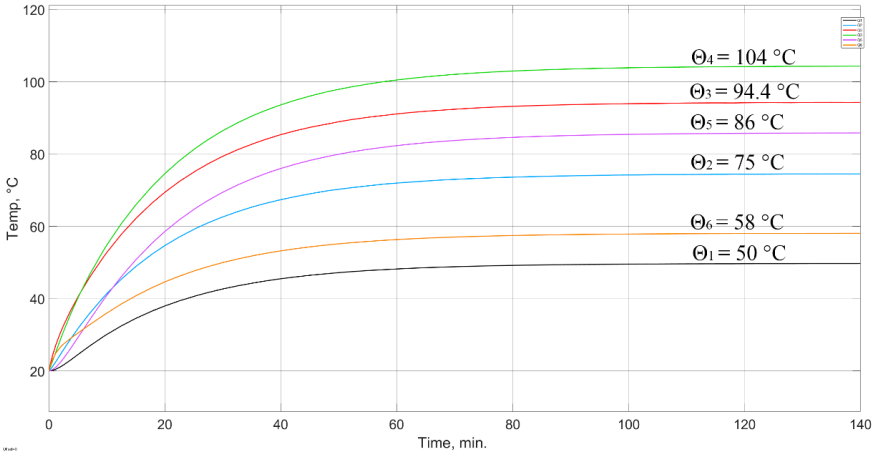

Figure 3. *Mode 1. Nominal continuous mode with forced ventilation and mode 2. Nominal continuous mode with self-ventilation.*

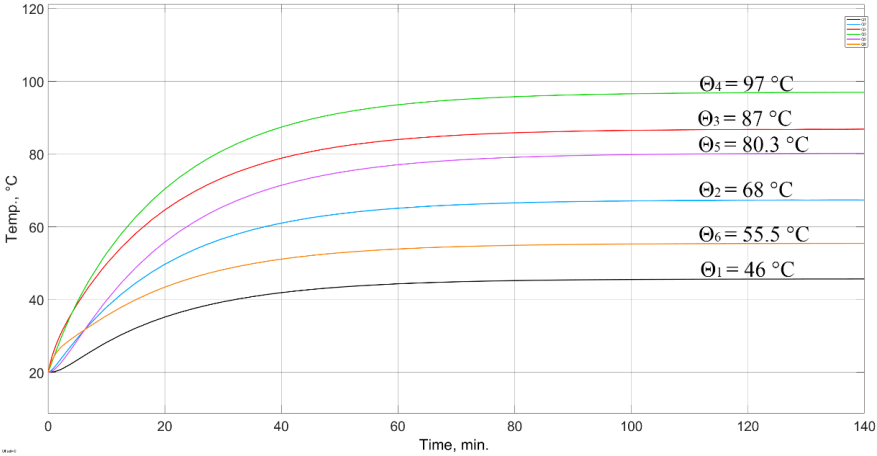

Figure 4. *Mode.3. Continuous mode with forced ventilation, rated load and motor speed of 0.25Wn*

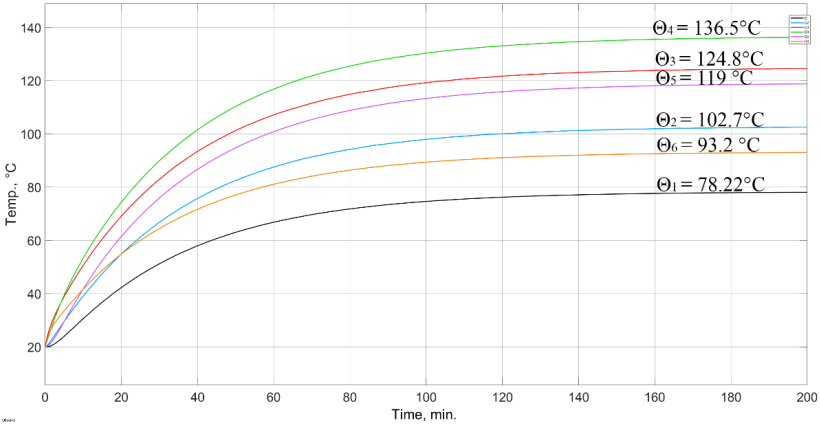

Figure 5. *Mode 4. Continuous mode with self-ventilation, rated load and motor speed of 0.25Wn*

Table 3 summarizes the results of studies on steady-state temperatures of the 6-mass thermodynamic model of the 4A90L4Y3 induction motor

Table 3

The steady-state temperatures of the modes under study

Mode	type of ventilation	W/Wн	b0	Θ_1	Θ_2	Θ_3	Θ_4	Θ_5	Θ_6
1	forced	1,0	1,0	50	75	94,4	104	86	58
2	self-ventilation	1,0	0,33	50	75	94,4	104	86	58
3	forced	0,25	1,0	46	68	87	97	80,3	55,5
4	self-ventilation	0,25	0,33	78,22	102,7	124,8	136,5	119	93,2

The first and second modes are identical because the heat transfer coefficients are assumed to be the same at nominal speed for self-ventilation and forced ventilation. In the third mode total losses are slightly reduced due to reduction of additional losses and losses in steel. Temperatures of masses slightly decrease. In the fourth mode, due to self-ventilation, coefficient A_{10} significantly decreases, thermal losses in windings increase, which leads to a significant increase in temperatures of separated masses.

Temperature control of real asynchronous motor can be performed using temperature sensors [18], installed on the case, stator magnetic core or stator winding. The developed thermal model of asynchronous motor is applicable for calculation of temperatures of dedicated thermal masses Θ_1, Θ_2, Θ_3, which can be used for thermal protection of asynchronous motor or in closed-loop regulation systems of automatic electric drive for motor temperature control

CONCLUSION

1. Developed multi-mass thermodynamic computer model is designed to study the thermal modes of induction motors with phase or squirrel-cage rotor.

2. Calculation of initial parameters of the model is carried out according to given formulas on the basis of nominal and constructive data of the motor.

3. The computer model can be easily integrated into static or dynamic models of an automated electric drive by the NFAH system.

4. Algorithm of model operation takes into account breakdown of asynchronous motor into 6 thermal masses with changing of temperature conditions as a function of supply voltage and frequency, speed of rotation and winding active resistance, change of heat generation and heat transfer coefficients.

5. The developed thermal model of AD is applicable for calculation of temperatures of thermal masses, which can be used for thermal protection of AD or in closed-loop control systems of AEP for motor temperature control.

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DIAGNOSE THE CONDITION OF THE TUBING CLEANING UNIT

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Abstract. *The article deals with the problem of diagnosing the condition of mechanical scrapers used for cleaning tubing from asphaltene-resin-paraffin deposits (ASPO). A diagnostic model, which evaluates the pig condition according to four diagnostic parameters, is proposed.*

Keywords*: asphaltene-resin-paraffin deposits, ARPD, tubing, mechanical cleaning, pigging, diagnostic model, diagnostic parameter.*

Introduction

Most of Russia's oil fields today are at the last, late stage of development, characterised by an increasing proportion of hard-to-recover oil reserves, general watering of reservoirs and individual wells, and deterioration in the composition of the resulting oil reserves. All this has a negative impact on the condition of each well's interior in the course of operation of the well stock.

One of these negative factors is the reduction of the internal pipe cross-section due to the formation of asphaltene-resin-paraffin deposits (ARPDs). The formation of this type of deposits reduces oil flow rates, increases the need for well repairs and increases the cost of oil due to higher labour and material costs of oil production. The main places where ARPD are formed are well pumps, flowing lines, as well as tubing in the wells [1].

There are currently about twenty different methods of controlling wax deposits [2]. The need for such a wide arsenal of methods and devices for wax removal is due to the fact that the process of wax deposition is very complex from a physical point of view [3] and is individual for each field. The depth of the well, at which paraffin deposits start during oil production, i.e. paraffin transition from dissolved to solid state, changes within quite a great limits. In Perm Krai the depth at which paraffin deposits begin to appear is about 1000 m, in the Republic of Bashkortostan this figure varies in the range from 400 to 1700 m and in the gas-condensate field of Novy Urengoy - at a depth of 800-1600 m [4]. These data were obtained by measuring the thickness of paraffin deposits on the walls of tubing strings during tripping operations.

