# ТЕОРИЯ И ПРАКТИКА СОВРЕМЕННОЙ НАУКИ: ВЗГЛЯД МОЛОДЕЖИ

## МАТЕРИАЛЫ IV ВСЕРОССИЙСКОЙ НАУЧНО-ПРАКТИЧЕСКОЙ КОНФЕРЕНЦИИ НА АНГЛИЙСКОМ ЯЗЫКЕ

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# PROCEEDINGS

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## TABLE OF CONTENT

## СОДЕРЖАНИЕ

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# PROSPECTS FOR THE DEVELOPMENT OF THE CHATGPT MODEL AND ANALYSIS OF ITS IMPACT ON HUMAN ACTIVITIES

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**Abstract.** One of the notable achievements in the field of AI is ChatGPT by OpenAI, a powerful language model based on the GPT-3.5 architecture that can generate text resembling human responses. The article examines the prospects for the development of ChatGPT and its impact on human spheres, analyzes both possibilities of using its potential and the risks associated with possible misinformation in general, ethical standards in use and influence on traditional research processes. Despite the problems that arise, there is a high demand for ChatGPT and similar chatbots, which also have the potential to significantly transform scientific research and promote innovation.

**Keywords:** ChatGPT, AI (artificial intelligence), modern technologies.

# ПЕРСПЕКТИВЫ РАЗВИТИЯ МОДЕЛИ CHATGPT И АНАЛИЗ ЕЕ ВЛИЯНИЯ НА СФЕРЫ ДЕЯТЕЛЬНОСТИ ЧЕЛОВЕКА

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**Аннотация.** Одним из заметных достижений в области ИИ является ChatGPT от OpenAI – мощная языковая модель, основанная на архитектуре GPT-3.5, которая может генерировать текст, напоминающий человеческие ответы. В статье исследуются перспективы развития ChatGPT и его влияние на сферы жизни человека, анализируются как возможности использования его потенциала, так и риски, связанные с возможной дезинформацией в целом, этическими нормами в использовании и влиянием на традиционные исследовательские процессы. Несмотря на возникающие проблемы, существует высокий спрос на ChatGPT и подобные чат-боты, которые обладают потенциалом для существенного преобразования научных исследований и продвижения инноваций.

**Ключевые слова:** ChatGPT, ИИ (искусственный интеллект), современные технологии.

ChatGPT is a model related to InstructGPT that follows instructions in the form of hints and is trained to give detailed answers. ChatGPT uses reinforcement learning techniques to learn from reviewers' feedback and has demonstrated the ability to effectively provoke lively discussions and active exchange of ideas among members of the scientific community, and many artificial intelligence (AI) companies are also rushing to launch their own AI products to compete with ChatGPT.

The emergence of ChatGPT, an advanced artificial intelligence conversational system capable of producing human-like responses, has been called a breakthrough comparable to the invention of the Internet. Although modern AI technologies have made great strides in natural language processing, they have not yet achieved true understanding of the content they deal with.

ChatGPT represents a glimpse into the future of artificial intelligence, opening up possibilities that previously seemed unattainable. Today, many companies are moving towards creating virtual personas and Artificial Intelligence Generated Content (AIGC). Currently, there is no equivalent to ChatGPT that can offer such a variety of features and functionality. At the same time, technological development leaves bottlenecks where there is still potential for improvement and innovation. ChatGPT is at the forefront of the development of artificial intelligence, making a significant contribution to the evolution of human interaction with technology and opening new perspectives for the future of the digital world.

ChatGPT also encounters obstacles that artificial intelligence has historically faced, including ethical issues such as discrimination, fraud, political rumors, identity falsification, security issues and intellectual property rights. In January 2021, OpenAI said it was considering adding model watermarking, i.e. tracking special marks that the model can recognize, to ChatGPT to alleviate the problem of model misuse. These limitations are typical not only for AI, but also for many other areas. Currently, AI skills in tasks that require creativity, analysis and writing are still limited. Writers can easily correct bad writing in AI-generated articles, programmers can identify errors in AI code, and analysts can study the results produced by AI systems. This recognition underscores the idea that AI complements, rather than diminishes, human capabilities. Incorporating AI into these processes represents a paradigm shift and opens up new forms of collaboration: with AI, writers can be freed from having to devote all their energy to content creation, programmers can delegate routine coding tasks, and analysts can use AI to process data. This dynamism promotes new levels of productivity, with one person performing tasks that would normally require multiple people. It is worth noting that this type of collaboration does not necessarily require additional AI-related capabilities, but rather an innovative approach to completing tasks [1, p. 1].

The emergence of new artificial intelligence programs such as ChatGPT has great potential to improve office efficiency by helping with tasks such as writing receipts and emails, and thus revolutionize our world (Ahn and Chen, 2022 [2 , p. 2]).

In short, the emergence of ChatGPT has made the AI industry more prosperous: ChatGPT's large-scale pre-training language modeling technology has found application in many industries. For example, it structures data such as advertisements and research reports to make data preparation more efficient, allows users to write poems, articles, and codes on screenshots they receive over the Internet, and tracks and analyzes large volumes of information to find valuable investment information, solve customer problems more accurately and efficiently, and provide customers with high-quality services. ChatGPT is widely used in a variety of fields and can significantly improve user experience.

Since its release in December 2022, OpenAI's ChatGPT has been rapidly gaining popularity: this innovative chatbot offers a variety of functionalities, including question answering, text generation, language translation, data classification, code creation, and is capable of acting as a conversational artificial intelligence. In just the first five days after launch, the platform attracted more than one million registered users, and within two months, the number of users had already passed the 100 million mark. This impressive growth in the number of users clearly demonstrates the demand and importance of ChatGPT as a universal tool for communication, obtaining information and solving various tasks. Its versatility and ease of use make the platform popular and accessible to millions of users around the world, providing them with new opportunities to interact with artificial intelligence.

In March 2023, 1.6 billion people visited the ChatGPT website [3]. When analyzing usage statistics for OpenAI's ChatGPT portal, you should consider both access to the platform from computers and mobile devices. However, these statistics do not include users interacting with the chatbot through search engines such as Bing or other software that has ChatGPT integrated. The popularity and widespread use of ChatGPT clearly demonstrates the enormous impact and value of this application for users around the world. This demonstrates the significant role that ChatGPT plays in the areas of communication, intelligent interaction with technology and the empowerment of artificial intelligence. ChatGPT's integration into various platforms and software underscores its versatility and relevance, making a significant impact on users around the world.

ChatGPT has a conversation feature that allows users to ask contextual follow-up questions during the same conversation, and several other features of similar products. According to a survey conducted by Xiufeng Li from Tianjin University, the threat of artificial intelligence replacing core human activities has been confirmed, but this does not negate the value of future AI applications [1, p. 2].

However, there are still limitations to the use of ChatGPT and the optimization of the model: the upper bounds of the ChatGPT model are set by the reward model, which requires large amounts of data, high workload, and high quality annotators to match the real world. ChatGPT may have problems such as creating non-existent knowledge or subjectively guessing the questioner's intentions, so optimizing the model will be an ongoing process. If AI technology iterations are smaller than expected and NLP model optimization remains limited, progress in related industries

will be impacted. Additionally, ChatGPT's revenue model is still in the research stage and it is unknown whether further progress will be made in commercialization. Rapid and successful iterations in AI not only lead to the creation of innovative solutions, but also open up new opportunities for the application of technologies in various sectors of the economy. At the same time, stagnation in the processes of optimization of natural language processing models can become an obstacle to the effective use of text processing technologies and related innovations. Enhancing NLP models is crucial across various domains and serves as a primary catalyst for advancement. In addition, successful technology commercialization requires the development of effective monetization models. Using the ChatGPT revenue model as an example, it can be seen that uncertainty in this regard can slow down the scaling of the project and make it difficult to attract investment and customers. Therefore, it is important to carry out further research and development to ensure a sustainable business model and successful growth of the project.

In the future, ChatGPT's integration innovations will be complemented by advanced information technologies, including data mining and cloud computing resources, which will significantly expand the capabilities and efficiency of the service.

ChatGPT has a variety of future applications:

1. With the popularity of digital people and beautiful skins (a unique way to express your individuality and style through original designs, color combinations and decoration elements that make the appearance of something more attractive and aesthetic), models such as ChatGPT are necessary for enabling dialogue so that they can better accompany and serve people. At the same time, this ability can also be built into the robot's body, which will make the humanoid robot in the future smarter and more human-like [4, p. 15].

2. A large number of developers can use a core platform such as ChatGPT to optimize the model according to various industries and scenarios based on large models, creating many feature-rich applications that meet the needs of users, forming the ecology of conversational artificial intelligence [5, p. 2].

3. The opportunity to become a more professional human assistant in the fields of education, healthcare, advertising and marketing, e-commerce, market and strategy consulting, corporate services, coding and other professional services that can not only generate content, but also tap into various professional abilities and even replace part of the main professional work. Even if they don't attend a meeting, the Smart View feature can help users create meeting minutes and highlights. ChatGPT can also provide users with personalized timeline markers to quickly check the content of exchanges and discussions.

4. Combining innovation with other modal AI tools opens up broad prospects for content development. ChatGPT's integration with images, text-based videos, and even tools that can generate 3D models promises to revolutionize content creation processes. This approach can greatly enrich user generated content (UGC), which will be a key driver for the development of the content industry. The incredible

possibilities of combining technologies will allow one to create unique and stunning content, opening up completely new perspectives in visualization, information and interaction for creators and audiences. This trend will become the engine of content industrialization, creating unique opportunities for the development and scaling of content projects in the future [6, p. 16].

ChatGPT, at the forefront of AI development, has generated a lot of buzz, presenting a multi-faceted landscape for scientists and covering a range of opportunities and risks. Integral to this language model are unprecedented capabilities for data analysis, teamwork, and information dissemination. However, the use of this development must be approached with extreme caution, taking into account ethical aspects and the need to preserve human experience. Scientists need to view AI chatbots as a tool to enhance their skills and knowledge while maintaining transparency, fairness and accountability.

The use of Chat GPT also presents a number of potential issues, including potential bias, domain-specific knowledge requirements, and ethical considerations regarding data privacy and intellectual property. Therefore, it is important for researchers to carefully study these topics and develop thoughtful preventative measures to ensure the judicious and ethical use of Chat GPT in scientific research [7, p. 15].

ChatGPT has a huge impact on scientific research, generating new ideas, insights and increasing productivity. With the growing popularity of digital individuals and unique designs, it acts as an integral element providing the opportunity for cultural exchange and enrichment. ChatGPT's integration with industries ranging from education to e-commerce enables the creation of innovative applications that are tailored to user needs, artfully tying professional services together. The promising combination of ChatGPT with other artificial intelligence technologies, including integration with images, text, video and future 3D models, opens new horizons for industrial content, driving economic development and improving consumer experience. Further research and evaluation are needed to realize the full potential of this technology in scientific research and address the critical challenges currently facing society.

ChatGPT allows one to integrate into one's own application without creating an application from scratch, which also makes it possible to create various GPT shells, which in turn meet different needs. ChatGPT is also used to automatically execute multiple queries at once and then process the returned results.

Integrating with other AI technologies, ChatGPT has a high degree of potential for data personalization, as well as their customization, which requires constant improvement of ChatGPT models in order to improve natural language generation, for example, and more convenient and intuitive user interaction through the convergence of AI technologies.

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**УДК 620.9**

# TYPES OF TURBINES AND THEIR APPLICATION IN INDUSTRY

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**Abstract.** This review article presents a comprehensive analysis of modern technologies and principles of turbine operation used in various sectors of energy and industry. The main types of turbines, including steam, gas, hydraulic and wind, as well as their design features and applications, are covered.

**Keywords:** turbine, steam turbine, gas turbine, hydraulic turbine, wind turbine.

# ТИПЫ ТУРБИН И ИХ ПРИМЕНЕНИЕ В ПРОМЫШЛЕННОСТИ

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**Аннотация.** В данной обзорной статье представлен комплексный анализ современных технологий и принципов функционирования турбин, используемых в различных отраслях энергетики и промышленности. Освещены основные типы турбин, включая паровые, газовые, гидравлические и ветряные, а также их конструктивные особенности и области применения.

**Ключевые слова:** турбина, паровая турбина, газовая турбина, гидравлическая турбина, ветряная турбина.

Turbines are one of the key technological devices that have a significant impact on many areas of modern society. From energy to aviation to shipbuilding, turbines play an important role in the functioning of many critical systems and processes.

Despite their familiarity, turbines are complex and high-tech mechanisms that have come a long way of improvement. Turbines are engines with blades that convert the energy of steam, gas or water into mechanical work. From the first steam turbines to today's gas and wind turbines, turbines have become an integral part of our lives, allowing us to generate and convert energy with unprecedented efficiency. In this article, we will look at the different types of turbines and their applications in key industries.

The main task of the turbine is to increase the density of air entering the engine. As a result, more energy can be obtained and the power output can be increased accordingly. There are different types of turbines, including steam, gas, hydraulic, and wind turbines. Let's take a look at these types in more detail.

The first type of turbine is **steam turbines**. Steam turbines are turbines that use steam as a working fluid, which is obtained by heating water in a steam boiler, steam generator or special waste heat boiler. A steam turbine is an engine that converts the potential energy of steam into mechanical energy in the form of the rotation of the turbine shaft. The mechanical energy of the turbine shaft can then be transferred to various power generators. Steam turbines obtain rotational energy by converting the energy of compressed and heated steam [1].

Steam turbines consist of a casing, a nozzle, a rotating shaft, bearings, a capacitor, rotor blades, and an outlet. A turbine can have up to 40 rows of nozzles and blades, at the end of which there is a generator.

The working principle of a steam turbine is that the fuel is burned in a boiler, the heat from the burned fuel is transferred to the water, which is then heated to steam that enters the steam turbine.

The advantages of steam turbines are high efficiency, long service life and independence from fuel. High-efficiency steam turbines also reduce energy costs and are environmentally friendly. The lower pressure and temperature of the steam entering the turbine increases efficiency.

The disadvantages of steam turbines are that they have a relatively high cost per night. Steam turbines are less efficient than piston engines when operating at partial load. A reciprocating internal combustion engine is a type of internal combustion engine (ICE) in which the thermal energy of expanding gases formed as a result of the combustion of fuel in the cylinder is converted into the mechanical work of the forward motion of the piston due to the expansion of the working fluid (gaseous products of fuel combustion) into which the piston is inserted. Steam turbines have a longer start time than gas turbines and, of course, than reciprocating engines. They are less susceptible to changes in energy consumption compared to gas turbines and reciprocating engines [2].

Let us consider the internal classification of steam turbines. Steam turbines can be classified according to different principles, for example, by the principle of operation pulsed steam turbines and jet steam turbines can be distinguished.

Impulse turbines operate on superheated steam. Such turbines make it possible to increase efficiency at low speeds.

Jet turbines are also known as Parsons turbines. They operate on steam expanded in the front stage through a fixed nozzle.

It is possible to consider the classification according to the amount of steam used in the work and the amount of steam not involved in production: condensing, heating, heating with industrial steam extraction, back pressure.

Condensing turbines marked "K" are the most common type of steam turbines in production. Usually, such a turbine comes with a condenser-device designed to

collect used steam. Absolutely all the exhaust steam enters the condenser. The main task of condensing steam turbines is to generate electricity. Consequently, this type of turbine is used in power plants. You can also install them at thermal power plants, but usually they are not used there.

Cogeneration turbines are turbines of the “T” type. They are widely used in thermal power plants, since owing to them it is possible to generate not only electricity, but also thermal energy. The turbine is capable of extracting steam using a rotating diaphragm. This process is controlled. The extracted steam then enters certain heaters, from which the heat energy is transferred to the water. In the summer, cogeneration turbines are capable of operating in condensing mode. In this case, the steam does not reach the mains heaters, but is fully used to generate electricity. Cogeneration turbines with industrial steam extraction are turbines marked “PT”. The name of these turbines makes it clear that a certain part of the steam in the process of energy production is used for industrial needs, for example, for the operation of the plant itself. After that, the steam returns in the form of a liquid, that is, condensate, or completely evaporates. At the moment, cogeneration turbines are practically not used in production.

Back pressure turbines are marked “P”. A feature of backpressure turbines is the absence of a condenser where the used steam would flow. Therefore, the steam, in turn, goes to a third-party consumer for use, which is a bit similar to industrial-type cogeneration turbines. At the moment, backpressure turbines, as well as turbines marked “PT”, are not used in production, except for individual cases. In the absence of external consumers, it is impossible to use backpressure turbines for power generation, respectively, they have become unnecessary.

Based on the characteristics of the principles of operation of steam turbines, it can be concluded that nowadays turbines are used in energy production processes, such as thermal power plants, centralized cooling. Steam turbines are also used on ships. Steam turbines cannot be used in land or air transport, as large amounts of water must be used to do so.

The next type of turbine we will look at is **gas turbines**. A gas turbine is a blade machine with stages, in which the energy of compressed and/or heated gas is converted into mechanical work on the shaft. The main role of a gas turbine is to convert the kinetic energy of a hot gas flow into mechanical rotational energy.

Gas turbines consist of a rotor and a nozzle apparatus. The principle of operation of a gas turbine is as follows: the compressor compresses the air, and the compressed air enters the combustion chamber. In the combustion chamber, hot gas is formed under high pressure. The gas expands in the turbine, presses on the blades, rotates the turbine rotor and rotates the compressor shaft. Gas turbines convert the energy of a high-speed gas flow into torque by expanding the gas. A characteristic feature of gas turbines is that they do not change the collective state of the working bodies [3].

The advantages of gas turbines are as follows: simple design and less weight compared to a steam turbine, low water and oil consumption, ease of putting into

operation, operating on fuel of any quality and in any conditions, fewer harmful substances produced, the design includes a minimum number of friction parts, so the turbine has a long service life, and fewer vibrations are created during its operation, high energy efficiency, thanks to which the cost of buying a turbine quickly pays off.

The disadvantages of a gas turbine are as follows: high noise level, limited power, most of the power is spent on the operation of the compressor, the initial temperature during the operation of the turbine should be about 500 °C [4].

Let us consider the internal classification of gas turbines. Gas turbines are divided into two types: industrial turbines and microturbines.

Industrial gas turbines are large-sized installations with high efficiency, used in various types of power plants. Industrial gas turbines generate mechanical energy and serve to drive generators, pumps or gas compressors.

The advantages of industrial gas turbines are as follows: high efficiency, low maintenance, fast start-up, gas turbines can run on different types of fuel.

The disadvantages of such turbines include: power limitations, noise, maintenance, which requires qualified specialists, as well as high cost. They are used to provide autonomous power supply, produce clean energy and can be an emergency power source.

The advantages of micro gas turbines include: small size, light weight, high mobility, good scalability, multi-fuel capability, low noise and emissions, long-term maintenance-free operation and remote monitoring.

The disadvantages of gas microturbines include the following: high initial cost, power limitations, sensitivity to low temperature [5].

To summarize the above, gas turbines are driven by a generator and are used as part of gas turbine engines, stationary gas turbine units (GTUs) and combined cycle gas turbine units (CCGTs). Gas turbines have a lower thermal efficiency due to lower operating temperatures and pressures. They also usually have lower initial capital costs than steam turbines. Their installation and infrastructure requirements are less complicated and less expensive. In addition, gas turbines tend to have lower operating costs.

The next type of turbine that we will consider is **hydraulic turbines**.

A hydraulic turbine is a device that converts the energy of the water flow into mechanical work on the shaft, thereby rotating the rotor of the generator and converting mechanical energy into electrical energy. Hydro turbines consist of a spiral chamber of a hydraulic turbine, a guide system, an impeller and a suction pipe.

According to the principle of operation, hydroturbines are divided into active and reactive ones. The main working body of a hydro turbine is the impeller. The main difference between the two types of hydro turbines is that the water pressure in front of the impeller is equal to atmospheric pressure in active hydro turbines and higher than atmospheric pressure in jet turbines, and after exiting the impeller, it can be higher or lower than atmospheric pressure [6].

The advantages of hydro turbines include: operation on a renewable energy source, minimal maintenance, which reduces operating costs, they can also provide a stable supply of electricity to the grid.

The disadvantages of such turbines include: restrictions on location, the construction of hydroelectric power plants can affect the migration routes of fish and their reproduction, restrictions on seasonality.

Depending on the method of power regulation, jet hydroturbines can be divided into two types: single and double control ones.

Single-regulated hydraulic turbines include hydraulic turbines, which consist of a guide vane with rotating blades that supply water to the impeller (regulation is carried out by changing the angle of rotation of the guide vane blades), and blade hydroturbines, in which the impeller blades can rotate around the axis (regulation is carried out by changing the angle of rotation of the impeller blades).

Dual-variable hydraulic turbines include a rotating guide vane and a rotating blade impeller. In active hydraulic turbines, there are no suction pipes and spiral chambers, and the role of the flow regulator is played by a nozzle device with a needle that moves along the nozzle and changes the outlet area.

Depending on the location of the impeller shaft, hydraulic turbines can be divided into vertical and horizontal:

- The head is less than 10 m, the flow rate of the hydro turbine is 5-20 m3/s: the type of hydro turbine is a vertical propeller hydro turbine, the project of the small hydropower plant building is a building with a rectangular turbine chamber.
- The head is more than 20 m, the flow rate of the hydroturbine is 20-40 m3/s: the type of the hydroturbine is a vertical radial-axial hydroturbine (Francis turbine).
- The head is 10-20 m, hydro turbine flow rate 5-20 m3/s: the type of hydro turbine is a hydro turbine with a horizontal shaft and a vertical generator.
- The head is less than 20 m, the flow rate of the hydro turbine is 20-40 m3/s: the type of hydro turbine is a horizontal tubular hydro turbine.

Hydro turbines are an important source of renewable energy with a number of advantages, but they also have their limitations. The choice of a hydro turbine depends on the specific conditions and requirements. Most often, hydroturbines are used to drive hydrogenerators at small and medium-sized hydroelectric power plants.

The development and implementation of new technologies makes it possible to mitigate the negative impact of hydroelectric power plants on the environment and increase their efficiency.

Finally, the last type of turbine to consider is **wind turbines**. Wind turbines are rotating machines that can be used to directly grind wind or generate electricity from wind energy. They provide clean, renewable energy for both homes and offices. Wind turbines are a great way to save money and make the environment cleaner and more environmentally friendly. Their goal is reduced dependence on fossil fuels for energy production and producing it in a less wasteful way. Wind turbines use the

kinetic energy of the wind to push the turbine blades and rotate the motor, which converts the kinetic energy into electrical energy for the consumer to use [7].

A wind turbine consists of five main parts and many minor parts. The main components are the base, tower, rotor and hub (including three blades), nacelle, generator.

The principle of operation is that the wind (even a light one) causes the blades to rotate, generating kinetic energy. Rotating blades rotate the shaft in the nacelle, and the generator in the nacelle converts this kinetic energy into electrical energy. The efficiency is low, usually around 30-45 %.

There are two types of wind turbines: vertical-axial and horizontal-axial wind turbines.

The advantages of vertical-axial wind turbines are as follows: the generator and reducer can be installed on the ground, they are easy to maintain, produce lower noise than horizontal-axial turbines, have aesthetic appearance, can be started at low wind speed, there is need to consider wind direction and turbulence, they work well even in strong winds.

The disadvantages of such turbines are as follows: they require twice as much wind path area as turbines with a horizontal shaft, do not produce as much electricity as a turbine with a horizontal shaft – low efficiency, the cost is higher than that of horizontal-axial turbines.

Horizontal-axial wind turbines are reliable, omnidirectional and silent, as they do not create a load on the supporting structure.

The advantages of such turbines are as follows: high power output, high efficiency, cheap production cost.

Horizontal-axial wind turbines have disadvantages such as instability due to wind fluctuations, unsightliness, the need for large open spaces for installation.

Wind turbines are a promising solution for creating a sustainable future. Horizontal axial wind turbines are the most commonly used because they are more efficient, cheaper to manufacture, easier to design, have more power, and are more convenient to place than vertical wind turbines [8].

For the further development of wind energy, solutions are needed for wind turbine installation, operation, and environmental impact. Despite this, wind turbines play a key role in the transition to clean energy and reducing dependence on fossil fuels.

For decades, turbines have played a central role in the development of modern technology and infrastructure. From power generation to aircraft engines, this highly efficient mechanism has become a critical component in helping humanity reach new heights in a variety of fields.

With many different applications for turbines, from steam and gas to hydro and wind, there is no doubt that this technology continues to strengthen its position in today’s world. Continuous innovation and design improvements are opening up new opportunities to improve the efficiency, sustainability and reliability of turbines.

The future of turbines is promising. Turbines that convert wind, hydro and thermal energy into electricity will play an important role in the development of renewable energy sources. In addition, the integration of turbines with digital technologies will lead to the creation of intelligent systems that can adapt to changing needs and conditions.

Turbines will undoubtedly continue to shape our technological world, opening up new horizons in science, industry and everyday life. Due to their ability to convert energy, turbines are a crucial component that will continue to determine the development of modern civilization.

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# STUDY OF THE ENVIRONMENT OF FORMATION AND ASSESSMENT OF NATIONAL DEVELOPMENT STRATEGIES OF CHINA, RUSSIA AND THE USA IN MODERN CONDITIONS

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**Abstract.** The paper studies and defines national strategies of the major countries of the world – Russia, the USA, China, which depend on a large number of factors: available natural and labour resources, development of innovation environment, investment climate, transport infrastructure, presence of military actions, form of government, etc.

**Keywords:** national development strategy, Russia, China, USA, innovations, investment climate, formation environment.

# ИССЛЕДОВАНИЕ СРЕДЫ ФОРМИРОВАНИЯ И ОЦЕНКА НАЦИОНАЛЬНЫХ СТРАТЕГИЙ РАЗВИТИЯ КИТАЯ, РОССИИ И США В СОВРЕМЕННЫХ УСЛОВИЯХ

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**Аннотация.** В работе исследованы и определены национальные стратегии основных стран мира – России, США, Китая, которые зависят от большого количества факторов: имеющихся природных и трудовых ресурсов, развития инновационной среды, инвестиционного климата, транспортной инфраструктуры, наличия военных действий, формы правления и т. д.

**Ключевые слова:** национальная стратегия развития, Россия, Китай, США, инновации, инвестиционный климат, среда формирования.

In the conditions of increasing internationalisation and globalisation of the world economy, there is a quantitative and qualitative transformation of socio-economic interrelations between countries, international organisations, economic entities and individuals. In this regard, the study of the peculiarities of economic development strategies of countries becomes relevant.

The strategy of economic development of a country is a plan of activities aimed at achieving a certain goal in the long term. To define it, it is necessary to

understand what resources this or that country possesses, that is, at the initial stage of the study it is necessary to analyse the qualitative and quantitative indicators of the environment for the formation of development strategies of the countries under study (Russia, the USA and China). For the readers convenience, we will present the information in the form of Table 1.