However, despite the large number of methods of ARPD control, the main one is mechanical cleaning of the tubing string by running wire scrapers, which are a part of mechanized dewaxing units. The frequency of pigging to remove ARPD from well tubing varies from once every 7 days to once a month, depending on the flow rate of the well.

Relevance of the study

Mechanical method of cleaning the inner surfaces of tubing from ARPD is used in many fields, which is due to the low cost of the method and at the same time high efficiency. However, the operation of various scrapers imposes certain requirements to the condition of the inner surface of the tubing, namely, the absence of protrusions, burrs, pipe ovality, since the above factors lead to scraper jamming, breakage of the wire, on which it descends, incomplete removal of ARPD. That is why the task of pig condition control during lowering and pulling is topical. In order to solve this problem, a diagnostic model and diagnostic algorithm are required, which would allow to monitor the condition of tubing string cleaner in real time mode.

Statement of the research objective

The aim of this study is to identify diagnostic parameters and build a diagnostic model for the mechanical scraper.

Theoretical foundations of the study

The theoretical foundation for technical diagnostics is provided by two interrelated fields: pattern recognition theory and control theory [5]. Pattern recognition theory, using diagnostic models in the study of an object, determines the decisive rules for recognizing the current state and type of failure. The testability theory solves the issues of rational sequence of searching for the failed or faulty element, controlling the state of the object. Its task is to assess the testability of an object, i.e. its adaptability to the measurement of diagnostic parameters by diagnostic tools, the product's ability to provide reliable assessment of the technical condition and early detection of faults and failures.

A diagnostic model is a formalized description of a technical diagnosis object, necessary for solving diagnostic tasks. The forms of description of such a model can be different: analytical, tabular, vector, graphical [5].

A diagnostic parameter is a parameter (attribute) of an object that quantitatively or qualitatively characterises its technical condition. Each diagnostic parameter has several gradations, most often it is nominal, maximum permissible, maximum possible, emergency level.

At the heart of diagnostics is the solution to the problem of recognizing the technical state of an object. The state of an object, as applied to mechanical equipment, is characterised by a number of diagnostic parameters: input, output and internal (Fig. 1) [5].

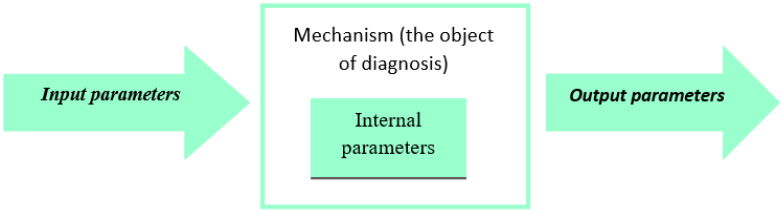

Figure 1. *Diagnostic object parameters*

Input parameters are external conditions and control actions (rotational speed, applied torque, force, power, pressure, feed rate, speed). Output parameters, or reactions - parameters showing the object's behaviour (vibration, noise, temperature, rotation uniformity, etc.). Internal parameters are the parameters that determine the structure of the object and characterise processes inside the object (dimensions of parts, clearances, roughness, distribution of forces and stresses, mechanical characteristics of the material, etc.). The influence of input parameters in determining the technical condition must be excluded by means of reduction to standard conditions. Diagnostic parameters must be measured at constant load.

Diagnostic parameters can be direct, i.e. directly reflecting internal parameters of diagnosed mechanisms (torque, frequency and uniformity of rotation, gaps, surface roughness) and indirect, i.e. reflecting connection between internal and output parameters (physical fields: vibration, acoustic, thermal). When solving the problems of diagnostics usually preference is given to indirect parameters due to greater availability to conduct measurements on the running equipment without disassembly of the mechanism [6].

The evaluation and prediction of the technical condition of an object under diagnosis based on direct or indirect measurements of state parameters or diagnostic parameters is the essence of technical diagnosis.

The value of a condition parameter or diagnostic parameter in itself does not yet provide an estimate of the technical condition of an object, so in order to assess the condition of a machine or equipment, one must know not only the actual values of the parameters but also the corresponding reference values, the difference between which is called the diagnostic symptom.

Thus, the assessment of the technical condition of an object is determined by the deviation of its actual values from their reference values.

Research results and their practical relevance

The following must be done when studying the operation of a facility

- determine the signs of normal functioning of the object under diagnosis;
- highlight its possible states, i.e. possible combinations of element failures;
- Analyse the technical possibilities for monitoring the signs that characterise the condition of the diagnosed object;
- Collect and process statistical material to determine the probability distribution of possible states of the object, as well as the failure patterns of its individual elements.

A diagnostic model is derived from the results of this work. For a scraper, this may take the form shown in fig. 2.

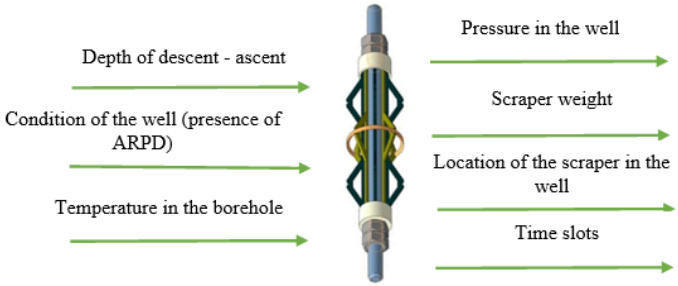

Figure 2. *Diagnosis model for the scraper*

In this work, the diagnostics are based on four parameters that are plotted together: in-pipe pressure, pig weight, pig position in the well and time intervals of pig movement. Normally, the normal values for the listed parameters are as follows:

- the pressure inside the pipe varies from 0 to 0.6 MPa;
- the current position (location) of the scraper is detected by means of an inductive position indicator (IPI), the output signal of which is a logic signal taking values of 0 or 1 only. In cases where the scraper has reached the top

of the borehole (parking position), the IPI signal momentarily takes on the value 1, remaining at this level for 7 to 10 minutes, while in other cases it always has the value zero;

- weight is the weight of the scraper together with the cable, the scraper itself weighs 50 kg, but together with the cable the weight reaches 200 kg, i.e. the normal condition is 0 to 200 kg, at a depth of 3 km;
- time intervals: the normal transit time for the whole pipe, i.e. all the way down and all the way up in a 3 km deep well, is 4 to 6 hours on average.

From this data, graphs were generated (Figure 3), and from these, 6 main events were predetermined that describe the position of the tubing cleaning device inside the pipe.

1. Scraper in top position.
2. Scraper in the down position.
3. Paraffin on the lift.
4. Paraffin on the descent.
5. Momentum of start and upward movement from the lowest point.
6. Momentum of start and downward movement from the top point.

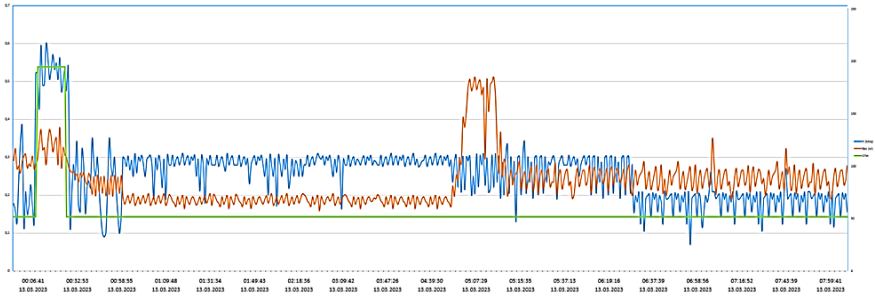

Figure 3. *Telemetry results (orange - weight sensor reading, blue - in-pipe pressure, green - IPI status)*

To obtain a set of images, the graph must be divided according to events, as shown in Figure 4.

Let's take a closer look at each event on the graph.

1. Scraper in top position. After some period of time t, approximately 15 to 25 minutes, the pressure inside the pipe, which is currently 0,01 - 0,2 MPa, gradually increases for 7 to 10 minutes to a certain level (0,5 - 0,6 MPa) and is kept there for some time, approximately 10-15 minutes. IPI goes to position 1 for 6 - 10 minutes, in parallel, the frequency and amplitude of oscillations in the weight sensor readings increases (similar to the pressure, but with a slight time lag of up to 3 - 4

minutes). The last weight readings decrease in conjunction with the pressure drop, but somewhat earlier, by 2 to 3 minutes.