Table 1 – Analysis of qualitative and quantitative indicators of the environment of development strategy formation in China, Russia and the USA

| Indicator / country | China | USA | Russia |
|---|---|---|---|
| **Quantity and quality of natural resources** | - total value of natural resources: $23 trillion;<br>- 13th in proven oil reserves;<br>- 13th place in proven gas reserves;<br>-wood reserves $6.5 trillion.<br>- one of the first places in the world in terms of coal reserves | - the total value of natural resources: $45 trillion.<br>- 12th largest proven oil reserves: 47.1 bar for 2022.<br>- 31.2 per cent of the world's proven coal reserves ($30 trillion);<br>- 2nd place in proven reserves of zinc and silver. | - total value of natural resources: $75 trillion;<br>- 1st in proven gas reserves in the world: 1.680 trillion cubic feet by 2022;<br>- 1st in oil reserves: 60bn barrels for 2022;<br>- 2nd largest coal deposits;<br>- 2nd largest rare earth mineral reserves.<br>- 3rd place in gold deposits<br>- 1st place in forest plantations. |
| **Quantity and quality of labour resources** | 2023:<br>- population: 1.43 billion people<br>- employment rate: 77.5 per cent<br>- youth unemployment rate: 14.9%;<br>- wages: $5.67/hour | 2023<br>- population: 335.89 million people<br>- employment rate: 60.1 per cent<br>- youth unemployment rate: 8%;<br>- level of economic activity: 62,5%;<br>- Wage: $29.51/hour. | 2023<br>- population: 146.4 million people<br>- employment rate: 61.3%<br>- level of economic activity: 63,2%<br>- wage: $3.54/hour |
| **Gross fixed capital formation** | 2023 – $71.68 billion | 2023 – $4.02 trillion | 2023 – $85000 |
| **Technologies**<br><br>- General Description | - China’s mobile payment system is one of the most developed in the world;<br>- Transport complex;<br>- High technology for home decoration;<br>- Next-generation information and communication technologies (hardware, software, telecommunications, including 5G);<br>- Nuclear Asset Recycling;<br>- Taobao Villages;<br>- Telemedicine | - Nanotechnology.<br>- Biotechnology.<br>- Genetic engineering.<br>- Next-generation information and communication technologies (quantum, optical and DNA computers, laser TVs, screenless displays, etc.).<br>- Cognitive technologies.<br>- Environmentally friendly (new or ‘green’) energy. | - Basic and critical military and industrial technologies for the development of advanced types of weapons, military and special equipment.<br>- Basic technologies of power electrical engineering.<br>- Biocatalytic, biosynthetic and biosensor technologies.<br>- Cellular technologies.<br>- Computer modelling of nanomaterials, nanodevices and nanotechnologies.<br>- Nano-, bio-, information and cognitive technologies.<br>- Technologies of nuclear power engineering, nuclear fuel cycle, safe radioactive waste management. |
| - Spending on research and development (% of GDP) | 2,43 | 3,46 | 1,09 |
| - IT exports (% of total exports) | 25,50 | 9,07 | 0,52 |
| - Export of high technology (hi-tech, % of total exports) | 23,12 | 17,85 | 9,69 |

*Continuation of Table 1*

| | | | |
|---|---|---|---|
| **Political and social institutions**<br>- political structure | One-party parliamentary republic | Presidential Republic | Presidential-parliamentary republic |
| - number of parties | 1 party | Republican and Democratic parties, as well as a host of federal third parties | 25 parties |
| - religion | Predominantly Confucianism, Taoism and Buddhism, in addition to Christianity (about 5.1 per cent) and Islam (about 2 per cent) | - of the USA population are Protestants,<br>-Catholics -20.8%<br>- Mormons - 1.6 per cent<br>- members of other Christian denominations-0.9 per cent<br>- Jews - 1.9 %<br>- Muslims - 0.9 per cent<br>- Jehovah's Witnesses - 0.8 per cent<br>- Buddhists - 0.7 %<br>- Hindus - 0.7%<br>- others - 1.8 per cent<br>- do not belong to any religious group - 22.8 per cent | - Orthodoxy - 66 %<br>- Islam - 6 %<br>- Protestantism - 1 %<br>- Buddhism - 1%<br>- Catholicism - 1%<br>- Judaism - 0 %<br>- do not belong to any religious group - 4 %<br>- unbelievers - 14 %<br>- oscillating between belief and unbelief' - 6 % |

*Compiled by the authors on the basis of [1-4].

Based on the data in Table 1, it can be concluded that China is the largest consumer of resources in the world due to its large population and rapid economic growth. The country has significant reserves of gas and rare metals.

The USA has vast reserves of energy resources: oil, natural gas and coal. They also have significant reserves of forests and minerals. The main competitor in terms of gas and oil reserves for the USA is Russia, which, due to its large and not fully explored territory, is in the TOP 1 in the world in terms of natural resources.

All the countries under study are republics. One of these countries (the USA) is presidential, China is one-party parliamentary, the Russian Federation is presidential-parliamentary. The number of political parties in these countries differs significantly.

The US has a diverse and skilled labour force. High levels of innovation and technology development contribute to labour productivity growth. However, differences in wages and access to healthcare can create inequalities among workers. Russia has a high level of education in science and engineering, but high levels of corruption, bureaucracy, and lack of investment in technology development limit the potential of the labour force.

Regarding technology, Russia has the lowest R&D expenditures – 1.09 % of GDP (2022), while the US has the highest – 3.46 % of GDP (2022). At the same time, China exports the largest amount of various information and scientific developments.

Let us analyse the factors of the external environment influencing the formation of development strategies of the countries under study (Table 2).

Based on the data in Table 2, the most important world institutions and agents of the USA are: the UNO, NATO, IMF, WTO and large corporations (Amazon, Google, Apple); Russia – the UN, SCO, EAEU, APEC; China – the UN, APEC, G-20, WTO, SCO, BRICS.

At the same time, the main world markets for the economies of the studied states were established. Oil and gas market – the USA and Russia; machine-building market – China, Russia, the USA; automotive industry market – the USA; decorative cosmetics market – China; agricultural products market – Russia; chemical industry market – China, the USA.

Table 2 – Elements of the external environment of development strategies formation in China, the USA, Russia, 2023.

| Groups of factors | China | USA | Russia |
|---|---|---|---|
| **Complexes of geopolitical relations** | BRICS countries, SCO countries | EU countries, Canada, PRC, UK, Japan | BRICS countries, EAEU countries, SCO, CIS countries, China |
| **The most important world institutions and agents** | UNITED NATIONS, ATES, G-20, WTO, SCO, BRIX, ILO, IMF, WTO | NATO, ATES, G-7, UN, NAFTA, WTO, FAO, ILO, WBG, ICSID, IFC, WHO, EBRD, WTO, IMF | BRIX, SCO, OTAC, EEC, APEC, IAC, ISO, ICAO, EAEU, JINR, UN, IMF, ILO |
| **The aggregate of the main markets for the state economy: resource markets (means of production, information, labour force, finance) and sales markets** | Labour market, chemical products market, decorative cosmetics market, engineering market | Chemicals market, automotive market, oil and gas market, machinery market, aircraft market, plastics market | Natural gas and oil market, ferrous metals market, agricultural products market, mechanical engineering market |
| **Relational socio-economic processes and phenomena:**<br>- economic conjuncture<br>- scientific and technological progress | <br>Very high<br>Very high | <br>Very high<br>Very high | <br>High<br>Medium |

*Compiled by the authors

Further on, we can note that the factors of economic growth have priority importance in economic development, but the effectiveness of their use is determined by the ability of their appropriate and optimal combination as a result of activation of secondary indicators of development created in the process of evolution of society. For this purpose, we will assess the elements of political, legal and regulatory environment. The data will be presented in the form of Table 3.

Based on the data of Table 3, we note that the development of ICT has a significant impact on the formation of development strategies of all countries under study, but is the most important for the USA.

Table 3 – Assessment of elements of the political-legal and regulatory environment for shaping country development strategies, 2022

| Groups of factors | China | USA | Russia |
|---|---|---|---|
| **Quality of statehood** | | | |
| 1) public debt (% of GDP) | 12,13% | 136,6% | 21,1% |
| 2) date of independence | 1949 | 1776 | 1991 |
| 3) presence of internal military conflicts | yes | no | yes |
| 4) corruption perception index | 45 | 69 | 28 |

*Continuation of Table 3*

| | | | |
|---|---|---|---|
| **Scale of threats and challenges** | | | |
| 1) terrorism index | 0,582 | 4,16 | 3,02 |
| 2) militarisation index | 80 | 154 | 204 |
| 3) environmental efficiency index | 28,4 | 51,1 | 37,5 |
| 4) security index (peacefulness index) | 2,01 | 2,45 | 3,14 |
| **Potential for international influence** | | | |
| 1) membership in the UN Security Council | yes | yes | yes |
| 2 possession of nuclear weapons | yes | yes | yes |
| 3) WTO membership | yes | yes | yes |
| **Quality of life** | | | |
| 1) human development index | 0,768 | 0,921 | 0,882 |
| 2) prosperity index | 62,15 | 77,44 | 58,5 |
| 3) happiness level index | 41,9 | 37,4 | 34,9 |
| 4) life expectancy (years) | 78,2 | 77,2 | 69,4 |
| 5) health index | 46,15 | 51,34 | 48,54 |

*Compiled by the authors based on [4-8].

It should be noted that the countries of the world are divided into five groups according to the level of economic freedom [7]:

1) countries with free economy (80-100 points);

2) countries with predominantly free economy (70-79 points): the USA;

3) countries with moderately free economies (60-69 points);

4) countries with predominantly unfree economies (50-59 points): Russia;

5) countries with unfree economies (less than 50 points): China.

In addition, in the course of analysing the economic environment for the formation of development strategies in the countries under study, it was found that the Central Banks of all the countries under study have the right to issue national currency, which is an important factor for conducting independent national economic policy.

The procedure of strategic planning includes the following stages: assessment of the world economy and forecasts of its development, including the leading countries in certain areas of the economy; assessment of national economic potential and forecasts of its accumulation; forecast of trends in the international division of labour; elaboration of the overall strategy for the development of the national economy.

Therefore, at the next stage of the study it is advisable to determine the vectors of national development strategies of the countries under study in the context of globalization. The data will be presented in the form of Table 4.

Based on the data in Table 4, it can be said that in the USA the emphasis is on reducing taxes, simplifying bureaucratic procedures, stimulating innovation and developing technological industries. Within the framework of infrastructure programmes, construction and modernisation of roads, bridges, railways, airports and transport development will be a priority. The US is also actively developing alternative energy sources and working to increase energy efficiency.

Russia is the only country among all the countries studied that is underutilizing and under-developing clean energy (renewable energy sources). This is due to a number of disadvantages of the RES system, such as:

1) comparatively high cost of production;

2) weak legislative base in the Russian Federation;

3) consumer factor (tariffs for energy produced by RES are 3-3.5 times higher than traditional ones);

4) impermanence of the system (efficiency of different types of RES depends on seasonal and weather conditions).

China, in its turn, is a leader in the development of renewable energy sources. In 2023, the country produced 1,453 GW of renewable energy. The rapid development of renewable energy (especially wind and solar) in China has been fuelled by a number of factors: comprehensive government support, new technological solutions and innovative developments in the industry.

Table 4 – Identification of national development strategies of the countries under study in the context of globalisation, 2022-2023

| Areas of economic development | China | USA | Russia |
|---|---|---|---|
| **Improvement of business and investment climate** | Foreign Investment Law: broad access of foreign investors to the Chinese market and guaranteed legal protection. In 2022, the law was amended to remove restrictions in the oil industry, automotive industry, nuclear fuel production, satellite broadcasting equipment production, financial sector, and utilities in investment transactions. | Providing maximum support to potential investors and creating effective incentives for investment, such as tax benefits, including tax credits, preferential bank lending, innovation grants, etc. | 'Regulatory guillotine'; law on protection of capital investments; creation of equal competitive conditions through tax administration and more equitable distribution of budget money; "Transformation of business climate" plan: allowing entrepreneurs to pay company debts already after liquidation of legal entity, creation of new services of FTS, allowing commercial enterprises for educational activities, taking into account the needs of employers in state accreditation of educational programmes. |
| **Modernisation, introduction of innovations, creation and development of new production facilities** | A 10-year plan for the development of basic science has been formulated, including in areas critical for the formation of 'industries of the future'; the activities of the relevant ministry have been optimised: its functions of controlling the performance of organisations performing R&D will be strengthened, with a number of powers being transferred to sectoral agencies; a central commission for science and technology is to be established to deal with the development of the national innovation system. | The Infrastructure Act (2022) allocates $20bn for new clean energy technologies, such as reducing carbon emissions, and nearly $8bn for charging stations for electric vehicles. The Innovation and Competition Act, (2021) proposes to invest about $250bn, including about $80bn for research in artificial intelligence (AI), robotics and biotechnology, $23bn for space exploration and $10bn for the development of new technologies. – for space exploration and $10bn for technology centres outside the Kremlin. - for technology centres outside Silicon Valley. Together, all of this could amount to nearly $100bn in annual industrial policy spending over the next few years (2023-2028). | To modernise and launch new high-tech enterprises, targeted loans at low interest rates of 3-5% per annum are now available from the Industrial Development Fund. In order to increase the output of priority products, a cluster investment platform mechanism was introduced in 2022 – low-interest loans for the implementation of major projects. Preparations are underway to launch new large-scale national projects: "Means of production and automation", "New materials and chemistry", "New nuclear and energy technologies", "Transport mobility". |
| **Energy development**<br>1) renewable electricity generation (GW)<br>2) access to electricity (% of population) | <br><br>1453<br><br>100 | <br><br>388<br><br>100 | <br><br>22<br><br>100 |

*Continuation of Table 4*

| | | | |
|---|---|---|---|
| **Development of transport and transport infrastructure** | The main strategic planning documents in the field of transport in China are the Comprehensive Plan for the construction of a national three-dimensional transport network until 2035. The strategic directions for the development of railway transport at the national level are laid out in the Medium-term and Long-term Plan for the Development of the Railway Network of the People's Republic of China until 2025 and in the perspective until 2030. This plan envisages the construction of new railway lines from the existing railway infrastructure of the PRC in the direction of the border with Russia. Also, according to the results of agreements reached in 2022 at the SCO summit in Uzbekistan, the development of international transport corridors is one of the priority areas of Russia's interaction with China and Mongolia. The directions linking the Eastern polygon of the Russian Railways network and neighbouring countries have significant development potential. | The plan would provide $4.1 billion in grants to purchase electric transit buses, create a $500 million grant programme to reduce traffic congestion in major metropolitan areas and $1 billion to address the shortage of parking for commercial vehicles. The additional funding will allow heavier electric vehicles to be used on roads in the U.S. and other cities, as well as provide additional safety features in new school buses. | Transport infrastructure development is planned within the framework of a comprehensive plan for the modernisation and expansion of trunk infrastructure for the period up to 2024.<br>The plan includes nine federal projects: 'Europe – Western China', "Sea Ports of Russia", "Northern Sea Route", "Railway Transport and Transit", "Transport and Logistics Centres", "Communications between Economic Growth Centres", "Development of Regional Airports and Routes", "High-Speed Railway Communication", and "Inland Waterways". |

*Compiled by the authors based on [1; 9-12].

Let us assess the quality of public administration in the countries under study (Table 5).

Table 5 – Analysing the quality of public administration in China, the USA and Russia

| Indicator | China | USA | Russia |
|---|---|---|---|
| Positives | Ability to react quickly to crisis situations, long-term planning of economic development, active participation of the state in the economy | Strong democratic system, separation of powers, high level of transparency, independent institutions and media | Stability of the political system, some success in digitalisation of public services |
| Negatives | Restrictions on freedom of speech and political activity, human rights deficiencies, corruption | Uneven quality of public administration at different levels (federal, state, municipal), bureaucracy. | Problems with corruption, restrictions on political freedoms, lack of transparency, bureaucracy |

*Compiled by the authors

Thus, the quality of public administration in the USA is at a high level compared to other analysed countries. It should be noted that the main problem in all analysed countries is corruption and bureaucracy.

In addition, in the course of the analysis, it was established which of the foreign trade policies (export orientation or import substitution) is a priority for the government of the countries under study (Table 6).

Table 6 – Analysis of modern foreign trade policies of the countries under study

| Type of policy | China | USA | Russia |
|---|---|---|---|
| Export-oriented policy | + | + | + |
| Import substitution policy | + | + | - |

*Compiled by the authors

Based on the data of Table 6, we can conclude that for Russia the priority direction of foreign trade policy in the conditions of sanctions and restrictions is the export orientation policy.

The USA and China, being the main actors of geopolitics, pay attention to both export orientation policy (in order to capture foreign markets and fill the budget revenues through export operations) and import substitution policy (in order to create competitive domestic analogues of foreign goods and protect the market from import expansion).

Thus, it can be concluded that the countries under study have different effectiveness level of national strategies. We can observe the highest one in the USA, China is at above average level and Russia has an average one.

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**УДК 7.05**

# INNOVATION IN DESIGN: HOW NEW TECHNOLOGIES SHAPE THE FUTURE

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**Abstract.** The development of technologies is occurring at a rapid pace, and the need for artificial intelligence is becoming more prevalent. It affects many areas of our lives, including design. Using AI in design opens up new opportunities for creating unique and creative projects, and also makes it possible to automate routine tasks. The article is aimed at exploring and evaluating the use of artificial intelligence in the context of design and its impact on the creative process.

**Keywords:** neural network, design, communication design, artificial intelligence (AI).

# ИННОВАЦИИ В ДИЗАЙНЕ: КАК НОВЫЕ ТЕХНОЛОГИИ ФОРМИРУЮТ БУДУЩЕЕ

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**Аннотация.** Технологии развиваются с такой скоростью, что искусственный интеллект становится все более популярным и востребованным. Он проникает во многие сферы нашей жизни, включая дизайн. Использование ИИ в дизайне открывает новые возможности для создания уникальных и креативных проектов, а также позволяет автоматизировать рутинные задачи. Целью статьи является изучение и анализ применения искусственного интеллекта в сфере дизайна, его влияния на творческий процесс.

**Ключевые слова:** нейросеть, дизайн, коммуникационный дизайн, искусственный интеллект (ИИ).

Artificial intelligence (AI) is the ability of a computer to perform tasks using algorithms and data based on machine learning. To begin with, the system collects all existing data from various sources: text, images, audio, video. Then it analyzes the collected data, selects the necessary one, and systematizes it. “As you can see, there is no thinking and consciousness in a neural network – only algorithms and

formulas. The only thing that distinguishes it from other programs is its ability to learn and adapt to new tasks" [1].

Neural networks help generate visual content. They create unique images, graphics, and other visual elements. Neural networks can be used to generate text, for example: Chat GPT, Yandex GPT; to generate images: Midjourney, Kandinsky, Shedevrum, Recraft; neural networks for generating video are Runway and Pika.

Neural networks help analyze how users interact with websites and apps. Based on the obtained data interfaces can be improved, made more intuitive and convenient, which contributes to more effective communication. Routine tasks such as image processing, choosing fonts or color palettes can be automated using AI. This allows designers to focus on more creative aspects of the work, freeing up time and resources. The analysis of data on how people understand visual design elements is becoming deeper and more accurate thanks to neural networks. This allows designers better understand which elements work and which do not. According to statistics on the SberUniversity website, "90 % of Internet content will be created using AI by 2026" [2].

Neural networks are becoming a powerful tool in communication design, providing a more flexible, adaptive and personalized approach to creating visual materials. They help designers not only improve the quality of their work, but also simplify processes, which ultimately leads to the creation of more efficient reading.

AI greatly simplifies the work. With its help, you can generate:

1. Visualization of the product in Midjourney without spending money on photoshoots (Figure 1).

Figure 1. Parfum visualization for an advertisement

2. Brand references for shooting, clearly showing what kind of decor, techniques, poses are needed.

3. Pictograms – stickers, graphic solutions for the brand (Figure 2).


Figure 2. Stickers for flower shop site

4. Illustrations in any style.
5. Viral content for brands, unreal hyperrealistic shoots (Figure 3).


Figure 3. Advertising company generation for CNS

6. Interior prints.
7. Furniture visualization.
8. Refine frames, enlarge the image, zoom out, change the background.

Among the major brands, there are those that have already implemented neural networks in their work. For example, the Levi's clothing brand replaced models with human generation in neural networks for a catalog with new collections of models (Figure 4).

Figure 4. Levi’s generative photoshoot

Levi’s signed a contract with a company that developed a neural network for generating people [3]. And it significantly saved the budget allocated for models and photo shoots.

Cosmopolitan magazine generates covers for its magazines using the DALL-E neural network (Figure 5).


Figure 5. Cosmopolitan magazine cover

Coca-Cola used the ChatGPT-4 and DALL-E neural networks to create a new flavor. The company first analyzed consumers' taste preferences, and then the neural network processed this data and created the "drink of the future" (Figure 6).


Figure 6. Coca-Cola can design

Back in 2017, Nutella used artificial intelligence to create unique, one-of-a-kind labels for 7 million pieces (Figure 7).


Figure 7. Nutella packaging

Neural networks are actively being introduced into communication design and brand advertising, which increases interest in the company and its products.

The quality of image generation by artificial intelligence depends on the specific program and its algorithms. There are a huge number of programs that can generate images on request, but not all of them do it well. For the sake of experiment, let us compare the neural networks "Midjourney" [4] and "Shedevroom" [5]. To do

this, the same request was specified for them – “a pink ladybug that flies in space and has a hat on its head” (Figure 8).

Figure 8. Comparing Shedevrum and Midjourney

The work of “Shedevroom” is on the left, and there 4 options created using “Midjourney” are on the right. We can see clear differences in the quality of the images, in the accuracy of the request perception by the neural network. Therefore, it is important to experiment with neural networks and select high-quality requests.

For a more detailed analysis of the implementation of AI technologies, let us consider a new program from Sber University, which is aimed at studying and implementing AI technologies. “Business with AI” is a training program aimed at developing skills and competencies in the field of artificial intelligence.

The description of this program provides for study of the basic elements of machine learning, natural language processing, computer vision, and other AI technologies.

Under this program, students will undergo the following training:

– the fundamental workings of machine learning algorithms;
– techniques for managing large datasets;
– resources for developing and training artificial intelligence models;
– applications of AI within the business sector.

The graduates will receive a certificate of completion of training, which means that they can continue their training course in the field of AI or use their knowledge and skills in their current work. Based on this, we can conclude that the largest companies and brands are now actively using AI in their projects and even educates.

When implementing neural network technologies in design, it should be taken into account that their use is associated with certain threats and risks. The biggest disadvantage of using neural networks in design is that they have no creativity. Artificial intelligence is not capable of creativity, it can only generate ideas based on data. Due to algorithms it follows, AI cannot create something unique and new. In addition, due to a number of errors or failures, artificial intelligence can give out

wrong information or generate the wrong images. The threats of the development of artificial intelligence in design include the loss of jobs for people, because the introduction of such inventions can lead to the automation of designers' tasks. Ethnic issues about the confidentiality of customer data and responsibility for the final design result may be raised. The future of neural networks in the field of design holds great promise for enhancing the quality of generated images, exploring innovative styles and trends, advancing technology, and much more. "Artificial intelligence can be both man's best friend and his worst enemy", as Stephen Hawking said.

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**УДК 62-6**

# THERMAL BATTERY SYSTEMS: PRINCIPLES OF OPERATION, TECHNOLOGIES AND DEVELOPMENT PROSPECTS

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**Abstract.** Modern challenges in the field of energy, such as the need for energy efficiency and reduction of carbon emissions, contribute to the development of energy storage technologies, including thermal batteries. This article examines the basic principles of operation of thermal batteries, their types, as well as the prospects for their application in various industries such as heating, industry and energy. Special attention is paid to innovations in materials and heat storage technology, which can become an important component of efficient energy management systems in the future.

**Keywords:** thermal accumulator, principles of operation, technologies, development prospects, energy management, heat storage, innovative materials.

# СИСТЕМЫ ТЕПЛОВЫХ АККУМУЛЯТОРОВ: ПРИНЦИПЫ РАБОТЫ, ТЕХНОЛОГИИ И ПЕРСПЕКТИВЫ РАЗВИТИЯ

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**Аннотация.** Современные вызовы в области энергетики, такие как потребность в энергоэффективности и уменьшение углеродных выбросов, способствуют развитию технологий накопления энергии, в том числе тепловых аккумуляторов. В данной статье рассматриваются основные принципы работы тепловых аккумуляторов, их типы, а также перспективы их применения в различных отраслях, таких как отопление, промышленность и энергетика. Особое внимание уделяется инновациям в материалах и технологии хранения тепла, которые могут стать важной составляющей эффективных систем управления энергией в будущем.

**Ключевые слова:** тепловые аккумуляторы, принципы работы, технологии, перспективы развития, управление энергией, хранение тепла, инновационные материалы.

The energy systems of the modern world face many serious challenges. One of the key issues is the uneven production and consumption of energy. Electric grids are often overloaded during peak hours, when demand for electricity increases sharply, which leads to significant fluctuations in the operation of power systems. To cope with these problems, it is necessary to search for new approaches to energy management. One of the most promising technologies in this regard is thermal battery systems. These devices allow you to accumulate excess heat, which is generated during periods of minimal load on the network, and then effectively use it at those moments when the energy demand is maximum. Thus, thermal accumulators help to smooth out the peak load on the power grid and stabilize the operation of thermal and energy systems. In addition, the use of thermal batteries opens up opportunities for more efficient use of renewable energy sources. Solar panels and wind turbines often produce more energy than is needed at a given time, especially during daytime hours. Thermal accumulators allow you to save this excess energy and use it later, when production from renewable sources decreases or stops altogether.

Thus, the introduction of thermal batteries represents a strategically important step towards creating a more sustainable and efficient energy infrastructure. In the future, we will consider the principles of operation of these systems, their various types, as well as the prospects for their application in various fields such as heating, industry and energy.

Thermal accumulators are based on the unique ability of certain materials to accumulate and transfer thermal energy through changes in their temperature. This process includes two main stages that determine the functioning of such systems.

At the first stage, heat is accumulated. Special materials with high heat capacity, such as water, stones, metals or special chemical compounds, are heated to a certain temperature. When the temperature of the material rises, it begins to accumulate thermal energy. This stage is critical for subsequent heat transfer, since the efficiency of the entire system depends on the amount of accumulated heat.

The second stage is the realization of the thermal potential. After the material is heated and has accumulated the required amount of heat, it can be transferred to perform various tasks. The most common examples of using stored thermal energy are heating rooms, providing hot water, or performing technological operations that require heat supply. As a result, continuous heat supply is provided, despite possible fluctuations in energy production or consumption.

There are several types of thermal batteries, each of which has its own advantages and applications, such as solid-state thermal batteries, phase transition batteries (PCM), liquid batteries, gas batteries. The choice of the type of thermal accumulator depends on the specific conditions and objectives of the project, as well as on the available resources and system requirements.

Solid-state thermal batteries (Figure 1) use materials with high heat capacity, such as concrete, stone or ceramics. These materials are capable of retaining heat for a long time, which makes them suitable for large heating systems and industrial facilities. Solid-state batteries are characterized by high energy density, durability and

ease of maintenance. However, they have a limited reaction rate to temperature changes and difficulties with heat transfer.

Figure 1. Solid-state thermal batteries

In phase transition batteries (Figure 2) phase transition materials (PCM) such as paraffins and salts absorb or release significant amounts of heat during the transition from one state to another (for example, from solid to liquid). These batteries have high energy density and can be effectively used in heating and cooling systems. They allow you to precisely adjust the transition temperature, which is an important advantage. However, the complexity of production and the high cost of some materials make them less attractive for widespread use [1].

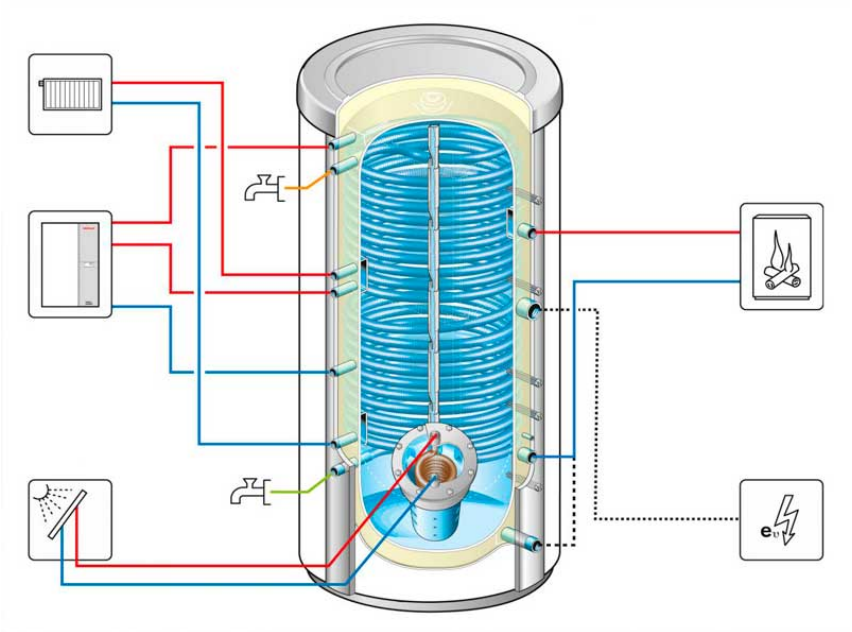

Figure 2. Phase transition battery

Liquid thermal accumulators (for example, water and salt) use liquids with a high specific heat capacity to accumulate heat (Figure 3). These systems may be more compact and economical than their solid-state counterparts, but require more sophisticated storage and transportation equipment. Liquid batteries are economical and use affordable materials, but they need high-quality thermal insulation and temperature control.

Figure 3. Liquid thermal accumulator

Gas accumulators using liquefied or compressible gases (for example, air or carbon dioxide) allow the accumulation of heat in gaseous form (Figure 4). These systems can be used in hybrid energy complexes and as backup energy sources. They are characterized by high flexibility of application and the possibility of integration with other energy systems. However, difficulties with ensuring tightness and temperature control remain the main obstacle in their use.

Figure 4. Gas accumulator

Thermal accumulators are actively used in heating systems of residential and commercial buildings. They help to reduce energy costs by accumulating excess heat during periods of minimal electricity consumption or the use of renewable energy sources. In the industrial sector, thermal batteries are used in technological processes that require constant maintenance of a certain temperature. They help reduce energy costs and increase overall production efficiency. Thermal accumulators play an important role in stabilizing energy networks by equalizing the difference between energy production and consumption. Their integration into renewable resource-based systems helps to compensate for the volatility of solar and wind energy generation [2].

Research is underway to create new materials with improved thermal conductivity and heat capacity characteristics. One of the promising directions is the development of composites based on graphene and nanotechnology, which can significantly increase the efficiency of thermal batteries [3].

The development of intelligent control systems makes it possible to optimally manage the charging and discharging processes of thermal batteries, taking into account changing operating conditions and external factors such as weather conditions and electricity tariffs.

Combining thermal batteries with other types of energy storage devices, such as lithium-ion batteries, opens up new possibilities for creating highly efficient and sustainable energy systems. Such hybrid solutions can provide reliable heat and electricity supply even in unstable production conditions.

The mass introduction of thermal batteries requires the development of cost-effective solutions and scaling of technologies. At present, many companies are working on creating mass-produced products aimed at various market segments – from household to industrial ones [4].

Government support programs and regulations aimed at stimulating the introduction of environmentally friendly and energy-efficient technologies will play a key role in the development of thermal batteries. Examples of successful initiatives already exist in a number of countries in Europe and North America.

Increasing awareness of the possibilities and benefits of thermal batteries among consumers and professionals will contribute to the widespread adoption of this technology. Educational programs and information campaigns will help people better understand how these devices can improve the quality of life and reduce environmental stress.

Thermal batteries are a key element of modern energy systems, playing a significant role in improving energy efficiency and reducing the carbon footprint. The development of innovative materials, the improvement of technologies and the creation of effective control systems open up new horizons for the use of these devices, making them an integral component of a sustainable future. As the demand for clean and affordable energy increases, thermal batteries are becoming more and more in demand due to their unique properties. These devices ensure a stable supply of heat even in conditions of fluctuations in energy production, which is especially

important for the integration of renewable energy sources such as solar and wind generation. Due to the accumulation of excess thermal energy during periods of low load on electrical networks, thermal accumulators help reduce the burden on infrastructure and reduce dependence on traditional fuel sources.

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**УДК 504.062**

# USE OF GEOTHERMAL SOURCES FOR HEATING BUILDINGS: TECHNOLOGIES, ADVANTAGES AND LIMITATIONS

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**Abstract.** Geothermal energy represents one of the most sustainable and environmentally friendly heat sources available for heating buildings. This article reviews the current technologies used to extract geothermal energy, as well as the advantages and limitations of this approach. We will analyze different geothermal heating systems, their efficiency, as well as economic and environmental aspects.

**Keywords:** Geothermal energy, building heating, geothermal heat pumps (GHPs), deep wells, direct utilization, environmental sustainability, economic efficiency, renewable energy, subsidies and tax incentives, geographical limitations, initial costs, maintenance.

# ИСПОЛЬЗОВАНИЕ ГЕОТЕРМАЛЬНЫХ ИСТОЧНИКОВ ДЛЯ ОТОПЛЕНИЯ ЗДАНИЙ: ТЕХНОЛОГИИ, ПРЕИМУЩЕСТВА И ОГРАНИЧЕНИЯ

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**Аннотация.** Геотермальная энергия представляет собой один из наиболее устойчивых и экологически чистых источников тепла, доступных для отопления зданий. В статье рассматриваются современные технологии, используемые для извлечения геотермальной энергии, а также преимущества и ограничения данного подхода. Авторы провели анализ различных систем геотермального отопления, их эффективности, а также изучили экономические и экологические аспекты.

**Ключевые слова:** геотермальная энергия, отопление зданий, геотермальные тепловые насосы (ГТН), глубокие скважины, прямое использование, экологическая устойчивость, экономическая эффективность, возобновляемые источники энергии, субсидии и налоговые льготы, географические ограничения, первоначальные затраты, техническое обслуживание.

Geothermal energy is heat stored beneath the Earth's crust that can be used for heating and hot water supply. In recent decades, there has been a growing interest in geothermal energy as an alternative to traditional heating methods such as gas and electric systems. This is due to the need to reduce carbon emissions and move towards more sustainable energy sources.

Geothermal heating utilizes the heat beneath the Earth's surface to heat buildings and provide hot water. There are several technologies used to extract and utilize geothermal energy (Figure 1).

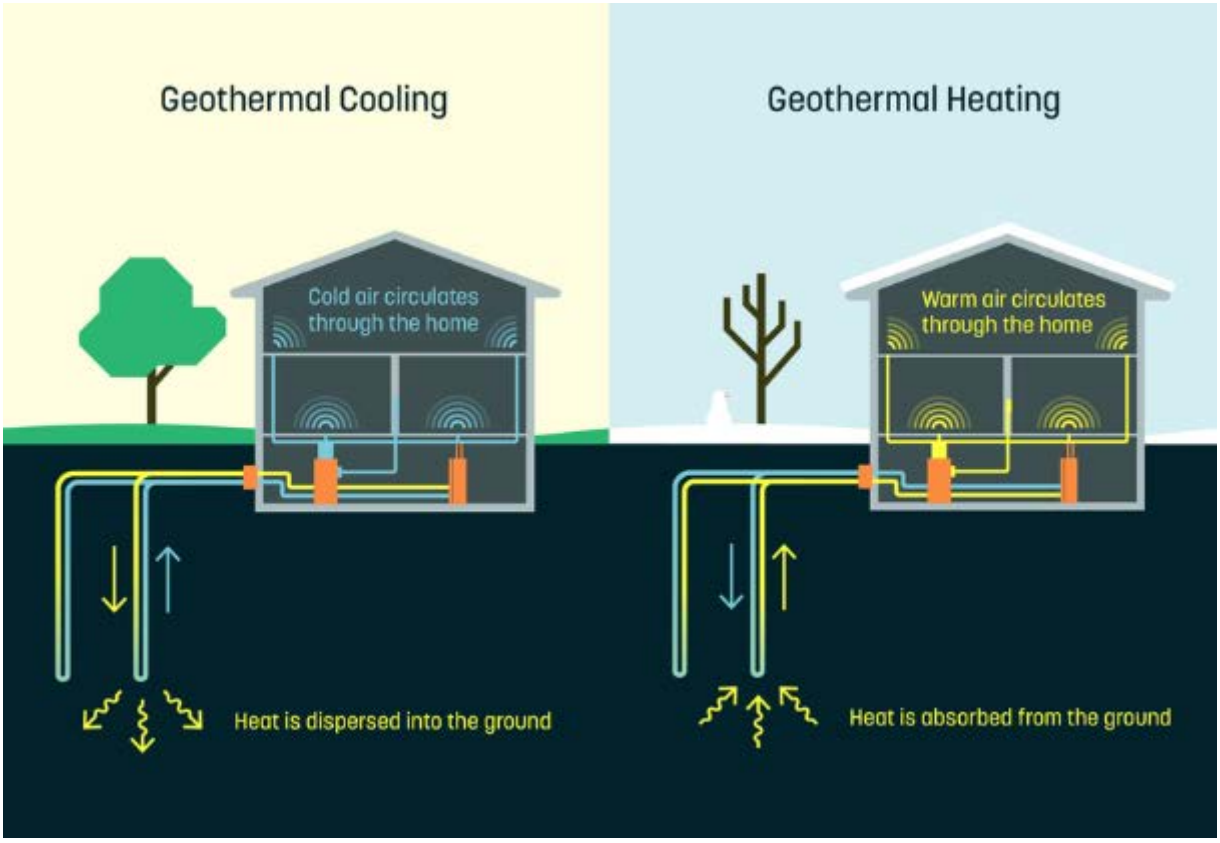


Figure 1. Working principle of geothermal heating

Geothermal heat pumps (GHPs) utilize heat from the upper layers of the earth or groundwater. GHPs can be vertical (wells) or horizontal (pipelines in the ground). They work on the principle of heat transfer: in winter they extract heat from the ground and transfer it to the building, and in summer they remove heat from the building to the ground. Direct use of geothermal energy implies that in some regions it is possible to directly utilize hot springs for heating. This may include supplying hot water to radiators or underfloor heating systems. Direct use can also be utilized to heat greenhouses, swimming pools, and other facilities. Deep geothermal systems utilize heat from deep within the Earth, where temperatures are much higher. Deep wells are drilled for this purpose. Deep geothermal energy can be used for large power plants and industrial needs. In closed loop systems the working fluid circulates in a closed loop, absorbing heat from the earth and transferring it to the building. This can be used in both GHPs and other systems. Open-loop systems utilize groundwater

that rises to the surface, transfers heat and then discharges back into the ground or into a body of water. Combined systems can combine geothermal heating with other energy sources, such as solar collectors or biomass boilers, to increase overall efficiency. Controls and automation systems can optimize the operation of geothermal systems, increasing their energy efficiency and reducing operating costs. Each of these technologies has advantages and disadvantages, and the choice of a particular system depends on local conditions, resource availability, and user needs [1].

Geothermal sources have several significant advantages that make them attractive for use in energy and other applications. Geothermal energy is considered a renewable source because the heat from the earth is constantly replenished, and it also results in significantly lower greenhouse gas emissions than fossil fuels, helping to reduce climate impact. The sources provide stable and predictable energy production, unlike solar and wind sources which are weather dependent. These installations take up less land compared to solar or wind farms, allowing more natural ecosystems to be preserved.

Although the initial investment can be high, the operating costs of geothermal plants are usually low, making them cost-effective in the long run. Geothermal energy can be used not only to generate electricity, but also to heat buildings, greenhouses, and in various industrial processes. Such sources are also less exposed to international energy prices and geopolitical risks. The development of geothermal energy can help create new jobs in the research, development and exploitation of geothermal resources.

Geothermal energy has some environmental benefits. Let us compare geothermal energy with other sources such as coal, oil, solar and wind energy in terms of carbon emissions and environmental impact.

Carbon emissions are minimal here. They mainly come from the construction and maintenance of the plants and from vapour and gas emissions from deep sources. Even so, emissions are significantly lower compared to fossil sources. Coal is one of the most polluting energy sources. Burning coal results in high emissions of carbon dioxide ($CO_2$), sulphur dioxide ($SO_2$) and other pollutants, contributing to global warming and acid rain, burning oil also results in significant emissions of $CO_2$ as well as other pollutants. The production and transport of oil can lead to spills and other environmental disasters. There may be $CO_2$ emissions during solar panel manufacturing and installation, but in general solar power plants do not produce emissions during operation. The carbon footprint is much lower than that of fossil sources. Like solar power, wind power produces no emissions during operation. However, as with solar panels, wind turbine production is associated with some $CO_2$ emissions.

Let us consider the environmental impacts. Geothermal energy can cause changes in local ecosystems and resource use (e. g., groundwater use). However, these impacts are generally less significant compared to coal and oil. Coal has significant environmental impacts: landscape destruction, water, air and soil

pollution. Coal mines can cause serious environmental problems. Oil has a high risk of spills, causing serious pollution of water bodies and ecosystems. Oil extraction can also negatively affect local ecosystems. Solar power generation takes up a large area to install solar farms, which can affect local ecosystems. However, solar panels can be integrated into existing structures (e.g. roofs of buildings) and wind turbines can negatively impact local fauna (e.g. birds and bats). However, these impacts are much smaller compared to fossil sources.

These benefits make geothermal an important element of a sustainable energy future [2].

Despite the many advantages, utilizing geothermal sources also has its limitations and challenges. Geothermal resources are unevenly distributed around the world. The most suitable locations for development are in regions with high tectonic activity, such as volcanic zones, which limits the availability of geothermal energy in other regions. The development of geothermal projects requires significant upfront investment, including drilling wells and building infrastructure. This may be an obstacle for some countries or companies. If such sources are overexploited, there may be a risk of resource depletion, especially if sustainable management measures are not followed. Drilling deep wells to extract heat can be technically challenging and expensive, especially in difficult geological conditions. Although geothermal energy has low carbon emissions, its development can lead to other environmental problems such as groundwater contamination, hydrogen sulfide release, and other emissions associated with drilling. In some cases, geothermal development can cause small earthquakes, which raises concerns for local communities and may require additional risk management measures. Technologies for utilizing geothermal energy are still evolving and not all regions have access to state-of-the-art methods, which can limit the efficiency and cost-effectiveness of projects. The efficient utilization of geothermal energy may require the development of additional infrastructure such as heat exchangers and heat distribution systems [3].

Let us consider the geographical spread of geothermal energy, highlighting the leading countries in this field and assessing the potential of different regions of the world. This will provide a better understanding of the current state and future of geothermal energy, as well as its role in the global energy system.

Iceland is the world leader in geothermal energy utilisation per capita. About 90 per cent of homes in the country are heated by geothermal sources. Geothermal energy is also used to generate electricity at geothermal power plants such as Nevdalsvik and Laugarvaldsvik. The United States is the second largest user of geothermal energy in the world. Major regions where geothermal resources are actively used include California (especially the Hot Springs area), Nevada, and Oregon. California is home to the world’s largest geothermal power plant, the Geysers. The Philippines is the third largest producer of geothermal energy in the world. Geothermal power plants such as Laoag and Macasasan provide a significant portion of the country’s electricity.

The potential for geothermal energy in Russia is significant due to the vast geothermal resources located in the country. Russia has one of the world's leading reserves of geothermal energy, and its utilisation can play an important role in the transition to more sustainable energy sources. Kamchatka has one of the highest levels of geothermal activity in the world due to the presence of volcanoes. It has large geothermal fields such as Paratunka and Mutnovskoye, which are used for power generation and heating. Sakhalin also has significant geothermal resources that can be utilised for power generation and heating. There are several geothermal springs in the region that can be utilised for both energy and medical purposes.

Despite the presence of significant resources, the utilisation of geothermal energy in Russia is still at an early stage.

Geothermal energy in Russia has a huge potential that can significantly contribute to the country's energy independence and sustainable development. In order to realise this potential, active investment in research and development is required, as well as the creation of a favourable legislative framework to attract investment in geothermal energy.

Geothermal energy has significant potential for growth and development in the future. Let us consider the key directions and trends that can contribute to this process. First of all, these are innovative technologies. Enhanced Geothermal Systems (EGS) makes it possible to extract heat from deep layers of the earth where traditional geothermal resources are not available. EGS includes the creation of artificial reservoirs, which greatly expands the geographical possibilities of geothermal energy utilization. The development of geothermal pump systems for heating and cooling buildings makes this technology more affordable and efficient for widespread use in residential and commercial construction. Next, it is worth mentioning the increase in investment. Many countries are beginning to recognize the importance of transitioning to renewable energy and are implementing programs to support geothermal projects through subsidies, tax incentives and grants, and the growing interest from the private sector in sustainable technologies may also contribute to increased funding for geothermal projects [4].

Sustainable development and the environment are also worth noting. In the face of global climate change, geothermal energy can be a key element in a strategy to reduce greenhouse gas emissions, making it more attractive to governments and businesses, and it can be effectively integrated with solar and wind energy, creating hybrid systems that provide a stable and reliable energy supply. The expansion of applications is not to be forgotten either. Geothermal energy can be used not only for heating and power generation, but also in industrial processes such as drying agricultural products, producing electronics or recycling waste, and countries with developed geothermal resources can share their experience and technology with other nations, which contributes to the development of a global geothermal energy market.

Educational programs and awareness campaigns can help raise awareness of the benefits of geothermal energy among the public and businesses, which will encourage its wider acceptance, and the development of geothermal energy education

programs will help prepare a skilled workforce for the industry. The outlook for geothermal energy looks promising due to innovative technologies, growing investments and increasing awareness of its benefits. Given the global challenges of climate change and the need for sustainable energy sources, geothermal energy can occupy an important place in the future energy landscape [5].

The use of geothermal sources for heating buildings represents a promising area for sustainable energy. Current technologies allow for the efficient extraction and utilization of geothermal energy, which helps to reduce the carbon footprint and improve the energy efficiency of buildings. Despite existing limitations such as high initial costs and geographical constraints, the advantages of geothermal heating make it an attractive choice for many regions of the world. The future of this approach will depend on further research, technology development and government support for renewable energy.

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**УДК 794.08**

# THE USE OF MATERIALS IN CREATING ATTRIBUTES FOR A COMFORTABLE “DUNGEON & DRAGONS” GAME SETUP RANGING FROM THE CHEAPEST TO THE MOST EXPENSIVE PREPARATIONS

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**Abstract.** This paper provides an overview of various techniques and materials designed to prepare for playing the popular tabletop role-playing game “Dungeon & Dragons”. Plotting and conducting battles are considered. The main elements of the gameplay are described, such as a world map, dice for throws, chips, etc.

**Keywords:** materials, miniatures, tokens, game master screen, dice, map.

# ИСПОЛЬЗОВАНИЕ МАТЕРИАЛОВ В СОЗДАНИИ АТРИБУТОВ ДЛЯ КОМФОРТНОЙ ИГРЫ В “DUNGEON & DRAGONS” В ГРАДАЦИИ ОТ САМОЙ ДЕШЕВОЙ ДО САМОЙ ДОРОГОЙ ПОДГОТОВКИ

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**Аннотация.** В данной работе проведен обзор различных техник и материалов, предназначенных для подготовки к игре в популярную настольную ролевую игру “Dungeon & Dragons”. Рассмотрено построение сюжетов и проведения сражений. Описаны основные элементы игрового процесса, такие как карта мира, кости для бросков, фишки и т. д.

**Ключевые слова:** материалы, миниатюры, токены, ширма, кубики, дайсы, карта.

Gaming activity has been an intrinsic part of human existence since the earliest stages of life.

The issues of engaging children and youth in various forms of extracurricular activities, including play, have been discussed in the works of O. V. Rovinskaya [1]. First, it is important to determine what is needed for the game. The following elements may be required during the game: dice, a game master’s screen, player pieces, game cards, as well as world maps that players navigate (Figure 1).


Figure 1. Attributes: a) dice, b) game master's screen, c) miniatures for gameplay, d) character token, e) game map, f) world map

With proper preparation, it is possible to reduce costs for all these materials. For example, dice can be rolled on various websites or mobile applications; if the game is played online, a screen is not necessary, and handouts can be electronic. However, we will focus on real-time games. First, we will categorize our games into three groups: simple, medium, and complex ones.

**Cube (Dice)**

Dice play an important role in the gaming process, as they are used by the master to conduct checks and determine the damage received or dealt to players and opponents.

For the simplest games, it is not necessary to buy your own dice; you can use various online services for virtual rolls that provide this service for free.

For games of moderate complexity, you can purchase your own dice made from epoxy resin. The price for such a set ranges from 300 to 500 rubles.

You can also make the dice yourself using a dice mold, epoxy resin, glitter, and dyes. The cost of the materials will be approximately 1300 rubles.

In the most expensive game, a variety of dice types are available: metal dice, epoxy resin dice with a “living” eye, and others. The average cost of a set of dice ranges from 1500 to 3000 rubles.

The most expensive dice available at the moment are made from real old human bones and are sold as a unique item. They come in a limited-edition box labeled “Memento Mori”. Currently, a single die costs around $293 (more than 28 500 rubles), while a complete set will set the buyer back $2,691 (over 264 000 rubles) (Figure 2).

For more information about these dice, see the article by Paul A. [2], and in the posted post “Memento mori” [3].


Figure 2. The most expensive cube in the world

**The master’s screen**

The master hides important game notes behind a screen that players should not see. Additionally, this is done so that players cannot see the master’s dice rolls.

For a simplified version of the game, you can create your own master’s screen using a large cardboard sheet and attach notes with adhesive tape.

For the medium category of the game, you can choose either a ready-made master’s screen or a custom option. The price of such screens ranges from 1400 to 2000 rubles.

For the most complex version, you can either create a detailed screen resembling intricate architecture yourself or purchase a special plywood constructor from UGEARS CLUB for 3990 rubles, or buy a beautiful wooden screen with various elements. The average price for wooden screens is between 5000 and 15000 rubles (Figure 3).

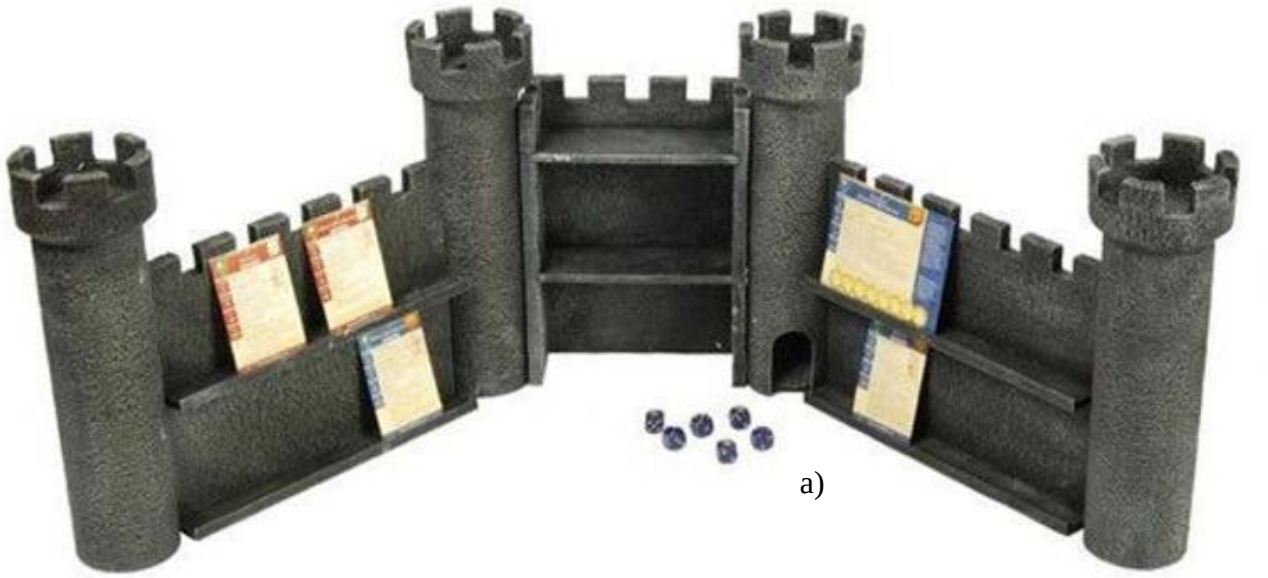



Figure 3. a) Homemade screen, b) Constructor screen, c) Purchased wooden screen

**Miniatures**

Player and opponent miniatures are necessary for determining their placement on the map.

In the first easy game, miniatures can be replaced with coins, buttons, or dice of different colors that are not currently used in the game.

In the second round, various tokens can be used. A character drawn or printed on a sheet of paper is attached to a disk made of cardboard (Figure 4, a).

In the third, more expensive game, you can purchase various figures printed with a 3D printer. The average cost of a single figure ranges from 350 to 600 rubles. Sets that include 7-8 standard-sized figures cost around 8000 rubles, and if the set includes large figures, their cost can reach 12,000-14,000 rubles (Figure 4, b).

The article «Необходимый минимум для НРИ (на примере DnD 5 редакции)» provides further insights into the minimum preparations for the party [4].

Figure 4. a) Character token, b) Set of miniatures

**Maps**

Maps play a crucial role in the gameplay, allowing real-time tracking of players' movements, actions, and strategies.

In the first simple game, we will need a laminated sheet of A4 or A3 size with a grid layout measuring 2.5x2.5 cm. To create various game scenarios on the map, we will use a marker designed for whiteboards. The cost of laminating a single sheet range from 60 to 100 rubles (Figure 5, a).

In the medium game, we can add various elements that are placed on top of the map, such as chariots, trees, castles, corpses, etc. These elements can be considered a type of environmental markers (Figure 5, b).

In the complex gameplay, there is a transition from a two-dimensional map to a three-dimensional terrain map. Creating terrain by oneself is a challenging process, so it is made modularly. A section of the map measuring 2×2 or 4×4 squares is taken and filled with various objects and structures, such as houses, architecture, and planted trees. All elements are then assembled to form a larger map. Various materials are used in the creation of the terrain, such as wood, polymer clay, plastic, and plaster, as well as additional tools to create different textures and finishes.

The average price of such maps can be high, reaching up to 20,000 rubles, although calculating the cost of terrains can be complex (Figure 5, c).

For more information, you can read about creating landscapes for your parties in the article «Делаем террейн для лесных путешествий» [5]. and in the article by Jones S. "Creating a Hirst D&D Landscape: An Introduction to a wonderful hobby of needlework" [6].

Figure 5. Types of maps: a) Simple field, b) Tokens for the map, c) Terrain

Table  summarizes the prices required for conducting each type of game.

Table – Final cost of each game type

| № | Attributes | Types of Games | | |
|---|---|---|---|---|
| | | Simple | Medium | Complex |
| 1 | Dice | 0₽ | 300-500₽ (1300₽) | 264 319,71₽ |
| 2 | Screen | 0₽ | 1400-2000₽ | 3990-15000₽ |
| 3 | Miniatures | 0₽ | 150-300₽ | 12999₽ |
| 4 | Maps | 60-100₽ | ±500₽ | ≈20000₽ |
| | Total | ≈100₽ | ≈4100₽ | ≈312318,71₽ |

Conclusion

Therefore, play continues to be a significant element of human activity, evolving and incorporating more and more new materials.

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# LEXICAL AND PHRASEOLOGICAL STYLISTIC DEVICES IN DONNA TARTT'S NOVEL "THE SECRET HISTORY"

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**Abstract.** The article examines lexical stylistic devices and expressive means used in the novel "The Secret History", written by the modern American writer Donna Tartt. In scientific society, it is considered that the novel made a great impact on modern culture. The study analyzes the original English text of the novel to find cases of use of lexical and phraseological stylistic means. The main lexical stylistic features of the author's style are analyzed according to I. R. Galperin's classification.