2. The scraper is in the bottom position. The pressure inside the pipe remains at approximately the same level. The SPI remains in position 0, the weight sensor reading gradually rises to a certain level, almost to the maximum value, more precisely 90 - 100% of the maximum of 200 kg, and is held in this position. Event no. 6 has occurred and some time t has elapsed, sufficient to reach the bottom without obstacles, but the time from event #4, where the paraffin is encountered when travelling downhill, is also taken into account, provided that it has occurred.

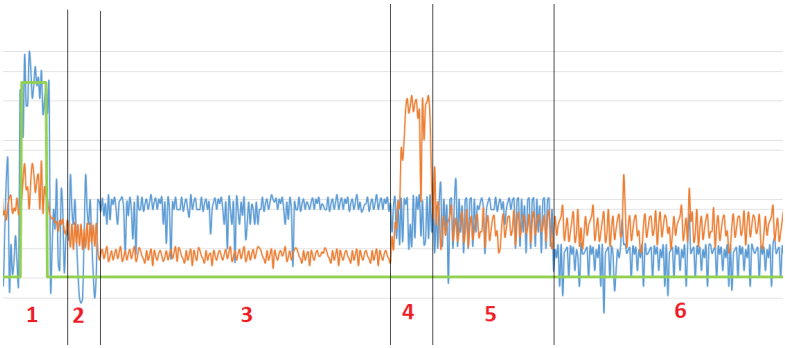

Figure 4. *Decomposition of the graph into composite images by event class (orange - weight sensor reading, blue - in-pipe pressure, green - LUT status)*

3. Paraffin when moving upwards. The pressure inside the pipe continues to decrease in steps and further stabilises at a certain level, an acceptable normal condition, the weight sensor reading fluctuates periodically at very short intervals. As the cable is periodically tensioned, the weight increases to 80 – 100 % of the maximum value of 200 kg, the SPI remains in position 0 and event no. 5 has occurred.

4. The paraffin waxes as it moves downwards. The pressure inside the pipe remains at the same level as from event 6, the weight sensor reading increases, but not to the maximum value as if it were already down, but only 50 % of 200 kg, and is held for a period of time t, approximately 5 to 7 minutes. The IPI remains in position 0. From event no. 6, the time parameter t is longer than the standard time to lower the scraper to the bottom position.

5. Moment of start and upward movement from the lowest point. After a certain period of time, approximately 15 - 25 minutes after event no. 2, the pressure reading together with the weight sensor reading gradually drops to a certain level correlated with the normal state, and remains in this position, the IPI is in position 0. Event no. 2 has occurred and some more time has elapsed.

6. Moment of start and downward movement from the top point. After some time t (5 - 7 minutes after event no. 1), pressure drops, but after a short period of time (1 - 2 minutes) returns to the previous level. SPI in position 0, the weight sensor reading is virtually unchanged, but small amplitude fluctuations are always observed. There was event no. 1.

Thus, by further comparing the diagnostic parameters with the specified normal values, it is possible to identify incorrect operation of the scraper, and after accumulation of sufficient statistical data to build an intelligent diagnostic system based on neural networks.

Conclusions

One of the most common, simple and affordable methods of removing ARPD in tubing is mechanical cleaning. The field of well mechanical cleaning is well developed and has a wide range of installations to meet the requirements. The disadvantages of the method are the probability of scraper wire breakage, formation of loops as a result of slack in the wire and pigging jams. Oil companies are interested in well dewaxing units that operate fully automatically, without an operator, to maintain production at an optimal rate. Successful work of such units is possible if automatic pigging diagnostics systems are also available. This article shows one of the possible options for its implementation.

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EXPERIMENTAL STUDIES OF QUALITY INDICATORS OF THE DECISIVE RULE FOR DETECTING SMALL-SIZED OBJECTS IN VIDEO IMAGES DURING SUBBAND INFORMATION PROCESSING

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Abstract. *To detect small-sized objects in video images, a parametric decision rule has been developed based on the construction of the likelihood ratio using the Neyman-Pearson criterion. The training and control samples are formed using the transformation of the original sample into spatial subband vectors. Experimental studies of the dependence of the probability of correct detection on the signal-to-noise ratio were carried out for given probabilities of the error of the first kind. It is shown that acceptable indicators of the probability of correct detection of 0.95 with a probability of error of the first kind of 10-4 are achieved with a signal-to-noise ratio of about 14.*

Keywords: *recognition; video image; small objects, decision rule; control sample; spatial subband vector; the probability of an error of the first kind; normal distribution, noise.*

Introduction

When detecting small-sized objects on video images, parametric decision rules are used with the construction of the likelihood ratio by the Neyman-Pearson criterion. The Neumann-Pearson criterion involves the calculation of the level of the detection threshold for a priori given value of the probability of an error of the first kind (probability of false alarm). In this case, the main indicator of the quality of the decision rule will be the probability of correct object detection. To

calculate the probability of correct detection by a statistical method, it is necessary to conduct a large number of similar computational experiments, which is not always possible. In this regard, it is necessary to use the methods of mathematical modeling. In this case, for example, when estimating the probability of correct detection, depending on the signal-to-noise ratio, it is possible to use the addition of a noise component to the control sample obtained from the image, which will be independent in each experiment.

Formation of training and control samples for use in the decision rule

To build a decision rule, the original video image is represented as samples of multidimensional spatial subband vectors [1]. This representation of video images preserves both the spatial and frequency structure of the image [2], which gives it an advantage over other methods that use recognition rules with a preliminary determination and use of parameters of information content of recognition features.

The original video image is represented as pixels with bit representation (for example, $P = 2^c$, c – bits) of brightness levels. The number of bits determines the number of gradations of brightness levels from black to white [3].

Each line of the image can be represented as a vector [2]

$$\vec{\mathbf{S}} = \left(s_1, \quad s_2, \quad \ldots \quad s_Q,\right), \; q = 1,\ldots,Q \tag{1}$$

where: Q - the number of pixels in a line; q is the pixel number; s is the number of pixel gradation levels (brightness).

Changes in the brightness of pixels in the stock image correspond to some "spatial frequencies".

The representation of the signal directly in the area of the originals can be written as a quadratic form [2]

$$U_k\left(\vec{s}\right) = \vec{s}^{\,\dot{o}}\mathbf{A}_k\vec{s}\,, \tag{2}$$

where: $\mathbf{A}_k$ - subband matrix with elements

$$a^k_{\gamma\xi} = \frac{\sin\left[\Omega_{2k}(\gamma-\xi)\right] - \sin\left[\Omega_{1k}(\gamma-\xi)\right]}{\pi(\gamma-\xi)} \text{ at } \gamma \neq \xi\,;$$

$$a^k_{\gamma\xi} = \frac{\Omega_{2k} - \Omega_{1k}}{\pi} \quad \text{at } \gamma = \xi\,; \qquad \gamma,\xi = 1,\ldots,Q\,.$$

For each frequency interval k a subband matrix is calculated $\mathbf{A}_k$. Vector (1) is transformed using transformation (2) into a vector of dimension k of the form [1,2]:

$$\tilde{\mathbf{U}} = \left(U_{(1)} \quad U_{(2)} \quad \ldots \quad U_{(k)}\right)^{\mathrm{T}}, \tag{3}$$

where: U – share (part) of signal energy in the frequency interval; k = 1,…,K is the frequency interval number; T is the transposition sign.

A vector of the form (3) can be called a space-subband vector (SSV).

An image of dimension N by Q pixels can be represented as a sample of vectors of volume N with dimension K.

$$\mathbf{U}^{(N)} = \begin{pmatrix} U_{(1)1} & U_{(1)2} & \dots & U_{(1)N} \\ U_{(2)1} & U_{(1)2} & \dots & U_{(1)N} \\ \dots & \dots & \dots & \\ U_{(k)1} & U_{(k)2} & \dots & U_{(k)N} \end{pmatrix}, \quad (4)$$

where: N – sample size; the first character (in brackets) with U - indicates the number of the frequency interval; the second character at U (without brackets) denotes the number of the vector in the sample $i=1,\dots,N$.

In this case, N will denote the number of image lines, and K the number of frequency intervals (subbands).

In this case, the vector is a multidimensional random variable. Moreover, its dimension is equal to the number of frequency intervals (subbands) [1]. In essence, this is a space-subband vector (SSV). The image formation process is subject to random perturbations, the probabilistic nature of which affects all stages.