**Keywords:** "Dark Academia", lexical stylistic devices, means of expression, novel, neo-romanticism.

# ЛЕКСИКО-ФРАЗЕОЛОГИЧЕСКИЕ СТИЛИСТИЧЕСКИЕ СРЕДСТВА В РОМАНЕ ДОННЫ ТАРТТ «ТАЙНАЯ ИСТОРИЯ»

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**Аннотация.** В статье рассмотрены лексико-стилистические приемы и средства выразительности, используемые в романе «Тайная история» современной американской писательницы Донны Тартт. Существенным является мнение научного сообщества о том, что роман оказал большое влияние на современную культуру. В ходе исследования был проанализирован оригинальный текст романа на английском языке на предмет использования лексических фразеологических стилистических средств. Были изучены основные лексико-стилистические особенности писательского стиля по классификации И. Р. Гальперина.

**Ключевые слова:** "Dark Academia", лексические средства выразительности, стилистические средства выразительности, роман, неоромантизм.

The study of stylistic means of expression in literature has always been important for understanding the peculiarities of the author's style and the deep meaning of the text. The analysis of the modern authors' novels, which actively influence the literary and cultural trends of the XXI century, becomes especially relevant. In this context, the novel "The Secret History" by American writer Donna Tartt becomes a topical object for scientific research.

Donna Tartt is one of the most outstanding postmodernist writers of the XXI century. In recent decades, the interest in her novels has significantly increased. In 2014, Tartt was awarded the Pulitzer Prize for Fiction. The writer is a modern representative of the neo-romanticism trend in fiction. Her debut novel "The Secret History", published in 1992, made a significant impact on the development of the campus novel genre and became widespread in the modern Internet community, contributing to the development of the "Dark Academia" subculture [1, p. 47]. This internet culture and aesthetic occurred during the pandemic in 2020 as a result of the shutdown of universities and schools. The "Dark Academia" embodies a duality that is both alluring and profound. On the one hand, researchers assert that this aesthetic celebrates a deep, almost reverent interest in learning and literature. It romanticizes the pursuit of knowledge, classical education, academic life and intellectual endeavors, often drawing inspiration from the grandeur of ancient universities, venerable libraries and the timeless allure of classical art and literature. This aesthetic idealizes the solitary, almost monastic dedication to study and reflection, encouraging individuals to seek wisdom and sight through the lens of ancient texts and philosophical inquiry [2, p. 4]. On the other hand, a stark exploration of the darker aspects of morality and human existence are intertwined. "Dark Academia" delves into themes of existential angst and the moral complexities that come with the pursuit of knowledge. In Donna Tartt's novel great attention is given to the moral issues and social problems of college-age youth. In "The Secret History" the characters are immersed in melancholy and disillusioned with life. Unable to find an outlet for their talents, they commit terrible deeds. The author's writing style is distinguished by a variety of literary speech, dynamic narration, and subtle allusions [3]. The aim of the work is to analyze the main lexical and phraseological stylistic features in Donna Tartt's novel "The Secret History".

Gothic architecture, somber natural settings, vintage clothing style, antiquarian books, classical music and a dark color palette, are elements of "Dark Academia" aesthetic. These components enhance the atmosphere of mystery and historical profundity, evoke a sense of nostalgia and timelessness, thereby enriching the dramatic and melancholic tone intrinsic to this aesthetic. Besides the visual elements, the "Dark Academia" aesthetic emphasizes a lifestyle that celebrates literature, classical education, intellectual pursuits, and a romanticized view of academic life. It includes a deep appreciation for ancient Greek culture and art and romanticizes the solitary. It also reveals the dark aspects of morality and human life.

Stylistic devices are an essential part of any fiction novel. They contribute to the realization of the aesthetic functions of language and convey the author's worldview. Their use creates a unique context of the work, and gives written speech saturation and brightness, facilitating the accurate transmission of the author's

thoughts. Stylistic means and techniques are studied within stylistics – a science that is actively developing as an independent branch of linguistics, and studies the aesthetic functions of language, its expressive means, synonymous ways of expressing thought, emotional coloring of speech, stylistic techniques, speech styles, individual artistic style of the writer [4, p. 3]. Nowadays, there are many different classifications of stylistic means. A significant contribution to this field was made by the Soviet linguist and Doctor of Philological Sciences I. R. Galperin, who developed his own classification of stylistic means of expression. The classification proposed by him is actively used by the scientific community for the analysis of literary texts. For current research, it was decided to consider lexical and phraseological stylistic means since their active use is typical for such genre as novel. I. R. Galperin defines lexical and phraseological stylistic means of modern English as "a variety of expressive means of language and stylistic techniques based on the use of semantic, stylistic and other features of a single word or phraseological unit" [4, p. 123].

The carried-out analysis of the original text of the novel revealed 110 cases of the use of lexical and phraseological stylistic means. According to the classification of I. R. Galperin, stylistic means were selected and divided into the groups proposed by him. Group A "Stylistic use of various types of lexical meanings" includes stylistic techniques based on the interplay of dictionary and contextual subject-logical meanings, stylistic techniques based on the interaction of subject-logical and emotional meanings, stylistic techniques based on the interaction of basic and derivative (including non-free) subject-logical meanings. Group B is a stylistic technique for describing phenomena and objects. Group C is a stylistic use of phraseology [4, pp. 123-177]. This paper presents the most illustrative examples for each group of stylistic means [5, pp. 1-26].

According to Group A, the following lexical and phraseological means were found and described:

1. *Metaphors* were often used to draw unusual parallels in images of:

a) surroundings and Hampden College.

For example, "imprisonment within the dreary round of school and home" [5, p. 6], "stunned and drunk with beauty" [5, p. 12], "endless dreary battle of paperwork" [5, p. 11].

b) book characters.

For example, "in a swish of black cashmere and cigarette smoke" [5, p. 22].

2. *Metonymy* was used to make images concrete and simple:

a) people, unknown to the main character.

For example, "... the cameras, the uniforms, the black crowds sprinkled over Mount Cataract..." [5, pp. 1-2], "ponytails flying" (about cheerleaders) [5, p. 12].

b) emphasizing the age of the main character using *synecdoche* as a type of metonymy.

For example, "I had never seen New England or Hampden College until I was nineteen..." [5, p. 5].

3. *Epithets* were used to show certain characteristics of the objects and characters:

For example, “quiet tears” [5, p. 1], “the fatal flaw” [5, p. 5], “showy dark crack” [5, p. 5], “fictive childhood” [5, p. 5], “ugly house” [5, p. 6], “a thin-blooded, capricious girl” [5, p. 6], “doomed and Pyrrhic gesture” [5, p. 8], “bohemian, vaguely Marxist dissatisfaction” [5, p. 9], “the sweet dark rhymes” [5, p. 10], “angular and elegant, he was extremely thin, with nervous hands and a shrewd albino face...” [5, p. 18].

4. *Zeugma* to create thoughtful and emotional effect:

For example, “I walked down the hall with spirits soaring, and two hundred dollars in my pocket.” [5, p. 26], “capricious girl with red hair and a rich daddy” [5, p. 6].

Group B included such lexical devices as:

1. *Similes* to create comparisons based on thought-provoking and aesthetic images.

For example, “like ants in a sugar bowl” [5, pp. 1-2] , “like a family on vacation” [5, p. 2], “talking like children” [5, p. 2], “past disposable as a plastic cup” [5, p. 5], “I would walk like a zombie” [5, p. 9], “soprano spiraled on and on in the darkness like some angel of death” [5, p. 13], “amiable as a sparrow” [5, p. 15], “look like a cross between a student prince and Jack the Ripper” [5, p. 13], “as a couple of Flemish angels” [5, p. 18].

Some of the lexical and phraseological means were included in group C. For instance, “A moi. L’histoire d’une de mes folies.” [5, p. 5] is *citation*. The words belong to the French poet Arthur Rimbaud. By this quotation, the main character Richard points out that the story he is about to tell is insane. Richard also uses the phrase “doctors made a lot of money quod erat demonstrandum” [5, p. 7]. It is a Latin set expression for “which was to be demonstrated”. An example of *allusion* and *irony* was also found. The main character reflects on the ideas of “Paradise Lost” written by the English poet John Milton. He agrees that the poet was right when he claimed that the spirit can create a paradise in its space from hell. But Richard further concludes that this statement does not apply to the creation of Plano, the city in which he was born and raised. He believes that the founders of Plano were not influenced by the idea of paradise, but something much more gloomy and mournful [5, p. 8].

The numerical distribution of the selected and analyzed stylistic devices is represented as a pie chart (Figure). Epithets dominate with a frequency of 53 %. It indicates that the text is highly descriptive. Metaphors follow as the second most frequently used device, accounting for 21 % of the lexical devices. Metaphors create direct and unique parallels between things that are normally unrelated. The third most used lexical device is simile, which represents 17 % of the stylistic means. This suggests that the text often explicitly compares different elements or concepts. Zeugma and metonymy each represent 2 % of the lexical devices, indicating a moderate use of these figures of speech. Zeugma is a figure of speech in which a single word is applied to two or more other words in different senses, while metonymy refers to a thing or a person by the name of something closely associated or connected with it. The remaining devices are quotes, set expressions, allusions, synecdoche and irony, each accounting for 1 % of the lexical devices.

To sum up, the pie chart is characterized by a high frequency of epithets, metaphors and similes with the other lexical devices being used much less.

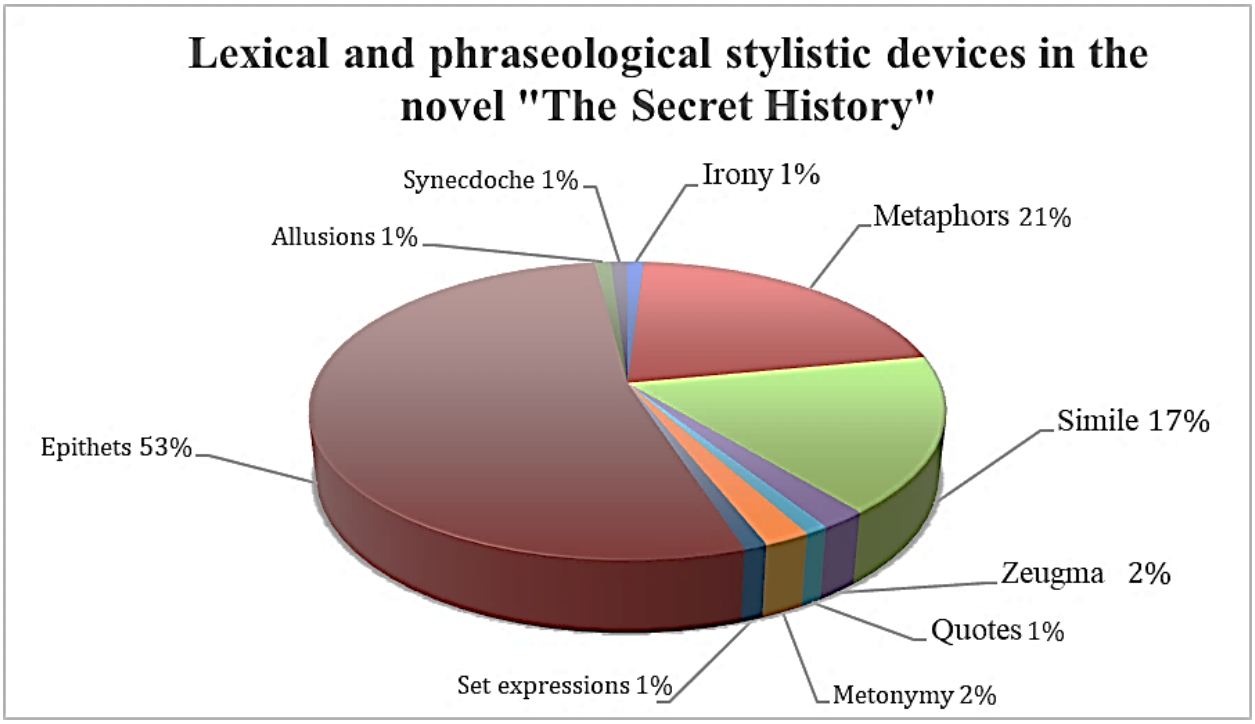


Figure. Lexical and phraseological stylistic devices in Donna Tartt's novel "The Secret History"

The analysis of the main lexical and phraseological stylistic means of expression showed that by them, Donna Tartt creates a unique atmosphere of the gloomy gothic university of New England – a historical area in the northeastern United States. According to the stylistic analysis, it can be concluded that the campus novel is characterized by a detailed description of student life. The detective atmosphere of the novel is saturated with high style that speaks eloquently about the fatalism and seriousness of the consequences that the actions of the characters of the novel have brought.

"The Secret History" has had a significant impact on modern culture among young people and has become an integral part of the subculture "Dark Academia", inspiring young people to intellectual searches. "Dark Academia" is a rich, multifaceted aesthetic that bridges the noble aspirations of learning with a candid acknowledgment of the darker facets of the human condition. The study of lexical and phraseological stylistic means of expression showed the variety and richness of images that develop the imagination. The multilayered plot, the complex system of references and arguments about moral issues in the novel force the reader to analyze it both thoughtfully and critically. This synthesis of modern literature and the culture "Dark Academia" continues to develop, filling the lives of young people with new ideas, meaning and inspiration.

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# FRIENDSHIP IN BURYAT AND RUSSIAN PROVERBS

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**Abstract.** The article analyzes the representation of friendship in Buryat and Russian paremiological worldview. The article aims at revealing the main features, images and evaluations realized in the verbalization of the concepts ХАНИ БАРИСААН and ДРУЖБА (FRIENDSHIP) in paroemias of the corresponding languages.

**Keywords:** friend, friendship, concept, paroemia, proverb, the Buryat language, the Russian language.

# ДРУЖБА В БУРЯТСКИХ И РУССКИХ ПОСЛОВИЦАХ

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**Аннотация.** В статье анализируется репрезентация дружбы в бурятской и русской паремиологической картине мира. Целью статьи является выделение основных характеристик, образов и ценностных установок, вербализующих концепты ХАНИ БАРИСААН и ДРУЖБА в пословицах соответствующих языков.

**Ключевые слова:** друг, дружба, концепт, концептуальные признаки, паремия, пословица, бурятский язык, русский язык.

The issue of studying the conceptual organization of friendship has been widely covered by many scholars on the basis of various languages [1-4], however, the study of conceptualization of friendship in the Buryat language has not been attempted so far.

A concept is a multidimensional mental formation carrying complex information about the reflected subject or phenomenon and possessing a certain structure. In this paper, we rely on the interpretation of the concept structure by V. I. Karasik and S. G. Slyshkin [5], who distinguish value, image and conceptual components of the concept.

Proverbs are an important source for the study of concepts, as they accumulate and preserve for a long time ideas about the world, ethical norms, information about

traditions, customs and the way of life of people, the experience of relationships. The cognitive features of the concept ХАНИ БАРИСААН and ДРУЖБА (FRIENDSHIP) were identified through an analysis of Buryat and Russian proverbs, taken from the dictionaries of Buryat and Russian proverbs [6-9] and containing such lexemes as Bur. *хани* (friend, buddy), *ханилалга* (friendship), *нүхэр, тала* (friend), *нүхэрлэхэ* (to be friends), *нүхэрлэлгэ* (friendship), Rus. друг (friend), дружба (friendship), *дружить* (to be friends). The proverbs that have the given lexemes in dictionary entries also were included in the study.

As a result of the analysis, the following groups of features of concepts under study were formulated: 1. Qualities of a friend. 2. Making friends. 3. Preservation of friendship. 4. The value of friendship.

The study revealed that the paremiological funds of both languages contain a common layer proverbs, whose semantic structure fully or partially coincide.

1. **Qualities of a friend.**

The necessary qualities of a friend, according to Buryat and Russian paremias, include loyalty and reliability. For example, a friend is compared to a stone wall:

Bur. ***Найн нүхэр шулуун хэрэмһээ бүхэ, һайн морин харсага шубуунһаа түргэн*** *(A good friend is stronger than a stone wall, and a good horse is faster than a falcon);* Rus. ***Любовь братская лучше каменных стен*** *(Brotherly love is better than stonewalls)*

The Russian proverb explains that brotherly love, something that binds people who are not necessarily related but have strong emotional and spiritual ties, is stronger, more reliable and more valuable than love based on material things, walls and possessions.

The duration of friendship is also very important: as in many other cultures, both Buryat and Russian people value an ‘old’ friend much more than a new one, for example:

Bur. ***Хуушан нүхэр хоёр шэнэһээ дээрэ*** *(An old friend is better than two new ones),* ***Инаг нүхэр хуушандаа дээрэ, эд бараан шэнэдээ дээрэ*** *(Friends are better when old, things are better when they are new)*; Rus. ***Старый друг лучше новых двух*** *(An old friend is better than two new ones),* ***Одежда лучше новая, а друг – старый*** *(New clothes are better than old ones, and an old friend is better than a new one).*

2. **Making friends.**

The search for a true friend can take quite a long time, as friendship between people is established through communication and joint activities, for example:

Bur. ***Нүхэрэй һайниие ханилан танидаг, мориной һайниие аялан мэдэдэг*** *(A friend is recognized by making friends with him, a horse is recognized by riding it)*; Rus.

Some proverbs also reflect the requirements for a person who wants to get a friend. A wicked and greedy person will find it difficult to make friends:

Bur. ***Хашан мориндо газар холо, харуу хүндэ нүхэр холо (****A long way for a lazy horse, and friends are far away for a miser).* Rus. ***Кто скуп да жаден, тот в дружбе неладен*** *(He who is stingy and greedy can’t be a good friend).*

It is also necessary to choose a friend thoroughly and not to make friends with those who can have a bad influence on you:

Bur. ***Абари мууга ноёнтой нэгэдэнхаар, ангууша нохойтой нүхэрлэһэн дээрэ*** *(It is better to be friends with a hunting dog than to get in touch with a malicious yonoi).* Rus. ***С кем поведёшься, от того и наберешься*** *(You'll learn from whoever you make friends with).*

3. **Preservation of friendship.**

The content of this component is prescriptive in nature, indicating what actions should be avoided in order not to spoil one's friendship. According to O. A. Arapova [1], it is the prescriptive function that is the leading one for the ethical concept of friendship in Russian linguistic culture. We believe that this statement is also true for the concept ХАНИ БАРИСААН. Partly the content of this component is determined by the features mentioned above: if you want to keep friendship, be kind and generous:

Bur. ***Khonyoor xүndelүүlbel, үherer xүndel*** (*If you are met by slaughtering a ram, you meet them by slaughtering a bull).* Rus. ***Для доброго друга не жаль ни хлеба, ни досуга*** *(For a good friend, neither bread nor leisure is spared).*

Expressing the vast experience of mankind purified by centuries, proverbs about friendship carry tips on how to recognize a true friend, state the need for loyalty and warnings about the bitter consequences of betrayal:

Bur. ***Найнда һайбар жороо, мууда модон мунса*** *(When everything is good, he fawns on you, when it is bad, he sticks you with a baton).* Rus. ***Дружба крепка не лестью, а правдой и честью*** *(Friendship is not made by flattery, but by truth and honour).*

4. The **value of a friend** in a person's life is conditioned, first of all, by its necessity, i.e. by the fact that a person is not able to be alone and needs a friend:

Bur. ***Үрэ морин эжэлээ олохо, эрэ хүн нүхэрθθ олохо*** *(A three-year-old horse will find a comrade in the herd, and a good young man will find a friend).* Rus. ***Добрый конь не без седока, а честный человек не без друга*** *(A good horse is not without a rider, and an honest man is not without a friend).*

The preference of friendship to material values is reflected in the proverbs of many cultures, including the Buryat and the Russian ones. The more friends a person has, the richer and happier he is:

Bur. ***Зуун үхэртэй байнхаар, зуун нүхэртэй*** *(It is better to have a hundred cows than to have a hundred friends).* Rus. ***Не имей сто рублей, а имей сто друзей*** *(It's better to have a hundred friends than a hundred roubles).*

The lack of friends, in turn, is considered a disadvantage and shows a person's inferiority, for example:

Bur. ***Танилтай хүн талын шэнээн, танилгүй хүн адхын шэнээн*** *(He who has friends is like a steppe, he who has no friends is like a handful).*Rus. ***Человек без друзей, что птица без крыльев*** *(A man without friends is like a bird without wings).*

The following section will examine the figurative aspect of the concepts ХАНИ БАРИСААН and ДРУЖБА within the paremiological part of the Buryat and Russian worldview. As evidenced by the analysis of the studied material, metaphors

and comparisons pertaining to the images of animate and inanimate nature and, to a lesser extent, artefacts (products of human activity) are employed to describe a friend and relations between friends (see Table).

Table – Source domains for metaphors and comparisons in Buryat and Russian paroemias about friends and friendship

| Source domain | Buryat | Russian |
|---|---|---|
| Nature | **tree**, **horse**, dog, sable, otter, steppe | bird, **horse**, mushroom, bee, beetle, **tree** |
| Artefact | **wall**, scissors, awl, flour, **cloth**, laptis, sheepskin | treasure, glass, **wall**, clothes, pot, cast iron, pies, plough, **cloth** |

As it can be seen from the table, the figurative component of the examined concepts is more reflective of the specifics of the way of life of the Russians and the Buryats, their living environment and world outlook than the other components.

To sum up, the conceptual and value aspects of the concepts ХАНИ БАРИСААН and ДРУЖБА in the paremiological fragment of the Buryat and Russian worldview represent a set of ideas about friendship and friendship-related matters. These ideas are expressed through the nomination of characteristics associated with friends and recommendations for maintaining friendship. Both in Buryat and Russian proverbs, a friend is primarily conceptualized as an individual who is similar, equal and close. In order to establish and sustain a friendship, it is essential to embody positive personal qualities such as benevolence, compassion, and generosity. Friendship represents a highly valued aspect of human life, and an individual's social network can serve as a barometer for assessing their personal attributes. The figurative dimension of the concept of friendship is exemplified in Buryat and Russian proverbs through a diverse array of linguistic devices, predominantly metaphors and comparisons drawn from the domains of animate and inanimate nature.

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# IMPACT OF AUTOMATION ON INDUSTRIAL LABOR PRODUCTIVITY

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**Abstract.** Automation of production processes has become a key factor contributing to the increase of labour productivity in industry. This article considers the main aspects of the impact of automation on the efficiency of enterprises, and analyses the advantages and disadvantages of implementing automated systems. The main attention is paid to changes in labour organisation, economic indicators and social consequences.

**Keywords:** automation, productivity, competitiveness, robotization, resource management, artificial intelligence.

# ВЛИЯНИЕ АВТОМАТИЗАЦИИ НА ПРОИЗВОДИТЕЛЬНОСТЬ ТРУДА В ПРОМЫШЛЕННОСТИ

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**Аннотация.** Автоматизация производственных процессов стала ключевым фактором, способствующим увеличению производительности труда в промышленности. В данной статье рассматриваются основные аспекты влияния автоматизации на эффективность работы предприятий, а также анализируются преимущества и недостатки внедрения автоматизированных систем. Основное внимание уделяется изменениям в организации труда, экономическим показателям и социальным последствиям.

**Ключевые слова:** автоматизация, производительность, конкурентоспособность, роботизация, управление ресурсами, искусственный интеллект.

Automation of production processes involves the use of technology to perform tasks that were previously performed by humans. In today's increasingly competitive economy, businesses are striving to increase their productivity and reduce costs, which leads to the active implementation of automated systems that can significantly change production processes.

Automation has a significant impact on labor productivity, which is one of the key factors for companies to be competitive in the current environment. Automated systems, such as robotic lines and computer numerical control (CNC) machines, are capable of performing tasks at high speed. For example, in the automotive industry, which was one of the pioneers in the introduction of automated lines, robotic systems are actively used in all stages of production from assembly to painting. Automation in the automotive industry has been an important driver of progress and innovation in the industry since the introduction of assembly line production of the Ford Model T. In today's automotive industry, automation encompasses everything from design and development of new models through computer modeling to final assembly and quality control. Robots and automated systems precisely stamp and weld body parts to ensure structural strength, while automated paint lines ensure a perfect finish. Components such as engines and interiors are assembled with high precision, reducing errors and improving the quality of the finished vehicles. Machine vision systems monitor every part for compliance with standards. Logistics and inventory management automation speeds up the movement of parts and finished vehicles, optimizing the entire production process [1].

In electronics and semiconductor manufacturing, where high precision is required, automation is essential to maintain innovation and competitiveness. The pharmaceutical industry relies on automated systems to meet stringent quality standards and accelerate the development of new drugs. In the food industry, automation helps ensure food safety and efficiency in packaging and transportation. The oil and gas sector uses automation to improve the safety and efficiency of extraction and refining processes. The chemical industry depends on automation to control complex processes and ensure safety. Metallurgy utilizes automated systems to control smelting and metalworking processes. The heavy machinery and aerospace industries need automation to ensure the accuracy and quality of their products. These examples show that automation is widely used in various sectors and is a key factor in supporting their growth, development and reducing potential errors.

Human error is often a source of error in the production process. Automation reduces these risks as machines and robots perform tasks with high precision. In electronics manufacturing, for example, automated systems can solder and assemble components with micron precision. This results in lower defect rates and returns, which in turn reduces the cost of error correction and improves overall plant efficiency [2].

Automation also allows for standardization of manufacturing processes, which also helps to reduce error (Figure 1). Each step of the process is executed according to predetermined parameters and algorithms, eliminating the variability inherent in

manual labor. This is critical in industries such as pharmaceuticals, where quality and safety standards must be strictly adhered to. Modern automated systems are equipped with sensors and monitoring tools that track process parameters in real time, allowing for immediate detection of deviations and prevention of errors. For example, if the temperature or pressure during the production process exceeds acceptable limits, the system can automatically stop the process or adjust the parameters, preventing rejects [3].

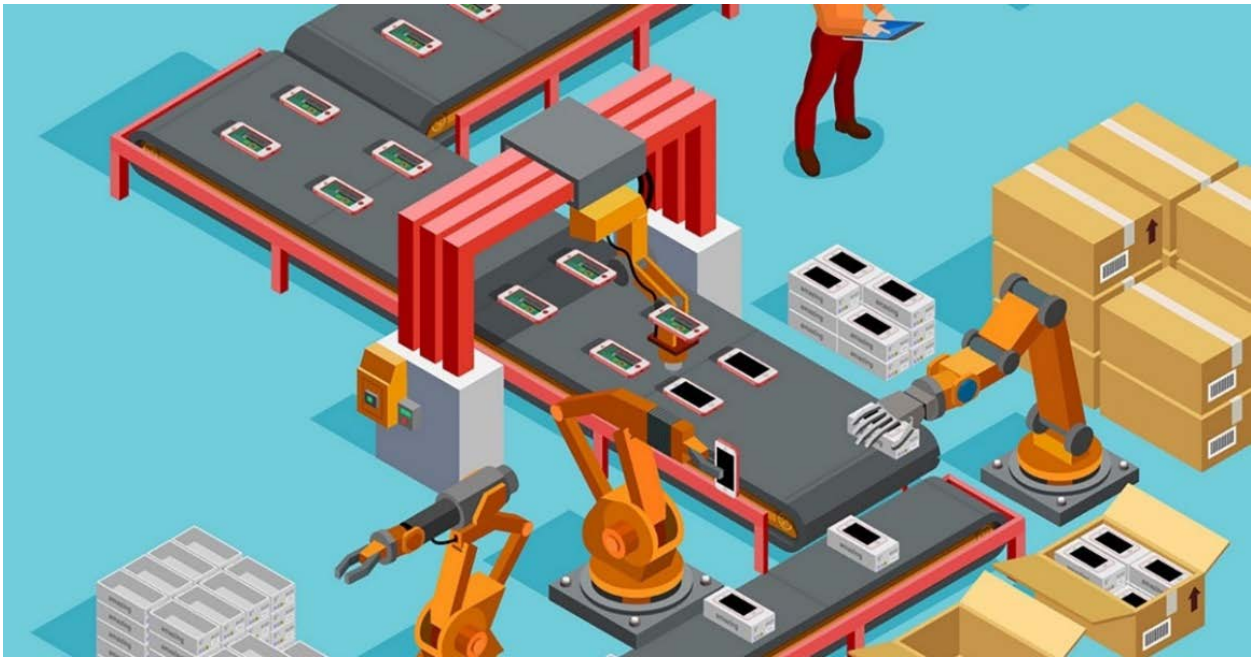

Figure 1. Industrial automation

Improving product quality is also an important aspect of automation. Automated systems provide a high degree of precision and repeatability in operations, which means that each unit of production will be produced with the same characteristics, significantly improving quality. In automotive manufacturing, automated systems can accurately control clearances between components, which affects the overall reliability and safety of the vehicle. Automating quality control processes can greatly improve its efficiency, as modern systems can use machine vision and other technologies to automatically detect defects during the production phase, allowing for early detection of defects and minimizing the amount of substandard products reaching the market.