Therefore, in order to construct a direct decision rule using SSV, it is possible to apply a parametric approach, which consists in preliminary obtaining estimates of the distribution parameters of a random variable. In this case, this is a sample of SSV. With a priori known form of the distribution of SSV in the decision rule, one can use the obtained estimates of the distribution parameters [3,4].

The process of obtaining a video image, converting it to SSV is subject to random factors, such as the number and magnitude of frequency transitions in a video image, noise, etc. [1].

All this allows us to assume that the type of distribution of the random variable SSV is Gaussian (normal) [4].

To describe the probability density of a Gaussian (normal) distribution, a priori knowledge of two distribution parameters is sufficient. This is the mathematical expectation and variance (or standard deviation) [3].

When constructing a decision rule, not the values of the parameters themselves are substituted into it, but their estimates. When used as samples of SSV, the probability density of the Gaussian distribution is multivariate. And, accordingly, estimates of the expectation vector m and the covariance matrix M [3,4] will be used.

A priori, it is necessary to conduct a learning process, which consists in obtaining estimates of the distribution parameters of the detected object. These estimates are the expectation vector and the covariance matrix of the SSV sample previously obtained for the object.

The evaluation of the expectation vector of the sample is determined by the expression

$$\vec{\mathbf{m}}_{(k)} = \frac{1}{N}\sum_{i=1}^{N}\vec{\mathbf{U}}_{(k)i}\ . \tag{5}$$

The dimension of the vector $\vec{\mathbf{m}}$ is K.

The estimate of the covariance matrix is calculated according to the expression

$$\mathbf{M}_{(k\times k)} = \frac{1}{N-1}\sum_{i=1}^{N}\left(\vec{\mathbf{U}}_{(k)i}-\vec{\mathbf{m}}_{(k)}\right)\left(\vec{\mathbf{U}}_{(k)i}-\vec{\mathbf{m}}_{(k)}\right)^{\mathrm{T}}. \tag{6}$$

The elements of the covariance matrix reflect the degree of statistical connection between the elements of the initial vector of fixed parameters.

Decision rule for detecting small objects

The parametric decision rule, using the likelihood ratio, has the form [5]:

$$\mathrm{L} = \frac{n}{2}\mathrm{h}\frac{\left|\mathbf{M}^{(1)}_{(k\times k)}\right|}{\left|\mathbf{M}^{(0)}_{(k\times k)}\right|} + \frac{1}{2}\cdot\sum_{i=1}^{n}\left(\left(\vec{\mathbf{U}}_{(k)i}-\vec{\mathbf{m}}^{(1)}_{(k)}\right)^{\mathrm{T}}\cdot\left(\mathbf{M}^{(1)}_{(k\times k)}\right)^{-1}\cdot\left(\vec{\mathbf{U}}_{(k)i}-\vec{\mathbf{m}}^{(1)}_{(k)}\right)-\right.$$

$$\left.-\left(\vec{\mathbf{U}}_{(k)i}-\vec{\mathbf{m}}^{(0)}_{(k)}\right)^{\mathrm{T}}\cdot\left(\mathbf{M}^{(0)}_{(k\times k)}\right)^{-1}\cdot\left(\vec{\mathbf{U}}_{(k)i}-\vec{\mathbf{m}}^{(0)}_{(k)}\right)\right) > \mathrm{h}\ C\,, \tag{7}$$

where: the superscripts in the estimates **m** and **M** denote the hypothesis (1 corresponds to the hypothesis H_1, 0 hypothesis H_0); subscripts define the dimension.

As a control sample, the sample obtained during the current estimation of the parameters of the image under study is used.

In expression (7) $\mathbf{M}^{(1)}_{(k\times k)}$ and $\vec{\mathbf{m}}^{(1)}_{(k)}$ and a priori, the obtained estimates in the learning process. A $\vec{\mathbf{m}}^{(0)}_{(k)}$ и $\mathbf{M}^{(0)}_{(k\times k)}$ - are estimates obtained from the control sample.

By setting the probability of an error of the first kind α (false alarm), you can determine the decision threshold. The smaller the given value, α, the larger the threshold.

In the case of using the Neyman-Pearson criterion, the decision threshold is determined in such a way that the probability of an error of the first kind F (probability of false alarm) is not more than a given value β_0.

$F = \int_{\infty}^{\infty} W(L/H_0)dL \le \beta_0$, где $W(L/H_0)$ - likelihood ratio distribution density L.

Let us denote the decision-making threshold at which the probability of error of the first kind F is ensured by the symbol $\mathrm{C}_{1\text{-F}}$, The threshold value $\mathrm{C}_{1\text{-F}}$ can be determined from the following equations [5]

$$\mathrm{F} = 1 - \Phi\left(\frac{\mathrm{C}_{1\text{-F}}-\mathrm{m}_{\eta_0}}{\sigma_{\eta_0}}\right), \tag{8}$$

where $\Phi(x) = \frac{1}{\sqrt{2}} \int_{-\infty}^{x} \exp^{-t^2/2} dt$ - probability integral.

Denote by $\xi_\alpha - \alpha$ - the percentage point of the deviation (quantile) of the normal distribution of the probability F and determine the decision threshold $C_{1\text{-}F} = \xi_{1-F}\sigma_{\eta_0} + m_{\eta_0}$, where ξ_{1-F} - the quantile of the normal distribution for a given probability F.

Estimation of the Probability of Correct Detection of a Small-Sized Object Using Experimental Data

The research was carried out using images of unmanned aerial vehicles such as a copter. On fig. Figure 1 shows the image of the object on which the training sample was formed (reference image) and the image under study.

Figure 1. *Reference and study image*

Since the objects in the image are small in size (i.e., the size of the object is significantly smaller than the image itself), the algorithm provides for the current estimation of the parameters of the control sample. The size of the "window" in which the estimation is performed is chosen to be commensurate with the size of the object. It is necessary to go through the entire image with such a "window" (for example, line by line and by columns, with a shift by a certain number of pixels). After each current estimation of the parameters of the control sample, it is necessary to calculate the logarithm of the likelihood ratio (7) and compare it with a given threshold.

This decision rule allows you to recognize a specific object (small-sized UAV) for which training was carried out.

For the experiment, we used control samples of the original image against the background of random noise at different signal-to-noise ratios. To do this, the control sample of the original image , where (number of rows), (number of columns), was noisy based on the following expression:

$$\hat{S}_{iq} = S_{iq} + \hat{\eta}_{iq}, \quad (9)$$

where: $\hat{\eta}_{iq} = d \cdot \frac{\sqrt{\sum_{i=1}^{M}\sum_{k=1}^{N}\left[S_{iq}\right]^2}}{\sqrt{\sum_{i=1}^{M}\sum_{k=1}^{N}\left[\eta_{iq}\right]^2}}\left|\eta_{iq}\right|$, d – the value of the signal-to-noise ratio.

$\eta(i,q)$ – an array of pseudo random "white noise" values, $i = 1,2,...,M$, $q = 1,2...,Q$.

For noise independence, the random number generator must be restarted each time.

With the use of this technique, the control samples received at the input of the decision rule were noised. In this case, the probabilities of an error of the first kind for each group of experiments were set $\alpha = 10^{-2}, 10^{-3}, 10^{-4}$.

The number of tests was chosen to be at least 200, for each given signal/noise value, to ensure a confidence interval of estimates of at least 0.98. In this case, the estimate of the probability of correct detection $\hat{D}_п$ was calculated as

$$\hat{D}_п = \frac{n_п}{n_o}, \quad (10)$$

where: $n_П$ - the number of trials in which the correct decision was made; n_O – the total number of trials.

Figure 2 shows graphs of dependence $\hat{D}_п$ (probability of correct detection) on the signal-to-noise ratio.