Reducing variability in production processes is an equally important factor in achieving high quality. In food manufacturing, automated lines can accurately dose ingredients to ensure uniformity of the final product and adherence to standards. In addition, automated systems can collect data on production processes and product quality, allowing for analysis and identifying areas for improvement. For example, if the system detects that a certain stage of production often results in scrap, this can be the basis for optimizing that process and making it more efficient [4].

Automation of production is one of the main ways of increasing its efficiency. And in this sense, both automation of production processes (automated lines, equipment, etc.) and automation of management business processes, expansion of tools for rational organization of production are equally important.

Automation of technological processes at enterprises is given priority attention, but if it is not supported by automation of control over how the process is organized, how all resources are used, then no production efficiency can be ensured or analyzed.

Automation also facilitates more efficient management of resources such as raw materials, energy and labor. Production management systems can analyze data in real time, identifying bottlenecks and inefficient processes. This can optimize production flow, reduce equipment downtime, and use resources efficiently. For example, AI-based systems can predict material needs and automatically order materials, which reduces inventory and associated costs [5].

Thus, automation of manufacturing processes significantly reduces errors and improves product quality due to the high accuracy of operations, standardization of processes, use of advanced quality control technologies, and the ability to analyze data. As a result, companies can not only improve their products but also increase customer satisfaction, which is an important factor for successful business in a competitive market.

With the introduction of automation, routine and repetitive tasks such as assembly, packaging or quality control can be handed over to machines. This allows employees to focus on more complex and creative tasks such as design, new product development or process management. In this way, employee skills are enhanced and team morale improves, as workers feel more involved in the process and have the opportunity to develop their skills.

Automation also helps to reduce production costs by reducing labor and optimizing resources such as raw materials and energy, which lowers costs. Using standardized automated processes requires less training for employees as they can focus on more complex tasks. Moreover, automation allows manufacturing to be more flexible and adaptive. Modern automated systems can be easily reconfigured to produce different products, allowing them to respond quickly to changes in demand, as well as integrate new technologies such as artificial intelligence and machine learning to optimize production processes [6].

From an economic perspective, automation can reduce operating costs and increase profitability for businesses. Investments in automated systems can be significant, but they pay for themselves quickly through increased efficiency and lower labor costs.

By reducing downtime, energy savings can be realized. The time when equipment is switched on and no output is produced costs the company a lot of money.

Increasing the efficiency of production lines is also an indirect reduction in the energy consumption of the line, since energy costs are worth considering in terms of their ability to create products and bring profit.

Thus, the electronic system of automation of accounting and control will save the enterprise a significant part of resources and will allow avoiding undesirable losses.

However, implementing automation in enterprises has a number of risks and challenges that can have a significant impact on the success and long-term sustainability of automation projects.

The first and perhaps most obvious risk is the significant capital investment required to implement automated systems. This investment includes not only the equipment itself, but also the costs of integration, customization, and training. If the investment does not pay off in increased productivity and reduced costs, the company may face financial difficulties. Technology risks are also significant. Automated systems can be prone to failures and technical malfunctions, which can lead to unplanned downtime and lost productivity. Integrating new systems with existing technology can be complex, and any errors in the process can lead to additional costs and delays. Another important aspect is change management. Employees may resist implementing automation for fear of losing their jobs or because of the need to adapt to new workflows. This can lead to a decline in morale and productivity if training and support for staff is not adequately addressed.

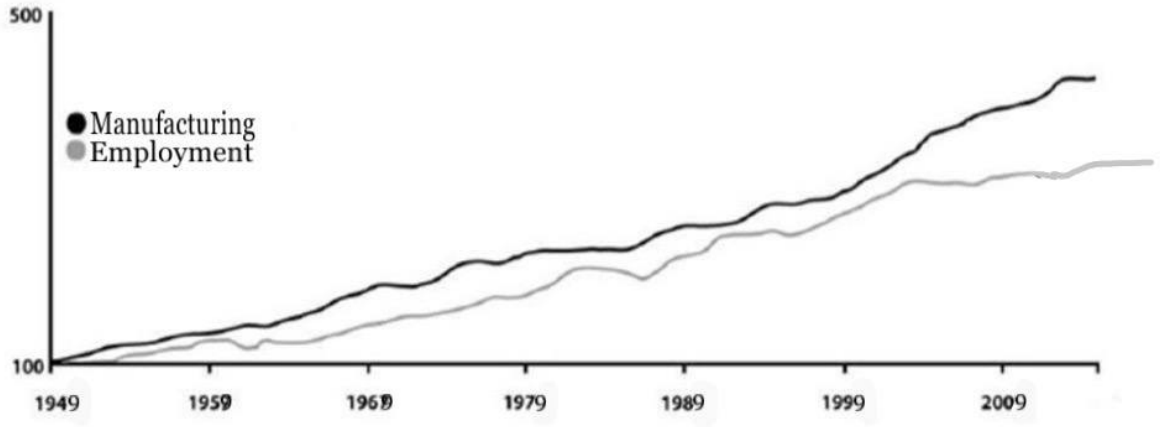


Figure 2. Dynamics of productivity and employment

Figure 2 shows two graphs – growth rates of labor productivity and employment in Russia. It can be noted that after the end of the Second World War there was active job creation and at the same time industrial development. But since about 2009, productivity growth rates have been significantly outpacing employment growth rates. It is quite possible that the emergence of new technologies and automation is to blame. This is why the shift to automated manufacturing can cause fear of job loss among employees

Finally, there is the risk of technology obsolescence. In a world where technological advances are happening at breakneck speed, today's advanced automated systems can quickly become obsolete, requiring additional investment in modernization and upgrades.

Successful automation implementation requires careful planning, consideration of all potential risks and the development of strategies to minimize them, and training and education of staff to ensure smooth integration of new systems into the production process.

Automation of production processes is an important tool for increasing productivity in industry. It brings significant benefits such as increased production, reduced costs and improved product quality. However, the adoption of automation also comes with challenges, including social impacts and the need for investment. It is important that enterprises approach the process in a balanced way, taking into account both economic and social aspects.

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# ROBOTIC SYSTEMS IN THE AUTOMATION OF PRODUCTION PROCESS

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**Abstract.** The article about robotic systems in the automation of production processes examines the advantages of the introduction of robotic systems, their areas of application, technologies that support robotics, problems and challenges of these systems, as well as the future of robotics in the process.

**Keywords:** robotic systems, automation, production processes, efficiency, productivity, technologies, robots.

# РОБОТИЗИРОВАННЫЕ СИСТЕМЫ В АВТОМАТИЗАЦИИ ПРОИЗВОДСТВЕННЫХ ПРОЦЕССОВ

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**Аннотация.** В статье о роботизированных системах в автоматизации производственных процессов рассматриваются преимущества внедрения роботизированных систем, области их применения, технологии, поддерживающие робототехнику, проблемы и задачи, стоящие перед этими системами, а также будущее робототехники в технологическом процессе.

**Ключевые слова:** роботизированные системы, автоматизация, производственные процессы, эффективность, производительность, технологии, роботы.

Robotic systems are a set of hardware and software necessary to automate various procedures using robots. Their main role is to perform repetitive or complicated tasks that can be difficult, dangerous, or require extremely high accuracy.

There are five types of robotic systems in total: industrial, medical, household, military and research ones.

Industrial robotic systems are automated gadgets that are necessary to overcome any difficulties in production and enterprises. They also perform a major function in our production process, and all this is due to the fact that industrial robotic systems are famous for their enormous efficiency, extreme accuracy and reliability. Here are the main characteristics and aspects of industrial robots.

Medical robotic systems are automated devices that are needed for testing, treatment and surgical interventions. They play a major role in current medicine, improving the accuracy of procedures and improving the quality of patient care.

Household robotic systems are devices that are necessary to automate everyday tasks in homes and apartments. They help to improve the quality of life, reduce the effort and time spent, ensuring the highest level of comfort and convenience.

Military robotic systems are multifunctional technical devices that are involved in combat operations. These include aerial (drone robots) in order to launch air artillery strikes, surveillance, reconnaissance and other things, ground (sapper robots, self-propelled tanks and armored personnel carriers), marine (surface and underwater vehicles for searching for mines, patrolling, escorting and others).

Research robotic systems are special devices that are necessary for conducting scientific research, experiments and data collection in various places of science and technology. They are developed in order to study the environment, perform difficult tasks and gain knowledge. Here is a more detailed review of their characteristics and applications [1].

Let us consider the following advantages in the implementation of robotic systems.

The first and main advantage of using robotic systems is their ability to increase productivity and efficiency of processes. Robots can work 24/7 without interruption on vacation, thereby giving the opportunity to improve the quality. For example, in the industrial field, industrial robots can collect details and perform difficult tasks with minimal time. This leads to a reduction in the time of the production period and allows enterprises to increase the size of their products. As a result, businesses can more quickly observe shifts in demand and offer new products to customers.

Reducing effort costs is another important advantage of implementing robotic systems. Although the first financial investments in robotics can be considerable, in the fundamental perspective they lead to significant savings. Robots are capable of performing operations that once needed a significant number of people, which allows companies to improve their staff costs. In conditions of radical confrontation, when companies seek to reduce costs and improve their productivity, this becomes the most relevant. By reducing the cost of effort, companies can allocate funds to other important business areas such as research and development or marketing.

The flexibility and adaptability of the latest robotic systems are also important advantages. They can simply be reconfigured to perform all kinds of operations without significant expenditure of time and money on rescheduling production equipment. This allows companies to respond quickly to changes in demand and

introduce new products without significant losses. In an unstable market, such flexibility becomes an important oppositional advantage. In addition, the proliferation of robotic systems is conducive to the improvement of modern technologies and new earning schemes. Robots can be used to perform research and development, test new products and processes, as well as to collect performance data. This creates opportunities for continuous improvement and optimization of earnings schemes, which is the main aspect of success in current conditions. Innovation becomes the foundation for the future growth of the company, and robotics opens a new path for development [2].

Let us consider problems and challenges of implementing robotic systems.

One of the main problems of implementing robotic systems is the high cost of initial investments. The purchase, installation and repair of robotic systems require significant monetary costs. For small and medium-sized companies, this can be a significant obstacle. Even if the company understands that automation can lead to minimal cost losses and increased productivity in the long term, the initial costs may be prohibitive. In addition, it is necessary to take into account the costs of training employees who will work with new systems, as well as technical services and equipment upgrades. With a small budget, many companies are forced to delay or refuse to introduce robotics.

Organizational problems can also become an obstacle to the introduction of robotic systems. It is important not only to install new equipment, but also to change the existing business processes for their acceptable operation. This may require a change in the organizational structure of the company, reassignment of responsibilities between employees and changes in the overall culture. For the successful integration of new technologies, it is necessary to provide cooperation between various parts of the company and establish conditions for the rational exchange of information. Companies often face a lack of coordination between groups, which leads to delays in the implementation of projects and a decrease in overall efficiency. Another difficult task is the need for long-term training and professional development of employees. With the transfer to new technologies, employees must learn new skills and knowledge to work productively with the latest equipment. This requires time and resources, and can also trigger additional training costs. Not all employees are able to adapt to changes, and some may feel uncomfortable with the development of new technologies. Therefore, companies need to develop policies to educate employees and maintain their incentive in the face of change.

Finally, it is necessary to take into account issues of ethics and public responsibility when introducing robotic systems. Automation of processes has the opportunity to lead to a decrease in jobs and an increase in unemployment in specific segments of the economy. This creates public problems and requires companies to create a strategy to insure employees who may lose their jobs due to automation. It is necessary to consider not only the economic approaches to the introduction of new technologies, but also their consequences for society as a whole [3].

Let us look at a few applications of robotic systems.

One of the most tangible uses of robotic systems is in industry, mainly in the manufacturing sector. Robots are intensively used on conveyor belts to install machines, electronics and other goods. Automation of production processes can significantly increase the speed and quality of production, as well as reduce the number of human errors. For example, in the automotive industry, robots perform tasks such as welding, painting, and assembling parts with increased accuracy and work pace. They not only hasten the process, but also reduce labor costs, making production more equal to others in the market. In addition, the introduction of robotic systems allows companies to adapt to unstable market conditions, respond more quickly to changing needs and add new types of products without incurring significant costs. The field of education too is triggering the introduction of robotic technology. Robots can be used in educational institutions to train students in programming, engineering and other engineering subjects. They can be interactive assistants for teachers, helping to explain difficult concepts and provide practical skills. Also, the use of educational robots can help develop important thinking and creative skills in students, which is most important in a rapidly changing environment. Robotic systems are also finding application in agriculture, where they help to increase the productivity and efficiency of farmers.

Current agricultural work contributes to the realization of the task of planting, plant care and harvesting. As an example, trained machines have the ability to cultivate fields involuntarily, to spray fertilizers with increased precision, which allows for reducing the use of chemicals and minimize their negative impact on the environment. Moreover, the use of robots for harvesting significantly speeds up this procedure and reduces labor costs. With the world’s growing population and increasing demand for food, such technologies are becoming particularly relevant. The healthcare industry is also dynamically adopting robotic technology. Recently, we have seen an increased interest in robotic surgeons who can perform heavy surgeries with excellent precision and the least amount of intervention. Such systems allow surgeons to perform surgeries using the least contagious means possible, which reduces the recovery period of patients and the likelihood of deterioration. In addition, robotic systems can be used to deliver drugs and medical instruments within hospitals, which enhances the performance of medical staff. In some circumstances, robots are even able to act as an assistant to those who are ill, giving them the care they need and managing their health [4].

We would also like to consider the future of robotic systems in industrial automation.

One of the main focuses is the development of collaborative robots or cobots. These devices are designed to work in conjunction with the workforce, allowing for a marked increase in the agility of production processes. Robots can perform everyday tasks, freeing up employees for more challenging and creative work. On assembly lines, robots can assist in carrying challenging parts or perform precise operations such as installing components, reducing the burden on humans and lowering the risk

of injury. In the coming future, we can expect robots to become more popular predominantly in small and medium-sized businesses, where conventional industrial robots may be inaccessible and heavy to implement. Robotic systems can help improve manufacturing processes by reducing waste and resource consumption. For example, with the support of robotic solutions, material consumption can be optimized, recycling processes can be improved, and energy use can be minimized. The introduction of such technologies will help companies meet today's environmental benchmarks and provide a competitive advantage in the marketplace. Robots increase productivity, lower production costs and reduce the impact of human error, minimizing errors and ensuring consistently high quality. However, modern automation goes beyond simple repetitive operations. We are seeing the introduction of robots with advanced machine vision, capable of adapting and making decisions in non-standard situations. This enables the automation of more complex production processes that require real-time analysis and situation assessment, such as high-detail product quality control. The growing popularity of collaborative robots (cobots) is about more than just the safe neighborhood of man and machine. Cobots are designed to work together, sharing tasks with humans and empowering them (Figure). They perform heavy, monotonous or dangerous work, freeing up employees for more creative and highly skilled tasks.

Figure. The future of robotization in manufacturing

Human-cobot interaction increases production efficiency, improves workplace ergonomics, and creates a more comfortable and safe working environment. Moreover, cobots are capable of learning specific skills, adapting to a person's individual work style. Modern robots are not rigidly programmed machines. Their versatility and ability to quickly adapt to different tasks is the key to success in an increasingly personalized manufacturing environment. This is especially true for

companies focused on small series and customized orders. Flexible robotic systems allow for rapid adaptation to changes in demand, minimizing changeover times and increasing competitiveness. It is important to emphasize that robotization does not mean the complete replacement of humans. On the contrary, it requires highly skilled professionals capable of programming, maintaining and managing complex robotic systems. The human role is shifting towards supervision, control, data analytics and strategic decision-making [5]. Therefore, investment in human training is as important as investment in the robots themselves. In conclusion, the future of robotization in manufacturing promises to be dynamic and filled with innovation. Smart factories, flexible manufacturing systems and collaborative robots are not just individual technologies, but elements of a new era of manufacturing based on the synthesis of automation, artificial intelligence and human potential.

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# RENEWABLE ENERGY SOURCES: ASSESSING POTENTIAL AND PROSPECTS IN COUNTRIES WITH DIVERSE CLIMATIC CONDITIONS

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**Abstract.** The article analyzes renewable energy sources (RES) in various climatic conditions. It examines the advantages, limitations, and prospects for RES integration, emphasizing the role of innovative technologies and international cooperation. The importance of RES for sustainable development and carbon footprint reduction is highlighted.

**Keywords:** renewable energy sources, solar energy, wind energy, hydro energy, sustainable development, climatic conditions, energy system, environmental technologies, innovations.

# ВОЗОБНОВЛЯЕМЫЕ ИСТОЧНИКИ ЭНЕРГИИ: ОЦЕНКА ПОТЕНЦИАЛА И ПЕРСПЕКТИВ В СТРАНАХ С РАЗЛИЧНЫМИ КЛИМАТИЧЕСКИМИ УСЛОВИЯМИ

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**Аннотация.** Статья посвящена анализу возобновляемых источников энергии (ВИЭ) в различных климатических условиях. Рассмотрены преимущества, ограничения и перспективы интеграции ВИЭ, а также роль инновационных технологий и международного сотрудничества в их развитии. Авторами сделан вывод о важности ВИЭ для устойчивого развития и снижения углеродного следа.

**Ключевые слова:** возобновляемые источники энергии, солнечная энергия, ветровая энергия, гидроэнергетика, устойчивое развитие, климатические условия, энергосистема, экологические технологии, инновации.

In today's world, the energy sector plays a crucial role in economic development and social stability. However, reliance on traditional energy sources such as oil, gas, and coal has led to significant environmental issues, including global warming, air pollution, and the depletion of natural resources. Under these circumstances, the transition to renewable energy sources (RES) is not only an ecological but also a strategic necessity.

Renewable energy sources, including solar, wind, and hydropower, have significant potential to replace fossil fuels. Their advantages lie in their environmental friendliness, resource renewability, and long-term economic efficiency. However, their successful implementation largely depends on climatic conditions, geographical features, and the level of technological development in different regions.

Each type of renewable energy has its strengths and limitations. Solar energy is most effective in regions with high solar insolation, wind energy thrives in areas with consistent wind flows, and hydropower requires rivers or water bodies with suitable characteristics. These specific requirements necessitate a detailed analysis of their potential and prospects in countries with diverse climatic conditions [1, p. 157].

The aim of this article is to explore the potential for utilizing solar, wind, and hydropower across various regions of the world, evaluate their capacity considering climatic features and technological advancements, and identify key challenges and development opportunities in these sectors. This approach provides a deeper understanding of how to most effectively integrate renewable energy sources into the global energy system and ensure sustainable development over the long term [2, p. 55].

Solar energy is one of the most versatile and accessible energy sources. Its primary advantages include environmental friendliness, vast potential, and applicability across regions with various climatic conditions. However, the effectiveness of solar technologies directly depends on the level of insolation, which varies according to geographic location and season.

Countries situated in tropical and subtropical climates have the most favorable conditions for solar energy utilization. Regions such as North Africa, the Middle East, South Asia, and parts of Latin America experience a consistent level of solar radiation throughout the year. For instance, the Sahara Desert receives an average annual insolation exceeding 2,000 kWh per square meter, making it an ideal location for solar farms. Projects like Morocco's Noor Solar Plant demonstrate the potential for large-scale adoption of this technology in high-insolation areas.

In countries with temperate climates, such as Germany, France, or Canada, insolation is seasonal. During winter, solar radiation levels decrease, limiting the performance of solar power plants. However, advancements in photovoltaic technology help mitigate these limitations. Modern solar panels with high conversion efficiency, combined with energy storage systems, enable the effective use of solar energy even in regions with variable weather conditions. For example, Germany,

despite its moderate climate, ranks among global leaders in installed solar capacity, highlighting the effectiveness of well-implemented solutions.

Polar regions, where low solar activity persists for much of the year, have minimal potential for solar energy development. Nevertheless, in these areas, solar energy can be combined with other sources, such as wind or diesel generators, to offset its limitations.

One of the key technological trends in solar energy is the development of more efficient and durable photovoltaic panels. For instance, bifacial panels that capture sunlight from both the front and rear sides enhance the efficiency of solar systems. Additionally, efforts are underway to integrate solar technologies into urban infrastructure, such as installing solar panels on rooftops, parking lots, and even building facades.

The adoption of solar energy comes with several challenges. One significant obstacle is its dependence on weather conditions and daily variations in sunlight. To address this, energy storage systems, such as lithium-ion and sodium-ion batteries, are being developed to store surplus energy for use at night or during periods of low insolation. Moreover, hybrid systems that combine solar and wind energy are gaining traction, offering more stable energy supplies.

The global prospects for solar energy are promising. Its cost continues to decrease due to technological improvements and economies of scale, making it competitive even in countries with robust traditional energy sectors. Over the next few decades, the share of solar energy in the global energy mix is expected to grow significantly, marking a crucial step toward reducing carbon emissions and achieving sustainable development [3, 4].

Wind energy is one of the most efficient and promising renewable energy sources, harnessing natural wind flows to generate electricity. The efficiency of wind power generation depends on wind speed, which varies based on geographical location and regional climatic conditions. Coastal areas and open spaces, where winds are steady and strong, offer the highest potential for wind energy utilization.

Wind speed is the primary factor determining the performance of wind turbines. Regions with consistently strong winds, such as the North Sea, the United Kingdom, and Denmark, have a high wind energy potential. These countries have developed both onshore and offshore wind farms, significantly reducing their reliance on traditional energy sources. High wind speeds are also observed in areas such as the U.S. Midwest, making wind energy highly viable in these zones.

Offshore wind energy offers the advantage of stable and strong winds at sea, enhancing generation efficiency. However, the high costs of constructing and maintaining offshore installations remain a key drawback. Onshore wind energy, while less expensive, faces challenges such as limited land availability and dependency on fluctuating wind speeds on land.

The prospects for wind energy depend on climatic conditions. In cold climates, issues such as freezing and ice formation on turbines require additional solutions, such as blade heating systems. In hot climates, like those in the Middle East, dust

accumulation can reduce turbine efficiency, which can be addressed with cleaning systems. In regions with variable weather, hybrid systems combining wind and solar energy offer a more reliable power supply [5, p. 326].

In conclusion, wind energy is an efficient and versatile energy source that can be adapted to different climatic conditions through innovative technologies. Its increasing adoption highlights its potential as a cornerstone of a sustainable energy future.

Hydropower is one of the oldest and most reliable forms of renewable energy, harnessing the energy of flowing water to generate electricity. Hydropower plants (HPPs) have long been critical to the global energy mix, supplying a significant share of electricity needs, especially in countries with well-developed hydrological infrastructure.

The potential of hydropower is highly dependent on the availability of water resources such as rivers, lakes, and waterfalls, as well as the terrain. Mountainous regions with large elevation differences are ideal for constructing large hydropower plants. For instance, China, Norway, and Brazil are global leaders in hydropower utilization due to a combination of favorable natural conditions and advanced technologies. China's Three Gorges Dam, the largest hydropower plant in the world, generates over 80 terawatt-hours of electricity annually and stands as a prominent example of large-scale hydropower application.

Hydropower, however, is not limited to large projects. Small and micro-hydropower plants are gaining popularity, particularly in remote and inaccessible areas. These systems require lower investments and have a smaller environmental footprint. They are especially effective in countries with numerous rivers, where localized plants can supply electricity to small communities.

In addition to its potential, hydropower faces several environmental and social challenges. Large dams can cause significant ecological changes, including land submersion, fish migration disruptions, and alterations to natural landscapes. Such changes often spark social discontent, as hydropower projects can necessitate the relocation of local populations. Therefore, it is crucial to consider both economic and environmental factors and ensure community engagement during project implementation.

Water resources are also vulnerable to climate change, creating additional complications for hydropower. Variations in precipitation patterns and the reduction of glaciers can destabilize water supplies for HPPs, especially in regions heavily dependent on seasonal snowmelt. These risks call for adaptive measures, such as constructing regulating reservoirs and employing innovative water resource management technologies.

Modern technologies are significantly advancing hydropower development. Floating hydropower plants, for example, are deployed on large water bodies and have a lower environmental impact. These systems can also support fishing and other water resource activities. Another promising direction is the creation of hybrid

systems combining hydropower with other energy sources, such as solar panels installed on reservoir surfaces.

The prospects for hydropower across different climatic regions depend on effective water resource management and the adoption of environmentally sustainable technologies. Despite its challenges, hydropower remains one of the most reliable and cost-effective energy sources. Its continued development will be pivotal in transitioning to a cleaner and more sustainable energy future, particularly in countries with abundant water potential [6, 7].

**Comparative Analysis and Integration of Renewable Energy Sources**

Each renewable energy source – solar, wind, and hydropower – has unique characteristics that define its effectiveness under different climatic conditions. A comparative analysis helps identify their advantages, limitations, and optimal applications.

Solar energy is particularly efficient in regions with high solar radiation, such as tropical and subtropical zones. Its primary strengths include versatility and the ability to be utilized in various locations, including remote areas and urban environments. However, solar energy is subject to daily and seasonal fluctuations, necessitating energy storage systems for consistent supply.

Wind energy excels in regions with steady wind flows. Wind turbines can be installed both onshore and offshore, broadening their applicability. However, the stability of wind energy output is weather-dependent, and large wind farms can have ecological and social drawbacks, such as impacts on landscapes and bird migration patterns.

Hydropower offers high reliability and the ability to provide a stable energy supply, making it ideal for base-load electricity generation. Its use, however, is restricted by the availability of suitable water resources. Large hydropower projects may cause significant environmental and social impacts, including habitat disruption and population displacement. Small and micro-hydropower plants provide localized energy solutions, especially in remote regions, but their potential is limited by scale.

Integrating various renewable energy sources into a unified energy system can offset the shortcomings of individual technologies and enhance overall efficiency. Hybrid systems, such as solar-wind or solar-hydro setups, provide more stable energy supplies by complementing each other. For example, in areas with fluctuating wind conditions, solar panels can compensate for reduced wind turbine output, while hydropower can act as a reliable backup source.

Digitalization and the development of smart energy management systems play a crucial role in the successful integration of renewables. Modern technologies enable efficient energy flow distribution, optimize usage, and minimize losses. For instance, smart grids can automatically redistribute loads among different sources based on real-time conditions [8, p. 100].

The comparative analysis also underscores the importance of a regional approach to renewable energy development. In countries with diverse climatic conditions, building integrated energy systems that utilize all types of renewable

energy is a prudent strategy. This not only enhances energy supply resilience but also reduces the carbon footprint.

In the future, the combined use of renewable energy sources, integrated with innovative technologies, will form the foundation of a sustainable global energy system. This approach will maximize the efficient use of natural resources, reduce dependency on fossil fuels, and minimize environmental impact.