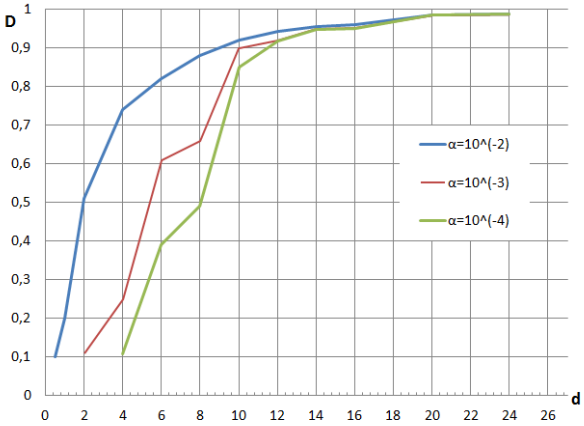

Figure 2. *Dependence on the signal-to-noise ratio for given α*

The dependences shown in Figure 2 allow us to analyze the influence of the signal-to-noise ratio on the quality indicators of the decision rule. In particular, as the signal-to-noise ratio increases, the probability of estimating the correct detection of an object increases. An acceptable value of the probability of correct detection of about 0.95 is achieved with a signal-to-noise ratio of about 14 times, for a given probability of error of the first kind 10^{-4}.

Conclusions

1. A parametric decision rule based on the construction of the likelihood ratio using the Neyman-Pearson criterion has been developed.
2. The training and control samples are formed using the transformation of the original sample into spatial subband vectors.
3. Experimental studies using field data confirm the capabilities of the developed decision rule for recognizing small-sized objects in video images. that acceptable indicators of the probability of correct detection of 0.95 with a probability of error of the first kind of 10-4 are achieved with a signal-to-noise ratio of about 14.

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ANALYSIS OF THE PRINCIPLES OF OPERATION OF PROTECTION TESTING DEVICES AND REQUIREMENTS FOR PREVENTIVE TESTS OF REMOTE PROTECTION IN RELAY PROTECTION AND AUTOMATION DEVICES

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Abstract. *A brief description of the technical capabilities of the RETOM-61, OMICRON CMC 356 measuring software and hardware complexes (MSHC), other devices for testing protection is given, a description of their software and principles of its operation is given. The structure of software systems and issues of automation of protection checks based on various MSHCs are considered. It also describes the main requirements of regulatory documents on the frequency and scope of tests of distance protection and resistance relays as part of relay protection and automation devices.*

Keywords: *relay protection and automation devices, digital signals, test modules, test automation.*

When operating complex technical systems, there is a need to check their components for compliance with their specified characteristics. This is most relevant for components such as control systems. In the power system, this role is assigned both to relay protection and automation at individual power facilities, and to the automation of individual large sections of power systems and associations. So, resistance relays are used in many areas of protection and control, for example, in distance protection, automatic elimination of asynchronous mode, protection against generator out of synchronism, and many other devices. There are many reasons why the parameters of control systems and their components deviate from

the specified parameters. One of the main reasons is damage during operation due to various natural and man-made factors, as well as manufacturing defects in both hardware and embedded software. From the point of view of the operating personnel, it is important to know the real state of the protection devices and automation of their measuring devices, their errors in determining the specified parameters and their operability in general. The same applies to measuring bodies - resistance relays, which, when implemented on a microprocessor base, due to the specifics of the transformations, have a redistributed error value, and the error value can have a random value that does not go beyond the limits determined by regulatory documents and the manufacturer's documentation, but under certain conditions having a significant impact on the results of some systems. Therefore, the determination of the actual characteristics of measuring bodies by a given manufacturer is an urgent task, and reducing the time for conducting checks, as well as their complete or partial repetition with little time is possible only with the use of one degree or another of automation of checks, which is also an urgent task.

Currently, all newly designed protection and automation systems are based on a microprocessor and contain a large number of functions. To perform inspections and commissioning tests, such systems require the use of complex and expensive equipment, for example, RETOM-61 or OMICRON CMC 356 measuring software and hardware systems, as well as qualified specialists, so reducing their time is economically beneficial.

Operating principles and structure of IPTC RETOM-61

The measuring software and hardware complex (MSHC) RETOM-61 is designed to perform manual and automatic testing of the characteristics and parameters of relay protection and automation devices of all types and generations [1]. The scope of RETOM-61 is power plants, industrial enterprises and electrical laboratories.

The MSHC consists of the RETOM-61 device, which is a software-controlled current and voltage amplifiers, a set of discrete inputs and outputs, as well as software and additional blocks that expand the functionality of the complex. Thus, MSHC is designed to: generate two three-phase current systems, three-phase voltage and 3U0, which are controlled independently of each other in terms of module, phase and frequency, which allows you to manually and automatically check the characteristics of relay protection and automation devices when simulating various types damage and other abnormal modes of operation of power systems (for example, the occurrence of oscillations, asynchronous running, etc.); searches for both static protection operation parameters with a smooth change in input parameters, and dynamic ones, when a push signal is given; using discrete signals, it simulates various modes of operation of external protection, while creating the

correct conditions for checking its various functions of digital relay protection and automation devices; the device receives and processes the information coming to the discrete inputs, controlling the response of the protection to the current impact.

In addition, RETOM-61 can determine the time characteristics of protection and automation, the operation of its discrete outputs; supply power to protection and automation during the test; records oscillograms of both output and external analog signals, which makes it possible to compare them with the data of the discrete signal recorder, to easily analyze the operation of protection and automation; performs various measurements of direct and alternating voltage and current. In addition, RETOM-61 has a large set of software modules, which allows you to automatically evaluate the correctness of protective functions and the accuracy of parameters and settings of almost all types of relay protection and automation, and create test reports.

If necessary, RETOM-61 can be supplemented with the RETOM-61850 device, which allows real-time exchange of logical signals in the form of GOOSE messages with the protection under test and the supply of digital current and voltage data in the form of an SV stream in accordance with the IEC 61850 standard. The RET-GPS device allows you to synchronize in time 2 or more complexes located at different substations, which is important when checking differential-phase protection devices.

The need to automate the verification of URZA is due to a number of factors. One of them is to minimize the human factor, and, as a result, reduce the number of errors made in the verification process. Another factor is the reliability of the testing complex. It should also be noted a wide choice of relays for testing in the RETOM-61 software shell, which further simplifies the process. Thus, automation of the process of checking the characteristics of the relay is necessary to achieve a better effect.

The operating principle of IPTK RETOM-61 is as follows. The user, using the complex control program, sets the mode of its operation. The computer, in accordance with the given algorithm, makes the necessary calculations and transfers the data to the internal controller of the RETOM-61 device. Based on the information received, the internal controller calculates an array of digital current and voltage samples. The interface module passes these samples to the digital-to-analogue converters, which generate an analog signal for the corresponding amplifiers. At the output of the amplifiers, analog signals of current IA, IB, IC, IA1, IB1, IC1 and voltage UA, UB, UC, 3U0 of the given values appear, which are fed to the measuring inputs of the protection under test.

The state of the discrete outputs of the tested protection device and the ADC inputs are interrogated by the internal controller, which synchronizes all this with real time and transfers the data to the computer. The received information is ana-

lyzed in accordance with the operation algorithm, and recorded in the form of operation parameters for the test report.

To create certain operating conditions for the tested protection, the controller controls its discrete outputs, simulating the operation of various signals, such as acceleration, RPO, RPV, blocking, etc. The device has two types of discrete output: relay and transistor. The latter are designed to give a signal with minimal time delays, but they can only switch a small current. The structure of MSCH RETOM -61 is shown in Figure 1.1

In addition to this device, RPE Dinamika produces various modifications of RETOM-51, RETOM-41 [2], as well as a specialized complex RETOM-21 [3], which is mainly used to test relays of various generations in manual mode. At the same time, it should be noted that the relay protection and automation manufacturers themselves produce devices for testing and adjustment [4], such as simulators, for example, I-901 (for modeling the logic circuits of relay protection and automation) and various testing complexes - Neptune, impulse, mercury, which are capable of issuing the necessary current and voltage levels in manual mode

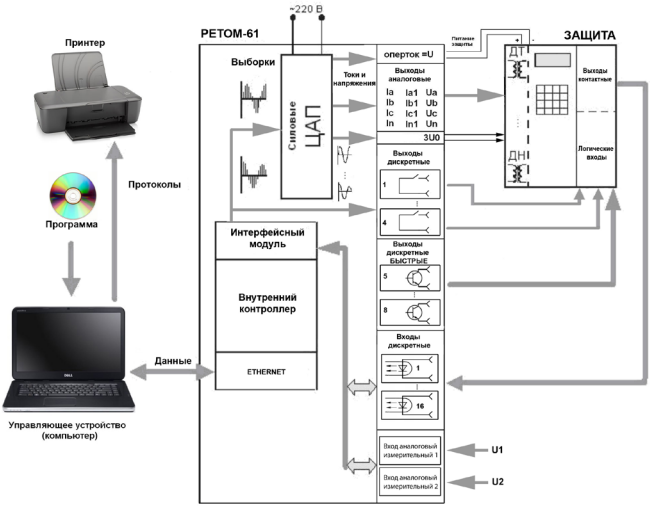

Figure 1.1. *Structural diagram of IPTK RETOM-61*

Description IPTC OMICRON CMC 356

The other most widely used test instrument is the OMICRON [5] IPTC, which is a whole line of test systems, such as OMICRON CMC 353, OMICRON CMC 256, as well as OMICRON CMC 356 [6], which is one of the most modern and functional IPTK in the line of the company.