**Challenges and Prospects for Implementing Renewable Energy Sources**

Despite the numerous advantages of renewable energy sources (RES), their implementation faces several challenges. These issues stem from technological, economic, social, and environmental factors that must be addressed for a successful transition to a sustainable energy system.

One major challenge is the high initial cost of RES projects. While the operational expenses of renewable energy are significantly lower than those of traditional energy sources, the construction of solar and wind power plants, as well as hydropower stations, requires substantial investments. This is particularly relevant for developing countries, where limited financial resources make it difficult to implement such projects [9, p. 245].

Another challenge is the limited availability of energy storage technologies. Since renewable energy generation is subject to seasonal and weather variations, sustainable energy supply requires effective storage systems. Modern battery technologies, such as lithium-ion batteries, have a limited lifespan, high costs, and environmental concerns related to raw material extraction.

Infrastructure limitations also pose significant barriers. Integrating RES into energy systems necessitates modernizing existing grids to accommodate variable generation. In some regions, the lack of a developed energy infrastructure complicates electricity delivery to remote areas.

Social aspects of RES adoption include a lack of awareness and resistance from local communities. For example, wind farm construction may provoke protests due to landscape changes and potential health impacts. Similarly, large hydropower projects often face opposition because of land flooding and the displacement of residents.

Environmental risks cannot be ignored either. While renewable energy sources are considered environmentally friendly, their use entails certain impacts on nature. For instance, solar panels require large land areas, and equipment production generates waste. Wind turbines can affect local ecosystems, including bird and bat migration patterns.

Despite these challenges, the prospects for RES development are promising. Technological advances are already reducing production and installation costs. For example, the cost of solar panels and wind turbines has dropped by over 70% in recent decades, making them competitive even without subsidies.

One promising direction is the development of local energy systems tailored to use regional resources. This includes microgrids and standalone installations that can provide power to remote communities without requiring large-scale infrastructure. International cooperation also plays a crucial role. Joint project development,

knowledge exchange, and funding from international organizations like the World Bank or the International Renewable Energy Agency (IRENA) accelerate the adoption of RES, particularly in resource-constrained countries.

In the future, digitalization will be a key factor in energy transition. The development of smart grids, weather forecasting systems, and energy flow management technologies will optimize RES utilization and minimize risks. At the same time, interdisciplinary research aimed at reducing the environmental impact of renewable energy will gain importance.

Thus, the transition to renewable energy sources, despite the existing challenges, is a realistic and strategically necessary goal. Investments in research, infrastructure, and environmentally sustainable technologies will lay the foundation for a global energy transition, ensuring sustainable development and reducing humanity's carbon footprint.

Renewable energy sources are a cornerstone in transitioning to a sustainable global energy system. Their adoption enables a reduction in carbon dioxide emissions, decreased reliance on fossil fuels, and minimized environmental impact. Solar, wind, and hydro energy hold immense potential that can be effectively harnessed when considering the climatic and geographic features of various regions.

The analysis reveals that each type of renewable energy has unique advantages and limitations. Solar energy is ideal for regions with high solar insolation, such as tropical areas, while wind energy is most efficient in coastal and steppe zones with consistent winds. Hydropower remains a reliable source of base-load energy in countries with abundant water resources, particularly in mountainous and flat areas with developed hydrological networks.

To maximize the potential of renewable energy sources, challenges such as high technology costs, infrastructure constraints, environmental risks, and social barriers must be addressed. Solutions include investments in innovation, the development of localized energy systems, and the integration of various renewable energy types into unified systems.

The implementation of digital technologies, smart grids, and energy storage systems presents new opportunities for stable and efficient use of renewable energy. Additionally, international cooperation focusing on knowledge exchange and joint technological development plays a crucial role.

Thus, renewable energy holds significant potential for ensuring sustainable development. It can not only meet humanity's growing energy demands but also lay the foundation for an environmentally clean future.

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**УДК 336.71**

# THE IMPACT OF ARTIFICIAL INTELLIGENCE ON THE BANKING SECTOR IN RUSSIA

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**Abstract.** Artificial Intelligence (AI) is actively transforming the Russian banking sector, reshaping processes and approaches to financial management. Major areas influenced by AI include customer service automation, credit risk management, financial trend forecasting, and cybersecurity enhancement. In response to digitalization and rising customer demands, leading Russian banks such as Sberbank, VTB, Alfa-Bank, and T-bank are heavily investing in AI technologies, enabling them to improve operational efficiency and market adaptability.

**Keywords:** artificial intelligence, banking sector, customer service, cybersecurity, credit risk, big data, financial analytics.

# ВЛИЯНИЕ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА НА БАНКОВСКИЙ СЕКТОР В РОССИИ

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**Аннотация.** Искусственный интеллект активно трансформирует российский банковский сектор, изменяя процессы и подходы к управлению финансами. Основные направления, на которые ИИ оказывает значительное влияние, включают автоматизацию клиентского сервиса, управление кредитными рисками, прогнозирование финансовых трендов и повышение уровня кибербезопасности. В условиях цифровизации и растущих потребностей клиентов ведущие российские банки, такие как Сбербанк, ВТБ, Альфа-Банк и Т-банк, активно инвестируют в технологии ИИ, что позволяет повышать операционную эффективность и адаптивность к рыночным условиям.

**Ключевые слова:** искусственный интеллект, банковский сектор, клиентский сервис, кибербезопасность, кредитные риски, большие данные, финансовая аналитика.

The Russian banking sector is undergoing a profound transformation driven by Artificial Intelligence (AI), which reshapes processes in financial management and

customer service. The application of AI spans across customer service automation, credit risk management, financial forecasting, and cybersecurity. To meet the demands of digital transformation, major Russian banks, such as Sberbank, VTB, Alfa-Bank, and T-bank, are making substantial investments in AI technologies, which help increase operational efficiency, enhance market adaptability, and improve customer satisfaction.

AI is particularly instrumental in enhancing customer experience and automating client interactions. By implementing chatbots and virtual assistants, banks can reduce the workload on call centers and provide 24/7 access to services. Sberbank's virtual assistant, for example, handles hundreds of thousands of requests daily, assisting clients with basic operations such as transfers and bill payments, as well as providing information on products and services. This tool has become an essential part of the customer service structure, enhancing accessibility and client loyalty. Alfa-Bank also uses chatbots capable of handling more complex tasks, including processing applications for credit products, thanks to the self-learning and adaptive capabilities of AI, which improve the quality of service and offer clients more personalized solutions [1, 2].

Beyond customer service, AI has revolutionized credit scoring and risk management. In traditional banking, institutions rely on standard metrics such as credit history and client income. However, AI allows the inclusion of hundreds of factors, such as transactional activity, social connections, and online behavior. T-Bank, for instance, has developed scoring models based on machine learning to analyze data. These models enable the bank to predict risks more accurately and make credit decisions with current data, which significantly reduces default rates and improves the bank's financial performance.

In financial forecasting and analytics, AI plays a key role in predictive analysis, enabling banks to better assess macroeconomic conditions and market trends. Gazprombank employs machine learning algorithms to forecast currency exchange rate fluctuations and stock market trends. This predictive capability enables the bank to build more accurate financial strategies and offer investment products that consider anticipated market changes. Additionally, big data analytics help identify hidden correlations and patterns, which is particularly valuable in a volatile economic environment.

AI is also a powerful tool in cybersecurity, playing a critical role in fraud detection and cyberattack prevention. With increasing cyber threats and data protection requirements, AI enables banks to instantly analyze millions of transactions and detect anomalous activities. Sberbank, for example, has developed AI-driven systems that monitor client behavior in real-time and block suspicious activities. The deployment of such technologies helps minimize financial losses and protect client funds from fraudsters. Similar systems have been implemented by other major banks, such as VTB and Alfa-Bank, where AI aids in protecting the infrastructure from attacks, including social engineering methods and automated

attacks. These measures significantly enhance client trust and bolster the bank's reputation in a digitally driven world [3, 4].

Additionally, Russian banks employ AI to improve operational efficiency. Machine learning and robotic process automation streamline banking processes, reducing costs and accelerating workflows. For example, Alfa-Bank introduced an automated system for credit application processing, allowing for faster decision-making and reduced documentation processing costs. This enables clients to access credit quickly, while the bank benefits from cost savings on data processing. Similar systems are being integrated across other banks, contributing to internal process optimization and improving interdepartmental coordination.

One of the main challenges facing Russian banks is integrating AI into existing infrastructure while adhering to regulatory requirements. AI development requires significant investment and highly skilled professionals, which presents a challenge for many banks. Furthermore, regulatory mandates require banks to protect client data, and AI algorithms must consider these requirements to ensure privacy and security. Nonetheless, leading Russian banks are actively collaborating with government bodies to develop regulatory frameworks that will accelerate AI adoption while safeguarding client data.

AI technology is also significantly contributing to operational efficiency within the Russian banking sector, enabling institutions to optimize various internal processes. Many banks are implementing AI-driven automation in routine back-office tasks, which traditionally consumed considerable time and resources. These tasks include data entry, transaction reconciliation, and document processing. By automating these processes, banks can reduce the likelihood of human error, streamline workflow, and lower operational costs. For instance, Alfa-Bank has adopted AI for document processing and loan application reviews, which expedites approvals and minimizes manual verification steps. This approach allows employees to focus on more complex, value-added activities, enhancing overall productivity [2, 3].

Furthermore, AI in Russian banking is driving innovative approaches to predictive analytics and financial forecasting. By analyzing large datasets, machine learning models can predict future market trends, customer needs, and potential economic shifts. This insight is particularly valuable for Russian banks aiming to align their strategies with changing market conditions. For example, AI-based predictive models help banks adjust loan offerings, anticipate customer demand for specific products, and proactively manage asset portfolios. This forward-looking approach gives banks a strategic advantage, enabling them to prepare for fluctuations in the economy and remain resilient against market uncertainties [4, 5].

Another noteworthy application is in regulatory compliance, where AI helps banks navigate Russia's complex financial regulations. Compliance with these regulations is crucial for avoiding penalties and ensuring sustainable growth. AI solutions can process regulatory updates, monitor compliance across bank operations, and detect potential regulatory risks. For instance, VTB Bank employs AI to enhance

compliance processes by automating the monitoring of transactions for compliance with anti-money laundering (AML) and “know your customer” (KYC) requirements. This not only ensures adherence to regulatory standards but also improves risk management and transparency [2, 5].

Artificial intelligence (AI) continues to expand its transformative role in the Russian banking sector, reaching areas that were previously considered beyond the scope of automation and technological advancement. One significant area of impact is financial inclusion, particularly in underserved and rural regions of Russia. By utilizing AI-driven mobile banking platforms, banks can now provide tailored financial services to individuals who traditionally lacked access to them. These platforms enable remote account management, personalized loan assessments, and financial literacy tools. For example, AI solutions implemented by major banks like Sberbank and T-Bank empower users in remote areas to access credit facilities without the need for physical bank visits. This level of accessibility helps bridge the gap between urban and rural financial systems, fostering greater economic participation nationwide.

Moreover, the increasing reliance on AI has led to an evolution in the ethical frameworks governing the banking industry. Issues such as algorithmic transparency, data privacy, and unbiased decision-making have become central to the deployment of AI technologies. Leading Russian banks are adopting initiatives to address these concerns, including the establishment of ethical AI committees and investments in secure data-handling practices. For instance, Sberbank has implemented robust measures to ensure its AI systems operate within ethical boundaries, reducing the risk of discrimination or data misuse. Similarly, AI training programs are being introduced to educate employees on the ethical dimensions of AI deployment, enhancing trust between institutions and their clients.

Collaboration between financial institutions and other sectors has also accelerated AI innovation. Russian banks are increasingly working with technology firms and academic institutions to refine AI solutions tailored to specific financial challenges. Alfa-Bank’s partnership with Skolkovo Institute of Science and Technology, for instance, has yielded sophisticated machine learning models that improve the precision of credit risk assessments and fraud detection systems. These collaborations not only advance the technological capabilities of AI systems but also address the skills gap in the labor market by producing a new generation of AI specialists.

Despite the advancements made by major banks, medium-sized and regional banks face significant challenges in integrating AI technologies. Limited resources, underdeveloped digital infrastructure, and a lack of technical expertise hinder smaller institutions from achieving the same level of transformation as their larger counterparts. However, government initiatives and the development of cloud-based AI platforms are helping to mitigate these disparities. Smaller banks can now access cost-efficient AI tools and training programs, enabling them to enhance their operational efficiency and compete more effectively in the financial marketplace.

Looking to the future, Russian banks are exploring cutting-edge AI applications that could redefine the sector's technological landscape. Advances in natural language processing (NLP) are enabling more sophisticated client interactions, where AI-driven virtual assistants can process nuanced customer inquiries and offer in-depth financial consultations. Additionally, integrating AI with blockchain technology presents new opportunities for secure, transparent financial transactions. Pilot projects focusing on this integration are already underway, with Russian banks aiming to lead global innovation in these fields. Quantum computing, another emerging area, has the potential to revolutionize predictive analytics and financial modeling, offering unprecedented accuracy and processing speed. These developments suggest that AI will remain a cornerstone of Russian banking innovation for years to come.

The increased use of AI also extends to sustainability initiatives within the banking sector. By analyzing large datasets, AI algorithms can identify environmentally sustainable investment opportunities and evaluate the environmental, social, and governance (ESG) compliance of borrowers. This capability aligns with global trends towards greener economies and positions Russian banks as proactive participants in combating climate change. The adoption of AI-powered ESG analysis tools allows institutions to prioritize investments that contribute to sustainability goals, further reinforcing their role in fostering long-term economic stability.

While the transformative potential of AI is undeniable, the successful integration of these technologies requires addressing several obstacles. The cost of AI development remains high, making it difficult for some institutions to allocate the necessary resources. Additionally, regulatory requirements regarding data protection and algorithmic accountability must be harmonized with technological advancements to ensure that innovation does not come at the expense of customer rights. To this end, Russian banks are actively collaborating with regulatory bodies to create frameworks that balance innovation with compliance. These efforts not only enhance public trust but also establish a solid foundation for the broader adoption of AI across the financial sector.

As artificial intelligence continues to shape the Russian banking industry, its impact is becoming increasingly comprehensive, touching on customer service, operational efficiency, financial inclusion, and strategic innovation. By addressing current challenges and leveraging emerging technologies, Russian banks are poised to set new benchmarks in financial excellence, fostering resilience and growth in an ever-changing economic landscape.

As AI continues to evolve, Russian banks are likely to see even more extensive applications that support strategic decision-making and innovation. The integration of advanced analytics, automation, and personalized financial services positions AI as a central pillar in the transformation of Russian banking, creating new opportunities for growth and a competitive edge in a rapidly digitalizing economy.

In conclusion, artificial intelligence is reshaping the Russian banking sector, transforming approaches to client interaction, risk management, financial forecasting, and cybersecurity. Russian banks are increasingly investing in AI, enhancing competitiveness and improving service quality. With the growing number of successful AI applications, it is expected that the role of this technology will continue to expand, and banks will further integrate AI into their operations to boost efficiency and respond to market changes.

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# ANALYSIS OF THE MARKET OF LARGE-TONNAGE SYNTHETIC POLYMERS

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**Abstract.** The article provides a comprehensive analysis of the large-tonnage synthetic polymers market. The current state and dynamics of the market are examined, considering the key segments that demonstrate the greatest growth potential. The properties and applications of large-tonnage synthetic polymers such as polyethylene, polypropylene and others, as well as their role in various industries are described in detail. Innovative technologies in the production and processing of polymers, environmental aspects and challenges associated with the disposal and recycling of polymer materials are also covered.

**Keywords:** synthetic polymers, industry, waste, plastic, market analysis, recycling.

# АНАЛИЗ РЫНКА КРУПНОТОННАЖНЫХ СИНТЕТИЧЕСКИХ ПОЛИМЕРОВ

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**Аннотация.** В данной статье проводится комплексный анализ рынка крупнотоннажных синтетических полимеров. Исследуется текущее состояние и динамика рынка с учетом ключевых сегментов, которые демонстрируют наибольший потенциал роста. Подробно описываются свойства и применение крупнотоннажных синтетических полимеров, включая полиэтилен, полипропилен и другие, а также их ключевая роль в различных отраслях промышленности. Рассматриваются инновационные технологии в производстве и переработке полимеров, экологические аспекты и вызовы, связанные с утилизацией и рециклингом полимерных материалов.

**Ключевые слова:** синтетические полимеры, отрасль, отходы, пластик, рыночный анализ, переработка.

In the modern world, synthetic polymers play a vital role in various industries, from packaging materials to aircraft engineering. These high-performance materials, with unique properties such as lightness, strength and corrosion resistance, have

become an integral part of our daily lives. To date, the volume of global consumption of large synthetic polymers exceeds 265 million tons, with more than 65 % of this demand coming from polyolefins. PET consumption has increased at the highest rate over the past ten years (almost 7 % per year) and that of polyolefins has amounted to more than 4 % per year. The average annual growth in demand for PVC was about 3 %. At the same time, the polystyrene market has recently shown stagnation, due to its displacement by polypropylene and PET, as well as the introduction of restrictions on the use of polystyrene packaging in some countries due to its potential harm to health and insufficient fire safety of thermal insulation materials. The main driver of global polymer demand growth is the packaging industry, where various films and sheet materials account for more than half of global polymer consumption. The packaging segment has a significant impact on the polyethylene market, accounting for about 70 % of its consumption. The fastest growing segment, with an average annual growth rate of about 5 %, are films, the demand for which is increasing due to the needs of agriculture and the food industry.

The largest segment of the global polymer market is concentrated in Asia, where about half of the global demand is generated. In particular, China consumes about 25 % of all polyethylene and more than one third of polypropylene and polyvinyl chloride. The US and European markets occupy the second and third places, respectively. More than 50 % of polymer production facilities are located in Asia, and China is a leader in the development of production here. In recent years, the role of India has also increased, where large capacities have been created to replace imports. Important players in the market are the countries of the Middle East, which have launched large export-oriented production over the past decade due to the availability of cheap natural gas in the region. One of the main factors influencing the changes in the structure of the global polymer market is the active construction of new plants in the United States, caused by the “shale revolution”. In 2020, the market of large-tonnage polymers faced a serious crisis, as well as many other industries. This is not only due to the global recession, the inevitability of which is becoming increasingly obvious. Problems in the market began to arise even before the pandemic and were caused by an imbalance between supply and demand. The most critical situation has developed in the polyethylene market, which is due to both the launch of new capacities and an increase in the number of bans on the use of single-use plastic, in which polyethylene occupies a significant share [1, 2].

This study examines the markets of basic polymers: polyolefins (polyethylene and polypropylene), polyvinyl chloride, polyethylene terephthalate, polystyrene.

The areas of application of the polymers in question are extremely diverse. Polymer products are widely used in the construction and repair of both residential and commercial facilities, acting as finishing materials (for example, plastic windows, insulation, polyurethane foams, fasteners, siding, drainage systems, etc.). Panels, skirting boards, moldings and polymer self-leveling floors are produced for interior decoration. Polymer pipes, cable ducts, wires and switches are widely used in electrical and plumbing systems. These pipes are also widely used in housing and communal services and in the construction of pipelines. The main use of PET is in

the production of packaging (plastic bottles for beverages and packaging for food and non-food products). Packaging for food and non-food products is also a significant area of application for other polymers considered in this study. The examples given do not exhaust all possible areas of use of plastic products [3].

In the period 2010-2019, the volume of production of plastics in primary forms in the Russian Federation increased by 1.8 times, exceeding 8.7 million tons in 2019. During this period, production capacities were significantly updated and new plants were commissioned, which allowed the polymer industry to become one of the driving forces of the chemical industry development.

The share of the Russian Federation in the global polymer trade is still very small and does not exceed 1 %. And yet, the launch of new production facilities has led to an increase in the share of world trade, albeit not very significant on a global scale, but important for the country.

The largest participants in the polymer market in Russia are the leading petrochemical companies. The largest variety of basic polymers is produced by PJSC SIBUR Holding. The holding includes 9 plants, which are subsidiaries or joint ventures, with a total production capacity of almost 2 million tons of polymers per year. After the launch of the new ZapSibNeftekhim plant, the capacity of PJSC SIBUR will increase to 3.5 million tons per year. There are a total of 25 factories in Russia producing various types of large-tonnage polymers. The global polymer production in metric tons is shown in the Figure.

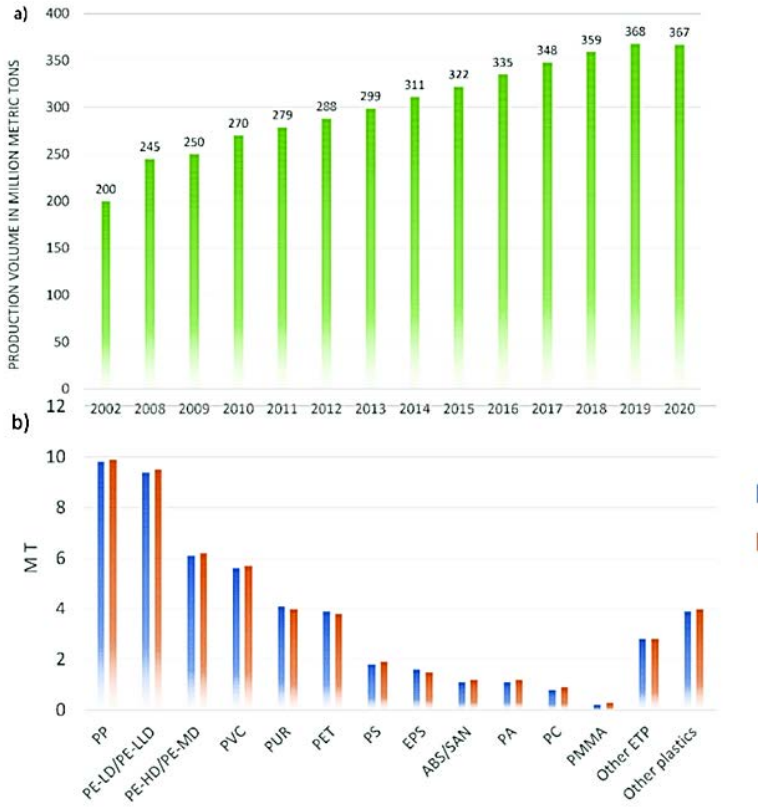


Figure. a) World polymer production in metric tons, b) Distribution of major polymers produced

There are currently eight plants in Russia engaged in the production of ethylene polymers. Low density polyethylene (LDPE) is produced at five plants: Kazanorgsintez, Tomskneftekhim, Ufaorgsintez, Angarsk Polymer Plant and Gazprom NeftekhimSalavat. High-density polyethylene (HDPE) is produced at four enterprises: Kazanorgsintez, Nizhnekamskneftekhim, Gazprom NeftekhimSalavat and Stavrolen. Until 2018, linear polyethylene was produced by only one plant – NKNH. In 2019, Kazanorgsintez began production of metallocene linear polyethylene and became the only producer of this type of LPE in the country with a planned volume of about 8 thousand tons per year, which will replace about 35 % of imports. Also in 2019, a new participant appeared in the market of large-tonnage polymers – ZapSibNeftekhim, which, after reaching its design capacity, will take a leading position in the production of ethylene polymers, controlling more than 55 % of the market [4].

In the world, the bulk of recyclable polymer waste is physically recycled. About 87 % of polymer waste is processed into semi-finished products such as flakes, crushed materials, agglomerates, granules, while the remaining 13 % is used to produce products with less stringent quality requirements, such as flower pots, artificial plants, garden furniture, as well as door mats and cars. Polymer solid industrial waste suitable for such processing usually comes from mixed polluted streams. Higher quality polymers can be used in various industries. Industrial polymer wastes with a homogeneous composition and in large volumes are in high demand, as they can be immediately included in the production process, which makes it possible to obtain intermediate and final products of high quality [5].

Thus, given the growing demand for sustainable and innovative materials, polymer manufacturers are faced with the need to adapt to rapidly changing market conditions. Already at this stage, it is important to conduct a full analysis and find a solution to the issue of recycling huge amounts of waste, as emissions into the atmosphere increase every year, which has a detrimental effect on the environment and the state of nature as a whole. An analysis of the large-tonnage synthetic polymers market has revealed significant trends and opportunities that can shape the future of this industry [6]. The importance of developing new products, optimizing production processes and reducing environmental impact has never been higher. In the face of these challenges, the large-tonnage synthetic polymers market promises to be dynamic and full of opportunities for those who are ready to invest in the future and participate in the development of this key segment of the global economy.

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# USING NUCLEAR ENERGY TO PRODUCE HYDROGEN

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**Abstract.** The article covers the issue of using nuclear energy for hydrogen production. It analyzes the potential of nuclear technologies as a source of heat and electricity for hydrogen production processes, emphasizing their efficiency and environmental friendliness compared to traditional methods. The way nuclear energy can contribute to reducing the carbon footprint of hydrogen production is considered, which is especially relevant in the context of global efforts to decarbonize the energy sector.

**Keywords:** hydrogen, electrolysis, membrane, atomic hydrogen energy, efficiency, process, fuel.

# ИСПОЛЬЗОВАНИЕ ЯДЕРНОЙ ЭНЕРГЕТИКИ ДЛЯ ПОЛУЧЕНИЯ ВОДОРОДА

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**Аннотация.** В статье рассматривается вопрос использования ядерной энергетики для производства водорода. Анализируется потенциал ядерных технологий в качестве источника тепла и электроэнергии для процессов получения водорода с учетом их эффективности и экологичности по сравнению с традиционными методами. Обсуждается, каким образом ядерная энергетика может способствовать снижению углеродного следа в производстве водорода, что особенно актуально в контексте глобальных усилий по декарбонизации энергетики.

**Ключевые слова:** водород, электролиз, мембрана, атомно-водородная энергетика, эффективность, процесс, топливо.

Today, there are many types of fuel for energy production, one of which is hydrogen. Hydrogen is a promising source that can be used in the form of hydrogen fuel to produce environmentally friendly energy. According to the IEA (International Energy Agency) report, by 2050, global demand for hydrogen should reach 528 million tons – against 87 million in 2020 – and its share in global consumption will be 18 %. To date, hydrogen strategies have already been approved in 26 countries.

Developing and developed countries are very interested in introducing hydrogen as the main new type of fuel. Therefore, a large number of pilot projects for large-scale hydrogen production have already been created in many countries around the world. The global market for energy equipment for hydrogen energy, primarily electrolyzers and fuel cells, is also actively forming; its volume today is $5-7 billion, and by 2050 it may reach about $200-225 billion. Hydrogen energy is becoming increasingly relevant in the modern world for several reasons:

- environmental sustainability: the use of hydrogen as an energy source helps to reduce emissions of greenhouse gases and other harmful substances, which helps to combat climate change;
- diversification of energy sources: hydrogen can be obtained from various sources such as water, biomass energy, sun and wind; this allows for the diversification of energy sources and reduces dependence on oil and natural gas;
- innovation and economic growth: the development of hydrogen energy helps create new jobs, stimulates innovation and promotes economic growth.

The object of research is the chemical element hydrogen, and the subject of research is the entire energy industry. Hydrogen energy is an energy industry based on the use of hydrogen as a means for transporting, producing, charging and consuming energy. It refers to alternative energy if hydrogen is produced using renewable energy sources [1].