OMICRON CMC 356 is a complex for generating analog and discrete signals, measuring digital and analog signals. The complex is controlled using specialized programs on a personal computer (PC). Block diagram of the device is shown in Figure 1.6. The device includes 2 three-phase current amplifiers, one three-phase voltage amplifier with an additional channel for zero-sequence voltage generation. There are 4 digital outputs and 10 digital inputs, the device is controlled via the Ethernet or USB interface. In accordance with the technology of work. When working with the Ethernet interface, an association between IPTC and a PC is required, since in this case it is possible to work with any device connected to the local network, and the PC can only work with the associated device.

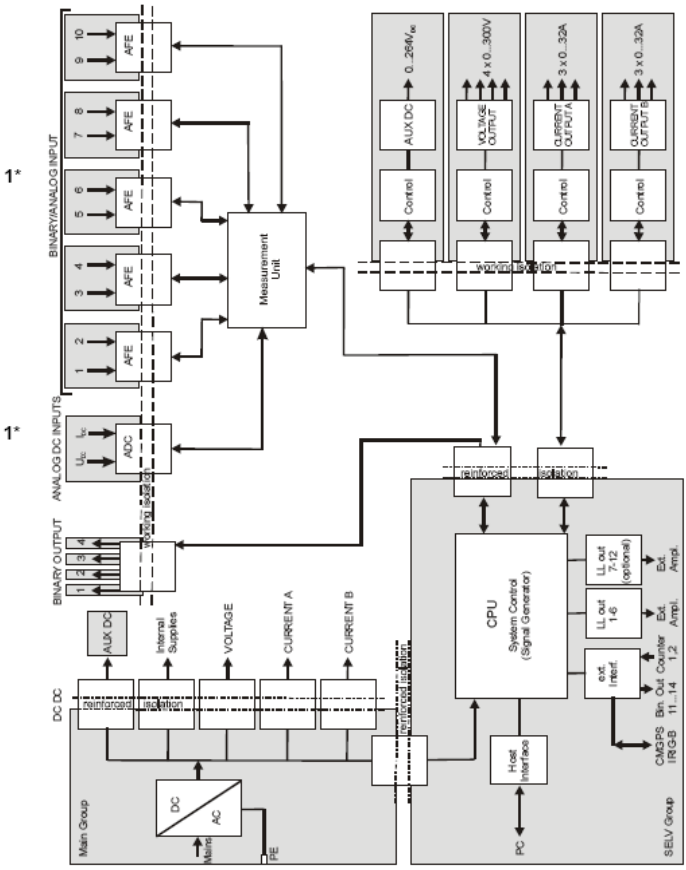

Figure 1.2. *Structural diagram of IPTK OMICRON CMC 356*

Technical characteristics of IPTC are given in [6]. Of greatest interest in practical terms is the possibility of automating the processes of protection testing using this software package.

During the operation of this IPTC, the *OMICRON Test* Universe software is used, which has in its composition a large number of software modules, such as: testing of distance protection, directional and non-directional overcurrent protection, etc. Figure 1.3 shows the architecture of the *OMICRON Test Universe* software and the interaction of the individual components of the software package down to the level of the test object.

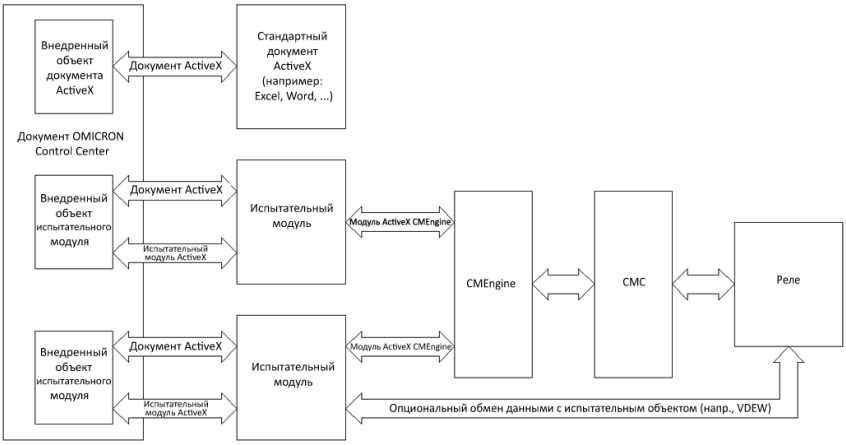

Figure 1.3. *Architecture of OMICRON TEST UNIVERSE*

As can be seen from Figure 1.3, the software structure is universal, regardless of the type of software modules used. The RPA device (relay) directly interacts with the OMICRON CMC test set, the operation of which is controlled by various modules through the CM Engine software interface. The user interacts with the software through the Control Center document, where various test modules are embedded, as well as standard elements using ActiveX technology. The test modules interact with the Control Center using standard ActiveX techniques. In addition, test modules are controlled from the Control Center document through the “test module - ActiveX” interfaces. This interface is also implemented on the basis of ActiveX technology.

Perhaps the implementation of test modules that communicate with the test object or measuring and testing equipment through other, special communication channels. For example, the test module can communicate with the test object through special software for setting relay parameters, which allows you to change

certain settings in the test object in accordance with a given test sequence directly in its process.

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RIVER CRUISE SHIP BASED ON PV300 "MUSTAI-KARIM"

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Abstract. *The article is devoted to the design solution for the modernization and creation of an updated river cruise ship "Strannik" on the basis of the existing motor ship "Mustai-Karim". The study was conducted on the basis of publicly available information taken from specialized analytical sites and from the Internet. An analysis was made of the state of the market for river communication and tourism in Russia, and reviews of tourists were also taken into account. The result of the study is a proposal worked out by the author on the modernization of the exterior and interior of the project of the existing motor ship "Mustai-Karim" (PV300), taking into account the requirements for increased comfort, efficiency and ease of operation, as well as the wishes of passengers (tourists).*

Keywords: *"Mustai-Karim", motor ship, modernization, reconfiguration.*

Cruise ships appeared in our country quite a long time ago, in the early 1900s. In 1907, the Kolomna Plant began building a series of passenger motor ships with a screw drive. The first ship of the series, named Borodino, was completed and launched in 1911. The construction of motor ships of this series continued until 1917. A total of 11 ships were built. The most durable ships of this series: "Uritsky", "Paris Commune" and "Memory of Comrade. "Markina" worked on the Volga River until 1991.

In general, motor ships became quite massive and by the thirties accounted for 10% of the world civilian fleet, and by 1974 they had reached a value of 88.5%. Compared to steamships, motorships have the following advantages: higher engine efficiency and reliability, lower fuel consumption and, consequently, greater carrying capacity, longer range and better efficiency in commercial use.

The most popular type of river vessels in the USSR and Russia for more than fifty years have been three-deck motor ships of project 588, built in the German Democratic Republic from 1953 to 1961. For their time, these were ships of dimensions unprecedented for Soviet rivers. At the same time, the ships retained the features of the "Volga antiquity". Quite a large number of motor ships produced

in that period, having undergone reconstruction, function and operate flights to this day.

If the proposed design solution is implemented, the Mustai-Karim may become the first majorly modernized (built) passenger ship in Russia over the past 60 years, since since the 1950s all sea and river ships operated in the USSR and Russia have been ordered for abroad. At the same time, Mustai-Karim, the first ship of the new PV300 series, originally named Peter the Great, was laid down on March 28, 2017 and launched on September 11, 2019, traditionally abroad. The built cruise liner has unprecedented dimensions and passenger capacity: its length is 141 meters, width and height (the maximum allowable for the passage of locks) are 16.8 and 12 meters, respectively. The ship can take on board 329 passengers. But, unfortunately, the liner did not take root in Russia. The design developed by "Marine Engineering Bureau" LLC (Odessa) does not retain the successive features of river ships of the 50-60s, which is why it is perceived with skepticism. Some passengers ironically even compare it to an iron.