Hydrogen is a promising source of energy, having almost three times the energy capacity than fossil fuels. This means that much less hydrogen is required to perform similar work. Since it is found everywhere, it can be used directly at production sites. Unlike batteries, which are not capable of storing large amounts of electricity for a long time, hydrogen can be obtained from excess renewable energy and stored in significant quantities. There are three main sources of emissions contributing to global warming: transportation, electricity generation, and industry. Hydrogen can be used in all these areas. When used in fuel cells, hydrogen energy shows minimal losses, and the only by-product is water, from which, in turn, hydrogen can be extracted again. Among the methods of producing hydrogen from water, electrolysis, thermochemical and thermoelectrochemical cycles are of the greatest interest in the context of atomic hydrogen energy [2]. Electrolysis of water is a process in which an electric current passes through water (usually with the addition of an electrolyte to increase conductivity), splitting it into oxygen and hydrogen. The efficiency of the electrolysis process depends on many factors, including the type of electrolyte used, electrode material, and temperature and pressure. Electrolysis of water is one of the methods of producing pure hydrogen for use as fuel. The method of producing hydrogen by electrolysis of water was first demonstrated in the early 19th century. Scientists William Nicholson and Johann Ritter independently conducted experiments on water electrolysis in 1800. This discovery laid the foundation for understanding the processes that occur when an electric current is passed through water and became the basis for developing methods for producing hydrogen for industrial use. Since then, electrolysis technology has improved significantly, making the process more efficient and economical. Among the various methods of decomposition of water (electrochemical, thermal, thermochemical,

biochemical, photochemical, etc.), the electrolytic method has acquired the greatest technical maturity, which allows producing hydrogen with the useful use of the spent electrical energy at a level of about 70% [3]. There are three main types of electrolysis for hydrogen production, which differ in the type of electrolyte used and the conditions of the process.

**Alkaline electrolysis**

This is a process in which an electric current passes through an electrolyte solution (KOH or NaOH solution in a concentration of 20-30 %) from the anode to the cathode, as a result of which hydrogen and oxygen gases are formed on the electrodes, respectively. It works at relatively low temperatures (usually 60-80 °C) and pressure. This is the most common and well-studied method, which has been used in industry for many years.

Process reactions:

$2OH^- \rightarrow 0{,}5O_2 + H_2O + 2e^-$ cathode;

$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ anode;

$H_2O \rightarrow H_2 + 0{,}5O_2$ overall reaction.

Research aimed at improving the traditional water electrolysis process and increasing its cost effectiveness includes the development of electrolyzers with solid polymer electrolyte (SPE). This method of hydrogen production is historically associated with the development of the perfluorinated ion-exchange membrane Nafion by DuPont. The first electrolyzers with solid polymer electrolyte (SPE), also known as proton exchange membrane electrolyzers, were developed in the mid-20th century and began to be widely used in the 1960s. They were used in space programs, such as NASA's Gemini Project, to produce hydrogen and oxygen from water in space conditions, as well as for the needs of civilian industry.

The electrolyte membrane plays a key role in electrolyzers such as those used in alkaline electrolysis and solid polymer electrolyte (SPE) electrolysis. The main functions and characteristics of the electrolyte membrane in these systems are:

1. Ionic Conductivity: the membrane must have high ionic conductivity for the electrochemical reactions to proceed efficiently.

2. Selectivity: the membrane must allow only certain ions (such as protons in SPE) to pass through, preventing the electrolysis products (hydrogen and oxygen) from mixing.

3. Chemical stability: the membrane must be resistant to aggressive chemicals such as alkalis or acids, depending on the type of electrolysis.

4. Mechanical strength: the membrane must be able to withstand high pressure and temperature while maintaining its integrity and functionality.

In alkaline electrolysis, the membrane is often a diaphragm that separates the anode and cathode and prevents gases from mixing, but allows ions to move between the electrodes.

In TPE, a solid proton exchange membrane is used, which only allows protons to pass through, providing higher gas separation efficiency and energy efficiency of the process.

Both types of membranes contribute to the efficiency of hydrogen production and are important components in the development of sustainable energy systems.

The membrane of such electrolytes is a non-porous polymer based on perfluorinated carbons, which has high strength, resistance to chemical influences and excellent electrical conductivity. In these membranes, the charge carrier is a hydrated proton:

$4H^+ + 4e^- \rightarrow 2h_2$ (cathode);

$H_2O \rightarrow o_2 + 4H^+$ (anode).

**High temperature electrolysis**

The process of high-temperature electrolysis of water vapor is carried out in cells with a solid electrolyte, which consists of zirconium oxides and is modified by adding 10-15 % (mol.) oxides of certain elements to improve electrical conductivity. Such oxides include calcium, yttrium, selenium and vanadium oxides. This electrolyte has unipolar conductivity; current through it is carried by oxygen ions, which are formed as a result of dissociation of water and hydrogen release at the cathode according to the following equations:

$H_2O$ (steam) + $2e^- \rightarrow o_2 + H_2$ (gas) (cathode);

$O2^- \rightarrow 0.5\ O_2$ (gas) + $2e^-$ [4].

Nickel with 10 % molecular zirconium is widely used as a cathode, as well as lanthanum cobalt and praseodymium as an anode in high-temperature water vapor electrolyzers. These materials are chosen for their ability to withstand extreme conditions such as high temperatures and aggressive chemical environments.

In the process of high-temperature electrolysis, the voltage is usually higher than the thermodynamic equilibrium value, and part of the electrical energy used for decomposition is converted into heat.

Water electrolysis makes it possible to obtain hydrogen and oxygen without the use of chemical reagents, which makes this process a fairly simple and effective way to obtain these important gases. First, you need to prepare an electrolytic bath by filling it with distilled water. After that, connect the electrodes to a DC power source. When a current passes through water, it decomposes into hydrogen and oxygen, which are released at the cathode and anode, respectively. Water molecules break down into positively charged hydrogen ions and negatively charged oxygen ions. Hydrogen is formed at the cathode, and oxygen is formed at the anode. These gases can be collected and used for various purposes.

Water electrolysis proceeds according to the general summary expression:

H2O = H2 + 1/2O2.

To decompose water into hydrogen and oxygen, it is necessary to expend at least as much energy as is released by burning hydrogen. This is due to the law of conservation of energy: the energy used for decomposition is equal to the energy released during combustion. However, not all of this energy should be electric – you can also use the thermal energy of water in electrolyzers. As the water temperature increases, the contribution of thermal energy increases, which reduces the need for electrical energy. In some cases, this can provide significant advantages: it is possible to use heat from various sources, for example, from a nuclear reactor. The greatest energy savings are achieved at water temperatures of about a thousand degrees, but in such conditions the water turns into steam, which requires the use of a solid heat-resistant electrolyte.

There are basic requirements for electrode materials in this process:

- high electrocatalytic activity: the electrodes must effectively accelerate the oxidation and reduction reactions of water;
- chemical and electrochemical stability: the electrodes must withstand aggressive electrolysis conditions (acidic or alkaline environment, high potentials);
- low cost and availability: for commercial implementation of the process, it is important to use inexpensive and common materials;
- mechanical strength: the electrodes must maintain integrity over a long period of operation.

The most common electrode materials for water electrolysis are platinum, iridium, nickel and their alloys. Research is underway to develop cheaper and more efficient electrode materials based on base metals.

**Pressurized water electrolysis**

This is a process in which the energy of an electric discharge is used to split water molecules into hydrogen and oxygen at elevated pressure. Projects of this kind are usually designed to improve the performance of the electrolysis process, as high pressure promotes a higher concentration of hydrogen and oxygen in the gas mixture. This can improve energy efficiency and lead to lower production costs for these two important chemical elements.

This method is of considerable technical interest. Decomposition of 1 liter of water produces about 1,242 liters of hydrogen and 621 liters of oxygen, which increases the pressure by about 1,800 times during electrolysis in a closed volume.

Pressurized water electrolysis is one of the oldest processes associated with the use of electric discharge energy to split water molecules. However, the exact history of its discovery and invention is not as clear as that of other technologies. As a rule, the first records of obtaining elements by electrolysis can be attributed to the 19th century. In 1826, Christian Friedrich Scholte began research into the electrolysis of water at atmospheric pressure, which made it possible to obtain hydrogen and oxygen. This was an important step in the development of modern electrolysis technology.

Energy savings in the electrolysis of pressurized water are significant, as the production process is simplified by not having to install gas cylinders and compressors. Hydrogen and oxygen are produced immediately under pressure, which eliminates the additional energy costs of gas compression. It is important to note that significant energy savings during the compression stage are achieved at a relatively low pressure. With a further increase in pressure, the savings do not increase to the same extent. Pressurized water electrolysis reduces the voltage on the cell. When high pressure is used in the electrolysis process, water is split with a lower current intensity than in atmospheric electrolysis. High pressure promotes a faster mass exchange between hydrogen and oxygen gas inside the cell, which improves the flow of current through it. As a result, this leads to a decrease in the voltage required to maintain a given rate of water electrolysis and obtain the desired amount of chemicals [5].

Data analysis has shown that hydrogen has significant potential to reduce dependence on fossil fuels, lower carbon emissions and create a greener energy

system. Hydrogen has a high energy density and can be stored for a long time. These features make it attractive as a clean energy source for various sectors, including energy, transport and industry. However, there are challenges, such as the high cost of producing hydrogen, the need to develop infrastructure for its use and safety issues.

It is assumed that within 10-15 years hydrogen will begin to actively displace organic energy sources in the market of developed countries.

Further research in the field of hydrogen energy can contribute to the development of more efficient and economically feasible technologies, as well as the expansion of the use of hydrogen in various areas of life. This will create a more sustainable and environmentally friendly energy system that promotes development.

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# COMPARATIVE ANALYSIS OF PROGRAMMING LANGUAGES KOTLIN AND SWIFT

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**Abstract.** This article presents a comparative analysis of two modern programming languages Kotlin and Swift which are widely used for mobile application development on Android and iOS platforms, respectively. Both languages are characterized by modern syntax features, support for type safety, and extensive code optimization capabilities. The study provides a comparative evaluation of their performance, multithreading capabilities, ecosystem and framework support, and entry thresholds for developers. The results of this research can assist in selecting the most appropriate language for development depending on the project's goals.

**Keywords:** Kotlin, Swift, mobile development, Android, iOS, cross-platform development, performance, multithreading, ecosystem.

# СРАВНИТЕЛЬНЫЙ АНАЛИЗ ЯЗЫКОВ ПРОГРАММИРОВАНИЯ KOTLIN И SWIFT

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**Аннотация.** Данная статья представляет сравнительный анализ двух современных языков программирования – Kotlin и Swift, которые широко используются для разработки мобильных приложений на платформах Android и iOS соответственно. Оба языка характеризуются современными синтаксическими особенностями, поддержкой безопасной типизации и широкими возможностями для оптимизации кода. В работе проводится сравнительное исследование производительности, возможностей многопоточности, поддержки экосистемы и фреймворков, а также оценивается порог входа для разработчиков. Результаты исследования помогут выбрать наиболее подходящий язык для разработки в зависимости от целей проекта.

**Ключевые слова:** Kotlin, Swift, мобильная разработка, Android, iOS, кросс-платформенная разработка, производительность, многопоточность, экосистема.

## Introduction

With the advancement of mobile technology, developing applications for Android and iOS platforms has become a crucial task for most software development companies. To simplify and speed up the development process, two modern programming languages were created: Kotlin and Swift. Kotlin, developed by JetBrains, was released in 2011 and became the primary language for Android development [1, p. 5]. Swift, created by Apple in 2014, replaced Objective-C in the iOS ecosystem and has gained widespread recognition for its simplicity and performance. Currently, Swift and Kotlin are widely used for mobile application development and continue to evolve thanks to support from the developer community and large companies like Apple and Google. The goal of this article is to conduct a comparative analysis of these languages based on key characteristics that affect the development process.

## History and Development of the Languages

Kotlin was initially developed as an enhancement to Java for the Android platform, aiming to eliminate its shortcomings and improve ease of development. Since Google's official endorsement in 2017, Kotlin has become the standard for Android development [1, p. 6].

Swift was developed by Apple as a replacement for Objective-C, an outdated language with more complex syntax. Swift offered developers code simplicity and safety, which significantly simplified application development within the Apple ecosystem. Regular updates to Swift continue to improve performance and expand its capabilities.

## Main Characteristics of the Languages

Comparison of these languages based on key parameters is provided in Table.

Table – Comparison of Kotlin and Swift Based on Key Characteristics

| **Technology** | **Swift** | **Kotlin** |
|---|---|---|
| Developed by | Chris Lattner with other Apple developers | JetBrains |
| Year Released | 2014 | 2016 |
| Performance | High | High |
| Language Type | Statically typed and compiled, supporting object-oriented, functional, and imperative programming paradigms | Statically typed |
| Best Suited For | Development of native applications for Apple platforms and server applications | Mobile app development, server-side development, web development, and desktop applications |
| Cost | Open source | Open source |
| Inheritance | Supported | Supported |
| Developer Availability | Moderate to high | Growing due to popularity in Android development |
| Current Stable Version | 5.8 | 1.8.20 |
| Learning Curve | Steep | Steep |
| GitHub Stars | 62K+ | 44K+ |

| | | |
|---|---|---|
| Popular Applications | Airbnb, LinkedIn, Uber, Slack, Pandora, Strava, etc. | Trello, Coursera, Postmates, Pinterest, Duolingo, Uber, Slack, Airbnb, Netflix, etc. |
| Community | Active and evolving | Fast-growing and active developer community |
| File Extension | .swift | .kt, .kts, .ktm |

Both languages offer concise and expressive syntax aimed at error prevention. Kotlin and Swift support null safety, functional programming, and high-level constructs that help minimize bugs and improve code readability. A key feature of Kotlin is its integration with Java and compatibility with the JVM, allowing the use of extensive Java resources and libraries. Swift, on the other hand, provides advantages for development within the Apple ecosystem, enabling fast and efficient application development for iOS and macOS [2, p. 41].

**Syntax and Ease of Use**

Kotlin and Swift have a similar approach to simplifying syntax. Both languages support higher-order expressions, lambda functions, and closures, allowing developers to write code more functionally and succinctly. This reduces the likelihood of errors and simplifies code maintenance [2, p. 93].

***Example Function in Kotlin***

```
fun greet(name: String): String {
    return "Hello, $name"
}
```

***Similar Function in Swift***

```
func greet(_ name: String) -> String {
    return "Hello, \(name)"
}
```

**Type Safety**

Type safety is critical in mobile applications, as incorrect data can lead to crashes and a poor user experience. Kotlin and Swift implement strict type systems that support nullable and non-nullable types. Kotlin introduces the “?”, “!!”, and “let” operators for handling null values, while Swift uses “?” and “!” operators for similar purposes, minimizing the risk of errors and enhancing stability.

**Performance and Memory Management**

Swift is a compiled language translated to machine code, ensuring high performance on Apple devices. Swift uses Automatic Reference Counting (ARC) for memory management, automatically managing object lifetimes and preventing memory leaks. Its performance is comparable to Objective-C and, in some cases, surpasses it. Swift allows developers to write programs that can execute multiple tasks simultaneously, known as concurrency, which enhances the speed and efficiency of programs. Swift includes tools such as Grand Central Dispatch and Operation Queues that simplify writing concurrent programs, enabling developers to

harness the power of multi-core processors for additional performance gains [3, p. 56].

Kotlin is designed for high performance and smooth execution. One of Kotlin's key features contributing to its performance is its static type system, which allows the compiler to optimize code for better performance. Since Kotlin runs on the Java Virtual Machine (JVM), it may slightly lag behind Swift in hardware-level interaction as it works with JVM bytecode. However, Kotlin Multiplatform enables cross-platform programming, making Kotlin a preferred choice for projects requiring multi-platform support [4, p. 115].

**Structs**

Kotlin and Swift have different approaches to structs. In programming, a struct allows developers to group a set of variables under a single name, representing a value or reference. Swift provides flexibility for developers to choose any structure that best suits their needs, whereas Kotlin doesn't have distinct struct types, although basic types like int, float, and Boolean are passed by value.

**Multithreading Support**

Multithreading is a critical aspect when creating mobile applications. Kotlin offers a powerful and easy-to-use multithreading model through Coroutines, allowing asynchronous operations to be executed with minimal complexity. Coroutines in Kotlin make code cleaner and more manageable, ensuring efficient background task execution.

Swift uses Grand Central Dispatch (GCD) for asynchronous tasks. GCD provides developers with a straightforward way to manage threads, enhancing application performance and making multitasking more manageable.

**Default Class Behavior**

Kotlin restricts adding or modifying code as a default function, whereas Swift allows extensions for additional functionality. This flexibility gives Swift an advantage by allowing developers more options for extension.

**Ecosystem and Development Tools**

Both languages are supported by powerful IDEs. Kotlin is integrated with Android Studio, making it convenient for Android developers. Kotlin also supports cross-platform solutions, such as Kotlin Multiplatform, allowing a single codebase for Android and iOS applications. Kotlin relies on Java's extensive ecosystem, enabling developers to use existing Java libraries and frameworks seamlessly. Additionally, Kotlin has its own standard library and supports Gradle for dependency management, simplifying the integration of external libraries.

Swift is used within Xcode, Apple's official development environment, which offers complete integration with Apple frameworks like UIKit and SwiftUI. Xcode provides developers with powerful tools for application optimization and working with native device features. The Swift Package Manager simplifies the process of integrating third-party libraries into Swift projects.

**Developer Entry Threshold**

Kotlin and Swift have a low entry threshold for new developers. For those already familiar with Java, switching to Kotlin is quick, thanks to similar syntax and integration with existing Java code. Swift is also considered intuitive, especially with extensive documentation and educational resources like Swift Playgrounds.

**Applications**

Kotlin is widely used for Android applications, including Trello, Pinterest, and Uber. Kotlin is also actively applied in server-side development, thanks to the Ktor framework [5, p. 73].

Swift, as the main language for iOS, is used in applications such as Lyft, LinkedIn, and Airbnb. Apple actively promotes Swift as the primary language for developing applications for iOS, macOS, and other Apple platforms.

**Community and Support**

The Kotlin community has expanded significantly since Google officially designated Kotlin as the primary language for Android development in 2017. The platform is supported by JetBrains, which actively develops the language and provides tools such as Android Studio, optimized for Kotlin.

**Advantages of the Kotlin Community**

Active forums and online resources: Kotlin has an active community on StackOverflow, Reddit, and GitHub, where developers can find numerous ready-made solutions and libraries.

Regular updates and JetBrains support: JetBrains releases language updates and improves the ecosystem based on community feedback.

Educational resources: a wide range of courses, documentation, tutorials, and webinars, such as those on Kotlinlang.org, make the language accessible to beginners and professionals.

Kotlin Multiplatform: the growing popularity of cross-platform development enhances community support as developers can use Kotlin for iOS and other platforms.

Swift also has a robust and active community. As the native language for iOS and macOS, it is supported by Apple, ensuring its development and integration with new technologies.

**Advantages of the Swift Community**

Apple support and Xcode integration: Apple actively updates Swift and develops frameworks such as SwiftUI, simplifying application development. Xcode offers reliable tools for debugging and testing.

Active developer community: Swift has a large number of active users on GitHub, Apple Developer forums, and StackOverflow, enabling quick solutions to emerging questions.

Documentation and resources from Apple: Apple provides extensive official documentation, code examples, and training courses, such as “Swift Playgrounds,” which help beginner developers.

Open-source support: Swift is an open-source project, and its development is actively supported by the community, contributing to language improvement and its libraries [6, p. 54].

**Developer Salaries by Qualification Level**

According to Habr Career data, entry-level developers with minimal experience earn between 55,000 and 70,000 rubles. Mid-level specialists (mid-level developers) receive an average of around 125,000 rubles, while senior developers typically do not consider offers below 200,000 rubles. As for development leads, their salaries can be significantly higher, as there is effectively no upper limit for this position. In the Figure you can see the difference between salaries of Swift and Kotlin Developers in the Second Half of 2020, according to Habr Career Data.

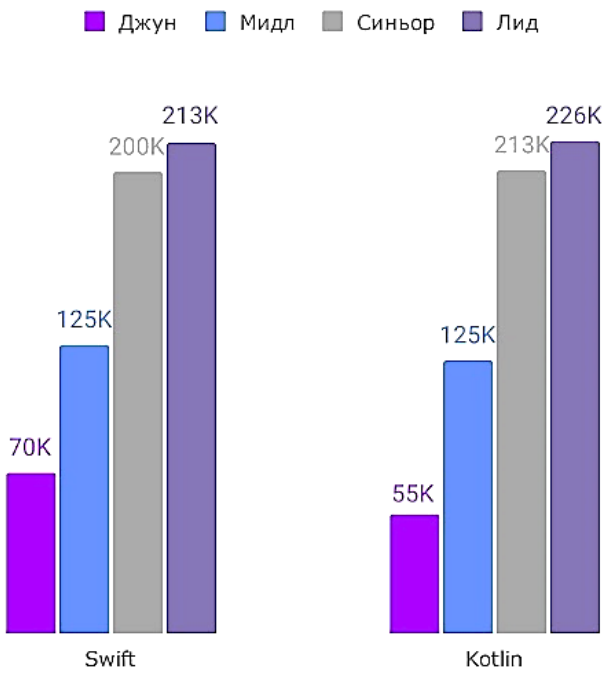


Figure. Salaries of Swift and Kotlin developers in the second half of 2020, according to Habr Career Data

**Conclusion**

This article conducts a comparative analysis of the Kotlin and Swift languages, which are actively used in mobile development. Kotlin offers seamless integration with Java and extensive cross-platform development capabilities, making it an excellent choice for projects targeting multiple platforms. Swift, in turn, demonstrates high performance and deep integration within the Apple ecosystem, making it the preferred choice for developing applications for iOS and macOS.

The choice between Kotlin and Swift depends on the platform and project specifics. Kotlin is better suited for developing Android applications or cross-platform solutions, while Swift is the optimal choice for native development within the Apple ecosystem.

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# EVOLUTION OF ARTIFICIAL INTELLIGENCE: FROM ALGORITHMIC FOUNDATIONS TO SELF-LEARNING SYSTEMS

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**Abstract.** This article provides an overview of the development of artificial intelligence (AI), from its algorithmic foundations to modern advances in deep learning. It describes key concepts and technological breakthroughs, such as machine learning, neural networks, and generative adversarial networks, and their impact on various areas of life. Particular attention is paid to the issues of ethics and social responsibility associated with the development of AI. The article concludes with a discussion of the current state of AI and its future prospects, including its potential impact on science and society.

**Keywords:** artificial intelligence, machine learning, deep learning, neural networks, generative adversarial networks, AI ethics, future of AI, reinforcement learning.

# ЭВОЛЮЦИЯ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА: ОТ АЛГОРИТМИЧЕСКИХ ОСНОВ ДО САМООБУЧАЮЩИХСЯ СИСТЕМ

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**Аннотация.** В статье представлен обзор развития искусственного интеллекта (ИИ), начиная с его алгоритмических основ и заканчивая современными достижениями в области глубокого обучения. Описываются ключевые концепции и прорывы в технологиях, такие как машинное обучение, нейронные сети и генеративно-состязательные сети, а также их влияние на различные сферы жизнедеятельности. Особое внимание уделяется вопросам этики и социальной ответственности, связанным с развитием ИИ. В заключительной части статьи рассматриваются текущее состояние ИИ и перспективы его будущего развития, включая потенциальное влияние на науку и общество.

**Ключевые слова:** искусственный интеллект, машинное обучение, глубокое обучение, нейронные сети, генеративно-состязательные сети, этика ИИ, будущее ИИ, обучение с подкреплением.

Artificial Intelligence (AI) is a field of computer science dedicated to creating machines that can mimic and augment human cognitive functions, including learning, problem solving, and perception. The concept of AI was first articulated and introduced into academia in the mid-20th century, when researchers began to explore the possibility that machines could perform tasks that required human intelligence.

The historical context of artificial intelligence began with myths, legends, and stories about mechanical humans and intelligent machines, long before computer programming was possible [1-3]. Ancient myths and stories often refer to automata that have traits and abilities similar to humans, reflecting humanity's longstanding desire to create artificial intelligence.

The beginning of the modern stage of AI development is often associated with the work of Alan Turing, who in 1950 published an article "Computing Machinery and Intelligence", in which he proposed the concept and criteria of machine intelligence, known as the "Turing test". This was one of the first attempts to quantify the intelligence of machines.

A seminal event was the 1956 Dartmouth Conference, which is considered the birth of AI as an academic discipline. At this conference, researchers such as John McCarthy and Marvin Minsky discussed the possibilities of creating machines that could use language, form abstractions and concepts, solve problems currently being solved by humans, and improve themselves.

In the decades that followed, AI continued to evolve, although it did not always go smoothly. Periods of intense research and optimism, referred to as "AI summers," alternated with periods of frustration and funding cuts, known as "AI winters". Despite these fluctuations, incremental improvements in algorithms, increased computing power, and the availability of big data have led to significant progress.

Today, AI is one of the most dynamic and influential areas of technology, covering a vast range of applications from automatic translation and speech recognition to self-driving cars and personalized medicine. It continues to evolve, transforming industry and society, and offers the promise and challenges that will shape the future of humanity.

The algorithmic foundations of artificial intelligence encompass a wide range of techniques and approaches that have been developed to mimic or replicate various aspects of human thinking and intelligence. The foundation of AI is algorithms – sequences of instructions for performing tasks that provide the foundation for the development of intelligent systems.

AI research began with the creation of models based on formal logic and rules. These early approaches, such as expert systems, sought to model human reasoning by applying sets of logical rules to a knowledge base. Expert systems were some of the first successful implementations of AI, applied in fields ranging from medical diagnosis to mineralogical research.

With advances in computing and mathematics, researchers' attention has shifted to more complex models, such as neural networks, which are inspired by the structure and functioning of the human brain. Neural networks consist of layers of interconnected nodes or "neurons" that can learn from data and perform complex tasks such as pattern recognition and natural language processing.

One of the key moments in the development of neural networks was the introduction of the error back propagation algorithm in the 1980s, which enabled efficient training of multilayer networks. This discovery led to significant advances in the training of neural networks and became the foundation for modern deep neural networks. Deep learning, a subsection of machine learning based on the use of deep neural networks, has been made possible by the increased computational power and availability of large amounts of data. These networks can contain hundreds of layers and millions of neurons capable of learning from raw data, detecting complex patterns, and performing tasks previously thought to be beyond the reach of machines.

Modern neural networks can perform a wide range of tasks, from automatically recognizing speech and images to creating autonomous agents that can learn to play games and drive autonomous vehicles. They have become the basis for many of the advanced AI systems we use in everyday life.

The transition from logic machines to neural networks reflects the evolution of artificial intelligence from strict, rule-driven systems to flexible, trainable models that can adapt and evolve to provide increasingly sophisticated and powerful tools for problem solving.

The development of machine learning (ML) has been one of the most significant advances in artificial intelligence, providing a framework for creating systems that can learn and adapt on their own without explicit programming. ML falls into three main categories: supervised learning, unsupervised learning, and reinforcement learning, each with unique approaches and applications [4].

Supervised learning is the most common type of machine learning. In this approach, the model is given examples of input data and their corresponding output data, and the model's task is to learn the relationships between them in order to make predictions or decisions. The data used for training is usually labeled by experts or through other methods to provide an accurate training sample. Examples of applications of supervised learning include speech recognition, where the model is trained to correctly interpret audio files, or medical diagnosis, where the model is trained to identify diseases based on clinical data from patients.

Unsupervised learning, unlike supervised learning, uses data without any labeling or annotation. The task of the model is to detect structures, patterns or clusters in the data. This type of learning is ideal for exploring data when the exact results are unknown or when potential relationships between variables are being explored. Examples include clustering customers for marketing purposes, where the model can identify groups of customers with similar buying habits, or principal component analysis to reduce the dimensionality of the data.

Reinforcement learning differs from the other two types in that the model learns on the basis of a reward or punishment for actions taken. In this approach, the

agent (model) interacts with a dynamic environment in an attempt to maximize some reward through a series of trial and error. This process is similar to how humans or animals learn from the consequences of their actions. Applications of reinforcement learning include the development of autonomous robots that must adapt to changing conditions in real time, or artificial intelligence systems that can learn to play complex games such as chess or Go, achieving levels that surpass the best human players.