The relevance and social significance of this project are high and economically significant, since to this day river ships occupy a leading position in the field of passenger transportation along the numerous inland waterways of Russia. In this connection, a decision arose to develop a new modern and concise appearance for the future cruise ship based on the existing Mustai Karim project.

The aim of the project is to create a new river cruise liner based on the existing "Mustai-Karim" project, which meets the requirements of efficiency and tourist attractiveness, and also harmoniously fits into the ensemble of ships of the Russian river fleet.

The objective of the project is to develop a new appearance of the liner, using modern technologies in the field of distribution and accommodation of passenger flows, organizing the area of the liner for entertainment and business events.

Russia occupies one of the leading positions in the world in terms of the length of river routes [Fig. 1]. At the same time, the fleet of motor ships departing from Moscow alone has about 40 ships, and, in total, there are more than 90 of them throughout the country.

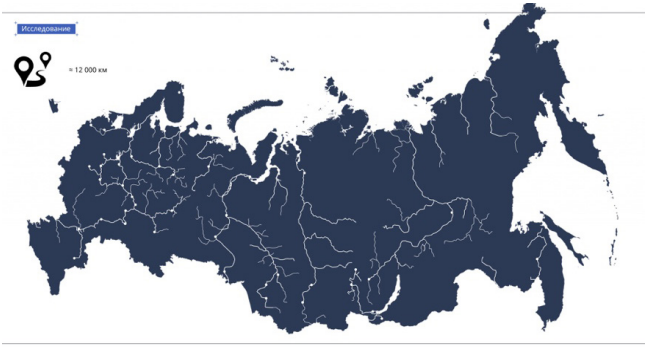

Figure 1

The main aspects that were considered in the analysis of the "Mustai Karim" project [Fig. 2] are:

1. Unusual appearance of the vessel that stands out against the background of other motor ships;
2. Small area of premises for business and entertainment events;
3. Controversial planning decisions.

Figure 2

Therefore, in addition to the task of layout and planning of the project, the main directions in the exterior were chosen as a symbiosis of a classic motor ship with the lines and contours of modern yachts and ships [Fig. 3].

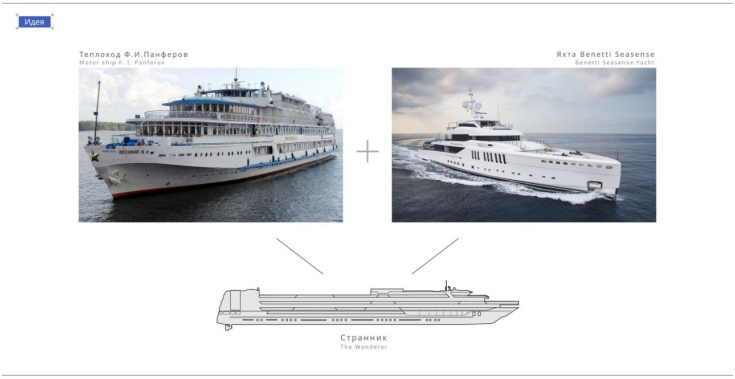

Figure 3

The main directions in the design of the external appearance were chosen: minimalism (accuracy and clarity of lines), the preservation of traditions (the continuity of the classics of motor ships of the 80s) and functionality (form follows function) [Fig. 4].

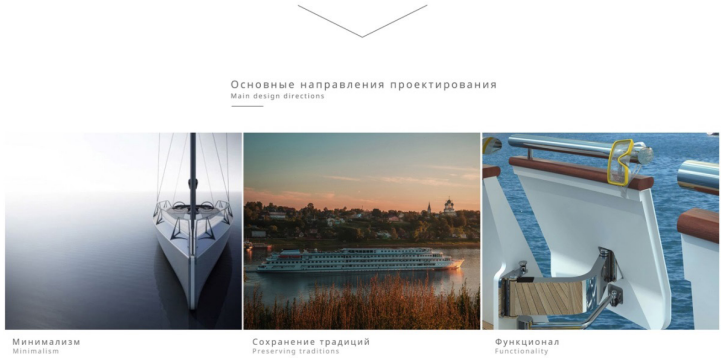

Figure 4

A deep analysis and synthesis of the appearance of the motor ship was made [Fig. 5].

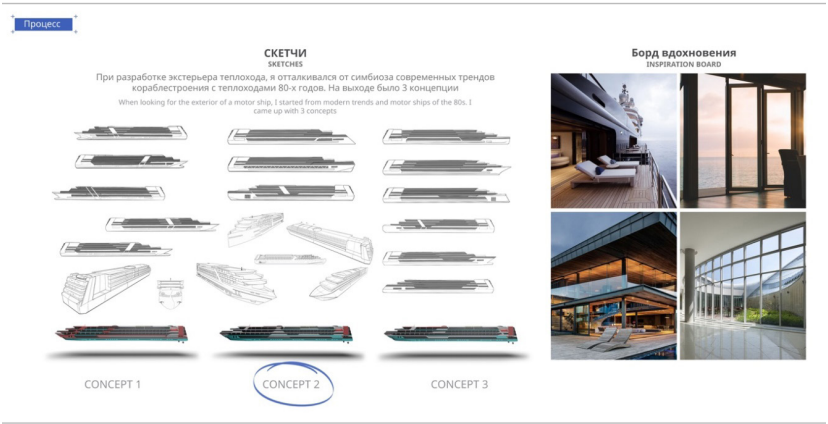

Figure 5

At the same time, the deck layout of the cabins, as well as the general space and layout of the liner, were completely redesigned. A large entertainment atrium is located amid and aft of the awning deck, including a spa, beach area, two cafes and a large meeting room for business meetings. At the same time, it is possible to re-equip the atrium for business meetings and conferences. Also in the stern there is a bar, a conference room and a restaurant. In the bow of the main deck of the vessel, a cinema, spa and casino are provided, and in the middle aft there is a large restaurant. On the roof of the wheelhouse there is an observation deck with folding railings for safe passage under low-span bridges [Fig.6].

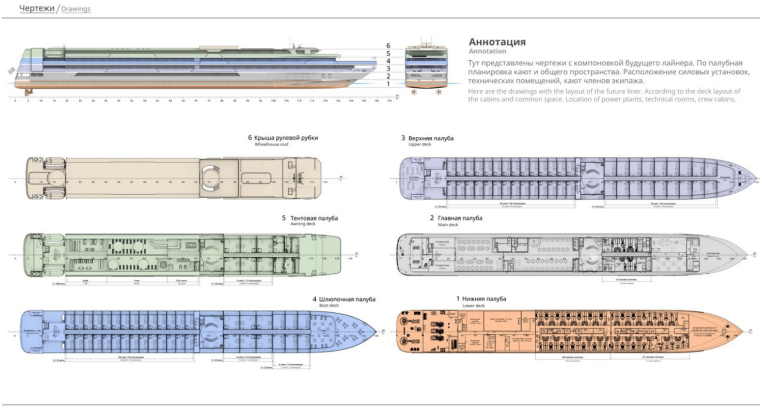

Figure 6

The redevelopment of the cabin layout was considered the requirements for increased comfort for first and luxury class passengers. In total, 92 cabins for passengers are provided on board. First and deluxe cabins are separated from deluxe cabins by an atrium staircase area. 12 cabins of the first class are located in the middle part on the tent and boat decks, as far as possible from the propulsion and anchor installations and, among other things, in this zone, the minimum level of noise and pitching. 24 junior suite cabins are located in the middle and bow parts of the upper and boat decks. 56 deluxe cabins are located in the middle and aft parts of the boat and upper decks of the liner. The cabins of the captain and senior staff are located in the bow on the awning deck, and the crew cabins are on the main and lower decks of the vessel [Fig. 7].

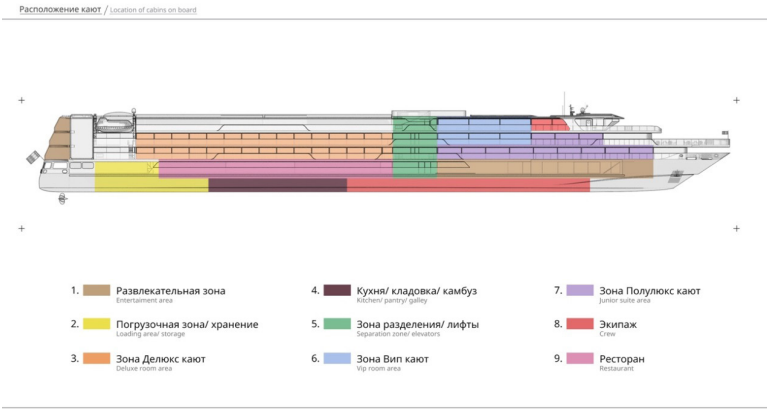

Figure 7

When reworking the general layout of the ship, to improve the convenience of passenger comfort, the interiors of cabins of different classes were redesigned [Fig.8-10], including:

1. Panoramic glazing for cabins of all classes;
2. The presence of a balcony in each cabin;
3. Fully customizable interior lighting;
4. Pleasant tactile finishing materials.

Figure 8

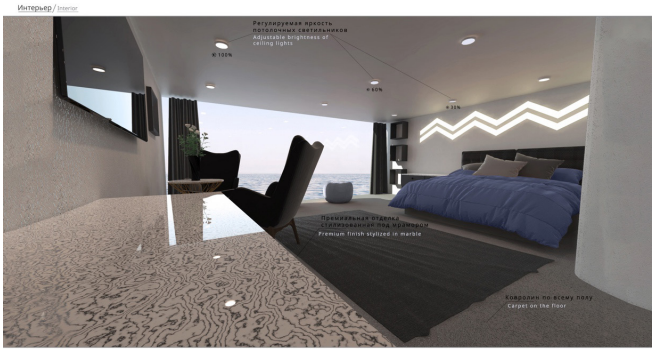

Figure 9

Figure 10

One of the innovations of the proposed concept of the motor ship is a side port with a crane-manipulator installed inside. Such a constructive combination makes it possible to facilitate and speed up the loading / unloading of goods on board the liner [Fig. 11-12].

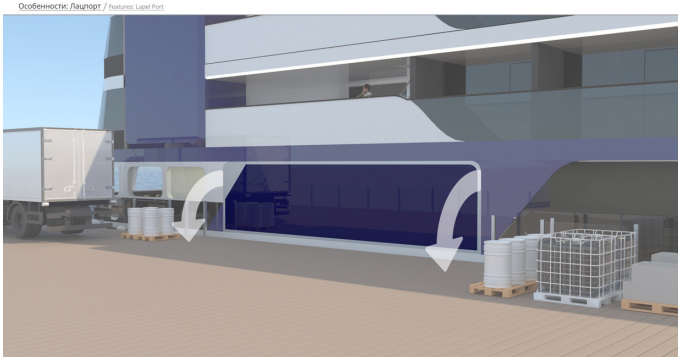

Figure 11

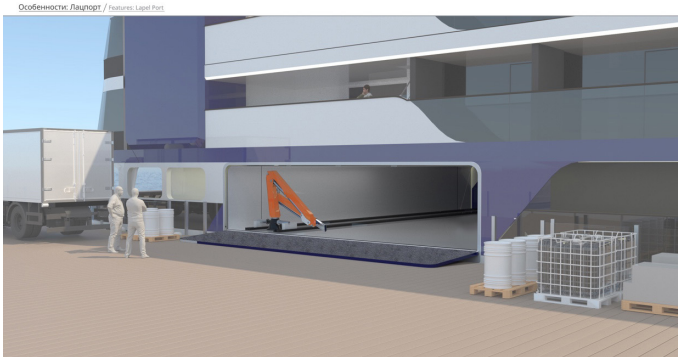

Figure 12

Another distinctive feature of the designed motor ship is the design of the opening central part of the atrium. In good sunny weather, the central part opens, and passengers can sunbathe and relax on sun loungers in the beach area [Fig.13-14]. At the same time, for comfort and protection from the scorching sun of individual passengers, awnings are provided that open along special guides [Fig. 15].

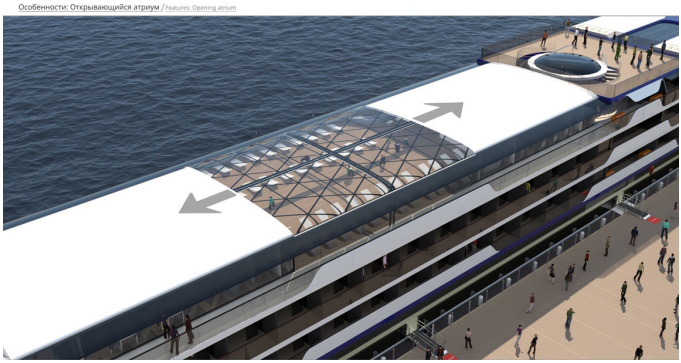

Figure 13

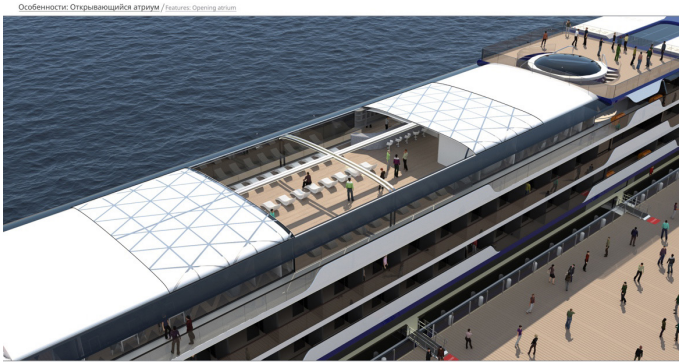

Figure 14

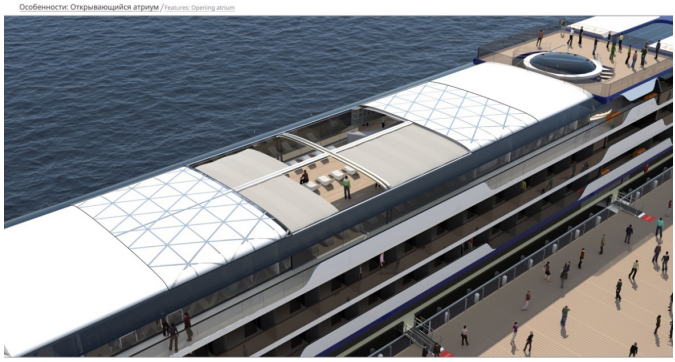

Figure 15

General views of the modernized motor ship [Fig.16-17].

Figure 16

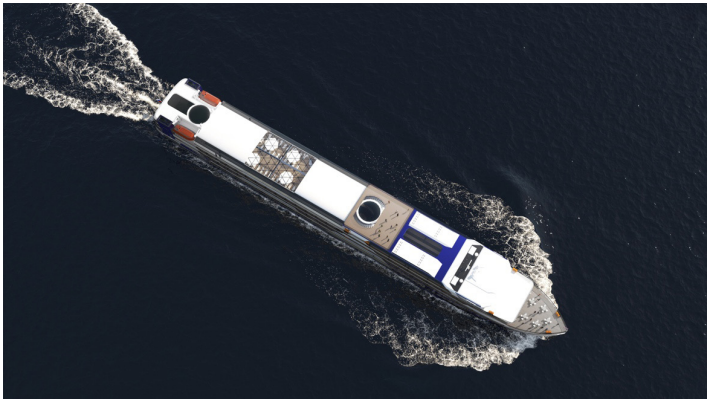

Figure 17

In conclusion, I would like to once again mention the relevance and significance of this project, since river ships occupy a leading position in the field of passenger transportation on the inland waters of Russia, and the presence of a modern, comfortable and cost-effective fleet of deck vessels has a high daily and tourist demand.

Cruises on the rivers of our country are very popular. The sailing regions of motor ships are extensive: from Northern cruises to St. Petersburg, to the Kizhi and Valaam islands, to Astrakhan and Rostov-on-Don, as well as in Siberia, along the rivers Ob, Yenisei, Lena. Duration of cruises - from 2-3 days to 19-20 days and more. In this connection, I hope that the proposed version of the concept

project for upgrading existing cruise ships of the river fleet, using the example of the modernization of the "Mustai-Karim" motor ship into a modern, comfortable, cost-effective and attractive cruise liner, will be interesting and in demand by potential customers.

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