Each of these machine learning approaches has its own advantages and limitations and can be applied depending on the specific task and data availability. Using these techniques together can also lead to hybrid systems that can take advantage of different approaches to achieve even more powerful results. The development of machine learning continues to be a dynamic and rapidly evolving field, with the promise of greatly expanding the capabilities of artificial intelligence in the near future.

Breakthroughs in deep learning, a subcategory of machine learning using deep neural networks, have been one of the key factors driving the current direction of artificial intelligence. Deep learning allows systems to self-learn by extracting high-level abstractions from data through hierarchical structures, which significantly improves their performance and generalization ability.

Self-learning systems based on deep learning are able to automatically find optimal data representations while requiring minimal human intervention. This is achieved through the use of multilayer neural networks that can process huge amounts of unstructured data and extract complex patterns from it. Such systems are trained using large data sets and the computing power of modern processors, which allows them to independently improve their algorithms [5].

The impact of deep learning on technological innovation is enormous. In the field of computer vision, for example, deep neural networks have enabled revolutionary results in image recognition and classification, which is being applied to automatic analysis of medical images, video surveillance systems, and autonomous vehicles. In natural language processing, deep learning has provided the basis for machine translation systems, chatbots and voice assistants capable of natural dialog with humans.

Self-learning systems have also influenced areas such as recommendation systems, which are used by online stores and streaming services to suggest products and content that match user preferences. In the financial sector, deep learning algorithms are used for fraud detection and risk management. In scientific research, deep learning is used to analyze large amounts of data, leading to new discoveries in genomics, high-energy physics, and many other areas.

However, despite significant advances, deep learning faces a number of challenges and limitations, such as the need for large amounts of data, high computational costs, lack of interpretability, and the risk of increasing bias in the data. Addressing these challenges is the subject of ongoing research, and future innovations are expected to address many of these limitations, paving the way for even more advanced and efficient deep learning systems.

One notable example of deep learning based technology is GANs (Generative Adversarial Networks) neural networks. These networks consist of two parts: a generator, which creates the data, and a discriminator, which evaluates how well the data matches the real data. Working together, they improve each other until the generator learns to produce very realistic images, texts or music. The way GAN works is shown in Figure.

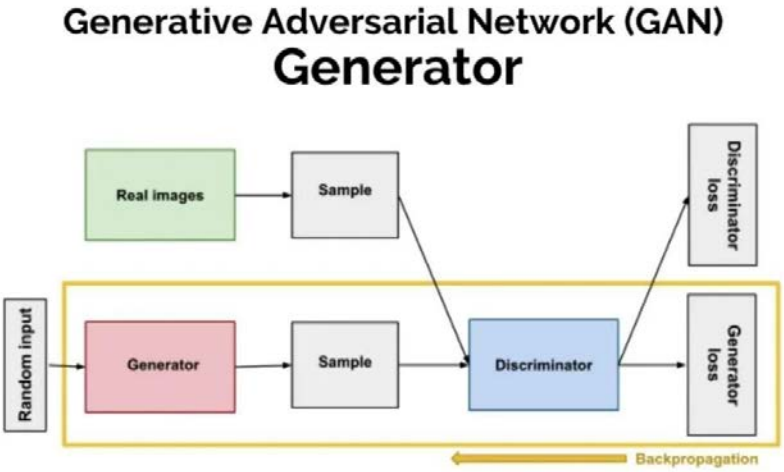


Figure. How Generative Adversarial Networks work

GANs have been used in a variety of applications, from creating photorealistic images of people's faces that never existed to improving the quality of old videos. In the fashion industry, GANs are used to create new clothing designs, and in the film industry, they are used to create more realistic special effects and even to "de-aging" actors, a process of visual rejuvenation on screen. GANs are also being applied in medicine, for example, to generate synthetic medical images to train computer vision systems, thereby improving diagnostic systems without the need for real patient data, thus reducing privacy risks [6].

These examples demonstrate how deep learning can be used to create groundbreaking applications that were previously thought impossible.

In the final part of the scientific article devoted to the evolution of artificial intelligence (AI), it is worth summarizing the results achieved and outlining the prospects for the future. Today, AI has reached incredible heights: from systems that can beat humans at the most complex games, such as Go and chess, to algorithms that predict protein structure with accuracy comparable to experimental methods. Machine vision systems can now recognize objects and faces with a level of accuracy that surpasses human ability. In the area of natural language processing, AI algorithms such as GPT-4 have demonstrated the ability to understand and produce text that is sometimes indistinguishable from human writing.

However, despite significant progress, there are many areas where AI is still just beginning to reach its potential. The amount of available data and computing power continues to grow, which is helping to improve the quality and speed of training AI models. New algorithms are emerging that can work with less data and

make more efficient use of available resources, making AI more accessible to a wide range of researchers and developers.

However, along with opportunities come challenges. The ethics and security of AI remain at the center of the debate. Systems need to be developed that are not only effective, but also transparent, fair and accountable. Social and legal norms must evolve with the technology to ensure it is used safely and responsibly.

Going forward, AI promises to revolutionize medicine, education, transportation, and many other fields. With the improvement of reinforcement learning technologies and the development of methods of knowledge transfer between different AIs, we can expect to see systems that not only perform given tasks, but are also capable of self-learning and adapting to changing conditions.

An important direction is the integration of AI with other technological advances, such as quantum computing and bioengineering, which can lead to synergies in scientific discoveries and technological innovations. Thus, the future of this technology is envisioned not just as the next step in automation, but as the basis for a new era in which the boundaries of what is possible will shift significantly.

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# HYDROGEN TECHNOLOGIES: THE PATH TO SUSTAINABLE ENERGY THROUGH ELECTROLYSIS AND STEAM CONVERSION OF METHANE

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**Abstract.** This article examines the evolution of scientific approaches to energy production with an emphasis on environmental aspects. Steam methane reforming (SMR) is one of the most promising methods for producing hydrogen with less environmental impact. This process involves converting methane into hydrogen and carbon dioxide at high temperatures using water vapor. Although SMR generates carbon dioxide, its carbon footprint is significantly lower compared to traditional methods.

**Keywords:** steam conversion of methane, pyrolysis, carbon dioxide, ecology, energy.

# ВОДОРОДНЫЕ ТЕХНОЛОГИИ: ПУТЬ К УСТОЙЧИВОЙ ЭНЕРГЕТИКЕ ЧЕРЕЗ ЭЛЕКТРОЛИЗ И ПАРОВУЮ КОНВЕРСИЮ МЕТАНА

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**Аннотация.** В данной статье рассматривается эволюция научных подходов к производству энергии с акцентом на экологические аспекты. Паровая конверсия метана (ПКМ) представляет собой один из наиболее перспективных методов получения водорода с меньшим экологическим воздействием. Этот процесс включает преобразование метана в водород и углекислый газ при высоких температурах с использованием водяного пара. Хотя ПКМ генерирует углекислый газ, его углеродный след значительно ниже по сравнению с традиционными методами.

**Ключевые слова:** паровая конверсия метана, пиролиз, углекислый газ, экология, энергетика.

Since the onset of the Middle Ages, when energy sources were primarily limited to biomass and coal, humanity has gradually transitioned to the use of fossil fuels. This shift has resulted in significant emissions of carbon dioxide and other harmful substances into the atmosphere. In today's world, the energy sector is confronted with serious challenges related to climate change and the urgent need to reduce its carbon footprint. Hydrogen technologies, particularly those involving hydrogen production through water electrolysis and steam methane reforming, are becoming essential for minimizing the carbon footprint within the energy sector. These methods not only facilitate the production of clean hydrogen but also aid in the capture and utilization of carbon dioxide, making them especially pertinent in the global fight against climate change. Steam methane reforming (SMR) is one of the primary methods for hydrogen production. This process entails the reaction of methane with water vapor, resulting in the creation of synthesis gas – a mixture of hydrogen ($H_2$) and carbon monoxide (CO). The SMR process consists of two main stages:

1. The first stage: methane reacts with water vapor to form a synthesis gas:

CH4+H2O→CO+3H2*CH*4+*H*2*O*→*CO*+3*H*2

2. The second stage: carbon monoxide (CO) undergoes a reaction with water vapor to produce additional hydrogen and carbon dioxide:

CO+H2O→CO2+H2*CO*+*H*2*O*→*CO*2+*H*2

This approach is known for its high energy efficiency, but it also results in considerable carbon dioxide emissions. To mitigate these emissions, carbon capture and storage (CCS) technologies are employed, which help lower the process's carbon footprint [1].

Water electrolysis involves breaking down water into hydrogen and oxygen using electricity. This method is regarded as cleaner than the steam conversion of methane, as it does not generate carbon dioxide when renewable energy sources are utilized for electricity generation. The electrolysis process unfolds as follows:

2H2O→2H2+O22*H*2*O*→2*H*2+*O*2

At the same time, the efficiency of electrolysis may vary depending on the technologies and energy sources used.

Table 1 – Comparisons of advantages and disadvantages of electrolysis and SMR methods

| **Method** | **Advantages** | **Disadvantages** |
|---|---|---|
| Steam reforming | High energy efficiency; the possibility of recycling $CO_2$ | Significant $CO_2$ emissions without CCS |
| Electrolysis of water | Purity of the process; no $CO_2$ emissions when using renewable energy sources | Low efficiency compared to SMR |

Methane pyrolysis is another method for hydrogen production, characterized by its unique features and benefits. Let's explore the primary advantages of methane pyrolysis compared to the well-established SMR process.

**Key Advantages of Methane Pyrolysis**

- No $CO_2$ emissions: methane pyrolysis takes place without the presence of oxygen, preventing the generation of carbon dioxide during the process. In contrast to SMR, which produces $CO_2$ as a by-product, pyrolysis enables hydrogen production without any direct $CO_2$ emissions.
- Production of solid carbon: this method yields solid carbon, which can be utilized in various industrial applications or recycled, making it a valuable by-product. This also contributes to reducing the overall carbon footprint of the process.
- Energy efficiency: while steam methane reforming is known for its high energy efficiency, methane pyrolysis requires significantly less energy per kilogram of hydrogen produced (ranging from 0.7 to 3.3 kWh) compared to both electrolysis and SMR. This makes pyrolysis a more cost-effective option, especially in environments with high energy prices.
- Reduced dependence on $CO_2$ capture technologies: unlike SMR, which necessitates the implementation of CCS technologies, methane pyrolysis does not incur additional costs for these systems, thereby lowering the overall expenses associated with hydrogen production.
- Flexibility in energy source utilization: pyrolysis can utilize a variety of energy sources, including renewables, which helps minimize the carbon footprint of the entire process. This adaptability makes it well-suited to evolving energy landscapes [2].

Hydrogen produced through methane pyrolysis finds applications across various industries, making it a crucial component in the shift towards more sustainable energy solutions. Here are some primary applications:

1. Energy Sector

- Fuel cells: hydrogen can be employed in fuel cells to generate electricity, thereby reducing carbon emissions and enhancing the environmental performance of energy systems.
- Alternative fuel: it serves as a clean fuel for vehicles, aiding in the decarbonization of the transportation sector.

2. Chemical Industry

- Ammonia production: hydrogen is essential for synthesizing ammonia, a key ingredient in fertilizers and other chemical products.
- Methanol and other chemicals: hydrogen acts as a raw material for producing methanol and various carbon-based compounds used in numerous industrial processes.

3. Metallurgy. Coal Substitution: hydrogen can function as a reducing agent in metallurgical processes, decreasing reliance on coal and lowering carbon dioxide emissions.

4. Waste management. Organic waste recycling: ethane pyrolysis can recycle organic waste, generating hydrogen and other valuable products from waste materials.

5. New materials. Carbon production: the process yields solid carbon that can be used to create advanced carbon nanomaterials such as graphene and carbon nanotubes, which have applications in electronics, construction, and other high-tech fields.

6. Domestic applications. Heating and hot water supply: hydrogen can be utilized in heating systems and hot water supply, helping to reduce emissions associated with traditional fossil fuels.

Despite these advantages, steam methane reforming still boasts higher energy efficiency – up to 75 % without CCS. However, when CCS is employed to mitigate $CO_2$ emissions, this efficiency drops to 60 % due to the additional energy costs associated with capturing and storing carbon dioxide, potentially increasing hydrogen production costs by over 30 %.

Table 2 – Comparison of different methods of hydrogen production with and without hydrogen storage technology

| **Hydrogen production method** | **Energy efficiency without CCS (%)** | **Energy efficiency with CCS (%)** |
|---|---|---|
| SMR | 75 | 60 |
| Pyrolysis of methane | 58 | 58 |
| Coal gasification | 60 | 43 |
| Biomass gasification | 30-50 | - |
| Thermochemical splitting of water | 20-45 | - |
| Electrolysis of water | 50-70 | - |

As can be seen from Table 2, steam methane conversion is more efficient than pyrolysis (58 %) and coal gasification (60 % without CCS) [3].

Unfortunately, the steam conversion of methane is accompanied by significant CO2 emissions: for every ton of hydrogen produced, about 10 tons of CO2 are released. This makes SMR less attractive in light of global decarbonization efforts. In contrast, methane pyrolysis avoids CO2 emissions, as the process takes place without oxygen access, producing only hydrogen and solid carbon.

The cost of hydrogen production by the SMR method is one of the key factors determining its competitiveness compared to other methods. Let's take a closer look at the cost of various technologies.

1. Steam Methane Conversion (SMR)

- Current value: about $1.7. /Kg at current gas prices, even taking into account CO2 capture and storage systems (CCS).
- Prospects: it is expected to decrease to $ 1.6/kg by 2030-2035 due to cheaper CCS technologies and increased efficiency.

2. Electrolysis of water

- Current cost: hydrogen production by electrolysis using electricity from nuclear power plants or hydroelectric power plants is about $3.2/kg. In the future, the price may decrease to $2.3/kg.
- Comparison: electrolysis from renewable sources (wind and solar energy) is much more expensive, with prices in the range of $3.7–$17.3/kg.

3. Pyrolysis of methane

- Current cost: about 0.5–1 USD/kg, which makes it one of the most cost-effective methods. This technology also does not require CO2 capture, which reduces additional costs [4].

Thus, steam conversion of methane remains the most cost-effective method of hydrogen production at the moment, especially in conditions of low natural gas prices. However, methane pyrolysis offers significant advantages both in terms of cost and environmental aspects. Electrolysis, although considered a cleaner method, is still expensive and less competitive without significant subsidies or lower prices for electricity from renewable sources. In the future, it is important to continue research and implement new technologies to increase efficiency and reduce environmental impact.

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# INNOVATIONS IN THE FIELD OF ROBOTIZATION OF EUROPEAN AGRICULTURE

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**Abstract.** The article is devoted to the impact of robotic technologies on sustainable development and the environment, as well as the problems and prospects of their implementation in agriculture. The possibilities of using robots to increase productivity, reducing costs and improving product quality are discussed, as well as the need for high investments, staff training and standards development. In conclusion, the prospects for the development of agriculture using robotic technologies are considered, attention is focused on their potential for ensuring food security and sustainable development of the agricultural sector.

**Keywords:** robotic technologies, agricultural robots, sustainable development, precision farming, automation, agrotechnology, environmental sustainability, innovation in agriculture.

# ИННОВАЦИИ В СФЕРЕ РОБОТИЗАЦИИ ЕВРОПЕЙСКОГО СЕЛЬСКОГО ХОЗЯЙСТВА

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**Аннотация.** Статья посвящена влиянию роботизированных технологий на устойчивое развитие и окружающую среду, а также проблемам и перспективам их внедрения в сельское хозяйство. Обсуждаются возможности использования роботов для повышения продуктивности, снижения затрат и улучшения качества продукции, а также необходимость высоких инвестиций, обучения персонала и разработки стандартов. В заключении рассматриваются перспективы развития сельского хозяйства с использованием роботизированных технологий, акцентируется внимание на их потенциале для обеспечения продовольственной безопасности и устойчивого развития аграрного сектора.

**Ключевые слова:** роботизированные технологии, сельскохозяйственные роботы, устойчивое развитие, точное земледелие, автоматизация, агротехнологии, экологическая устойчивость, инновации в сельском хозяйстве.

Agricultural robotics is one of the most promising areas of modern technology. Over the past few decades, automation and robotics have penetrated various industries, and agriculture is no exception. Robots and automated systems used in agriculture are designed to perform a variety of tasks, from planting and tending to harvesting and tillage. The main drivers for the development of agricultural robotics include population growth and food demand, labour shortages, the need for greater efficiency and accuracy, and environmental challenges. As the world's population grows, so does the demand for food, which means that agricultural production must become more efficient. In some regions, there is a shortage of labour to carry out heavy and monotonous agricultural work. Modern technology can significantly increase productivity and reduce costs, while improving product quality. Agriculture must become more sustainable and environmentally friendly, which requires the introduction of new technologies to reduce the use of chemicals and optimise resources.

Agricultural robotics includes a variety of devices and systems, such as autonomous tractors, drones for field monitoring, robots for planting and harvesting, and systems for precise application of fertilisers and pesticides. These technologies not only make farmers' work easier, but also open up new opportunities for increasing crop yields and sustainable agricultural development.

Automation in agriculture is important and has a multifaceted impact on different aspects of the industry. Firstly, automated systems and robots are able to perform tasks faster and more accurately than human labour, allowing significant increases in production volumes and reductions in time spent on routine operations. Secondly, the use of automated systems can reduce labour costs as well as fuel, water and chemical costs through more precise and efficient application. Precise and controlled processes provided by robots contribute to improved product quality. For example, harvesting robots can select the ripest and highest quality fruit, minimising loss and damage. Automation also allows the use of resources such as water and fertiliser to be optimised, reducing the negative impact on the environment. Precise chemical application systems help reduce the amount of chemicals used while maintaining efficiency.

Automated systems also take over heavy and dangerous tasks, reducing the risk of injury and improving working conditions for farmers. Modern automated systems are equipped with sensors and communication tools that allow real-time monitoring of field and crop conditions and control of processes using mobile applications and computer programs. The introduction of automation stimulates the development of new technologies and innovations in agriculture, opening up new opportunities for research and improvement of existing farming methods. Automation in agriculture thus plays a key role in ensuring food security, increasing the efficiency and sustainability of agricultural production, and improving the working conditions and quality of life of farmer [1].

One of the shining examples of innovative solutions in agricultural robotics is the John Deere See & Spray system, a real breakthrough in precision herbicide application. The system is designed to increase the accuracy and efficiency of chemical application in the field. Traditional methods of herbicide application often result in excessive use of chemicals, which not only increases costs but also damages the environment. John Deere See & Spray uses advanced computer vision and machine learning technology to solve this problem.

The See & Spray system is equipped with high-resolution cameras that scan the field in real time. These cameras are able to distinguish between crops and weeds with a high degree of accuracy. As soon as the system detects a weed, it immediately activates a nozzle that applies the herbicide only to the weed, without affecting the crop. This significantly reduces the amount of chemicals used and minimises their impact on the environment. This precision treatment also reduces the risk of weeds developing resistance to herbicides, an important aspect of sustainable agriculture.

John Deere See & Spray also integrates with other farm management systems, providing farmers with detailed data on field conditions and herbicide application efficiency. This data can be used to further optimise processes and make informed decisions. In this way, See & Spray not only increases the efficiency and cost-effectiveness of agricultural production, but also contributes to more sustainable and environmentally friendly agriculture.

Another example of advanced technology in agriculture is the Agrobot E-Series [2], a range of robots designed specifically for efficient berry and fruit picking. Picking berries and fruit is often a labour-intensive and costly process, requiring considerable effort and time. Traditional picking methods can result in damage to the fruit and loss of the harvest. The Agrobot E-Series offers a solution to these problems with robotic systems that can perform harvesting quickly, accurately and efficiently.

Agrobot E-Series robots are equipped with several manipulators, each equipped with special sensors and cameras. These sensors and cameras allow the robot to determine the ripeness of the fruit and select only those that are ready for harvest. The manipulators carefully pick up the fruit, minimising the risk of damage, and place it in containers. This approach not only improves the quality of the harvested crop, but also significantly reduces the time required for harvesting.

In addition, the Agrobot E-Series robots can work around the clock without the need for breaks or rest periods, significantly increasing productivity and reducing harvesting time. This is particularly important where weather conditions can limit the time available for harvesting. The robots can also be configured to work in different conditions and with different crops, making them versatile and multifunctional.

The introduction of such robots on farms not only reduces labour costs, but also increases the overall efficiency and profitability of agricultural production. Agrobot E-Series robots also help improve working conditions, freeing farmers from heavy and monotonous work and allowing them to focus on more complex and strategic tasks.

Systems such as John Deere See & Spray and Agrobot E-Series robots are important steps towards the automation and robotization of agriculture. Not only do

they increase the efficiency and cost-effectiveness of production, they also contribute to the sustainable development of the industry by improving working conditions and minimising the negative impact on the environment.

One of the most important innovations in agricultural robotics is the use of drones, such as the DJI Agras [3], for modern spraying of fertilisers and pesticides. DJI Agras drones are high-tech devices designed to increase the accuracy and efficiency of agrochemical application in the field. These drones are equipped with advanced navigation systems, sensors and cameras.

DJI Agras (Figure) can fly over fields, scanning the surface and collecting data on the condition of the plants. Based on this data, the drone can accurately determine where and how much fertiliser or pesticide needs to be applied. This can significantly reduce the amount of chemicals used, minimising their impact on the environment and reducing the cost of agrochemicals. In addition, the precise application of fertiliser and pesticides contributes to more uniform plant growth and higher yields.

Figure. DJI Agras T20 drone in action

DJI Agras drones can also work in conditions that traditional machines cannot, such as steep slopes or difficult terrain. This makes them ideal for a range of situations where tractors or other ground vehicles are not possible or effective. Drones can perform their tasks quickly and efficiently, which is particularly important in time-sensitive situations, such as when pesticides need to be applied urgently to combat sudden pest infestations.

Another important advantage of DJI Agras drones is their ability to operate autonomously. This means that they can perform tasks without constant operator supervision, freeing farmers from the need to be physically present in the field and allowing them to focus on other important tasks. Drones can also be integrated with other farm management systems, allowing them to receive and analyse data in real time, improving decision making and optimising resource management.

The use of drones like the DJI Agras is just one of many examples of how robots and automated systems are transforming modern agriculture. The benefits of using robots in agriculture are many and varied, covering different aspects of the production process and farm management.

Firstly, robots and automated systems significantly increase productivity. They can perform tasks faster and more accurately than humans, reducing the time needed to complete routine operations. This is particularly important in situations where rapid intervention is required, such as pest control or fertilisation.

Secondly, the use of robots helps to reduce labour costs. With labour shortages in agriculture, automation is becoming increasingly important. Robots can perform tasks that previously required large numbers of workers, helping to reduce wage and social costs.

Thirdly, robots help to improve product quality. They can perform tasks with a high degree of accuracy, helping to avoid errors and reduce damage to plants and fruit. This is particularly important during harvesting, when even minor damage can result in significant losses.

Fourth, the use of robots contributes to the sustainable development of agriculture. Robots and automated systems help to optimise the use of resources such as water, fertilisers and pesticides, minimising their negative impact on the environment. In addition, robots can perform tasks that require physical strength and endurance, freeing farmers from hard and dangerous work and improving working conditions.

Fifth, the introduction of robots stimulates innovation and the development of new technologies in agriculture. Automation opens up new opportunities for research and improvement of existing farming methods. This helps to increase the efficiency and profitability of production, as well as improve the quality of life for farmers.

The use of robots and automated systems in agriculture therefore plays a key role in ensuring food security, increasing the efficiency and sustainability of production, and improving the working conditions and quality of life of farmers. Technologies such as DJI Agras and other agricultural robots represent an important step towards a future where automation and innovation will play a central role in the development of agriculture.

The technical aspects and innovations of robotic systems play a key role in their successful integration into agriculture. Modern robotic systems are equipped with advanced technologies that allow them to perform a wide range of tasks with a high degree of accuracy and efficiency.

One of the key technologies used in robotic systems is computer vision. This technology allows robots to “see” the environment, recognise objects and make decisions based on visual information. For example, harvesting robots can use cameras and image recognition algorithms to detect the ripeness of fruit and pick it accurately without damaging it. Computer vision is also used in precision farming systems to monitor plant health and determine when to apply fertiliser or pesticides. Another key technology is machine learning. Machine learning algorithms allow robots to analyse large amounts of data and improve their work based on experience. For example, precision fertiliser application systems can use soil and plant health data to optimise application rates and timing. Machine learning is also being used to predict crop yields and identify potential problems at an early stage.

Navigation systems play an important role in ensuring that robots can navigate fields accurately and safely. Modern robots are equipped with Global Positioning

Systems (GPS) and Inertial Navigation Systems, which allow them to accurately determine their position and route. This is particularly important for robots operating in large areas where high precision is required.

Innovations in sensor technology are also helping to improve robotic systems. Modern robots are equipped with a variety of sensors that allow them to gather information about the environment and plant conditions. For example, soil moisture sensors can be used to determine the need for irrigation, while light level sensors can be used to optimise plant growth conditions. This data can be integrated into farm management systems to make informed decisions and optimise resource use.

Autonomous control systems are another important innovation in robotic systems. These systems allow robots to operate without constant human supervision, significantly increasing their efficiency and reducing labour costs. Autonomous control systems can use data from sensors and navigation systems to make real-time decisions and perform tasks with minimal human intervention. The cost-effectiveness and profitability of introducing robots into agriculture are important factors in determining their widespread adoption. Implementing robotic systems requires a significant initial investment, but the long-term benefits can significantly outweigh this cost.

One of the key aspects of cost-effectiveness is the reduction in labour costs. Robots can perform tasks that previously required large numbers of workers, reducing wage and benefit costs. This is particularly important in the context of labour shortages in agriculture, where it is becoming increasingly difficult to find skilled workers.

Another important aspect is increased productivity and efficiency. Robots can perform tasks faster and more accurately than humans, reducing the time required for routine operations and increasing crop yields. For example, robots for precision application of fertilisers and pesticides can reduce the amount of chemicals used, lowering the cost of agrochemicals and minimising their negative impact on the environment. Robots also help reduce crop losses and improve product quality. They can perform tasks with a high degree of accuracy, helping to avoid errors and reduce damage to plants and fruit. This is particularly important during harvesting, when even minor damage can result in significant losses.

The use of robots also helps to optimise the use of resources such as water, fertiliser and pesticides. Robots and automated systems make it possible to accurately assess the needs of crops and apply the required resources at the right time and in the right amount. This not only reduces resource costs, but also minimises their negative impact on the environment [4].

The long-term benefits of robotics also include increased sustainability and profitability in agriculture. Automation enables farmers to manage their resources and processes more efficiently, making them more competitive and resilient to market and climate change. In addition, robotics stimulates innovation and the development of new technologies, opening up new opportunities to improve existing farming practices. The economic efficiency (Table) and profitability of robotics in agriculture are driven by many factors, including reduced labour costs, increased productivity and efficiency, improved product quality, optimised resource use, and increased

sustainability and competitiveness. While robotic systems require significant initial investment, the long-term benefits can far outweigh these costs, making automation an important step towards a sustainable and efficient agriculture of the future.

Table – Examples of economic efficiency of introducing robots into agriculture

| **Parameter** | **Meaning** | **Note** |
|---|---|---|
| Reducing labor costs | up to 50 % | Depends on the type of robots and the scale of implementation |
| Increasing crop yields | up to 20-30 % | Using precision farming and monitoring |
| Reducing the use of pesticides | up to 90 % | Application of point application systems |
| Reducing the use of fertilizers | up to 30 % | Optimization of dosage and application time |
| Reducing crop losses | up to 10-15 % | Precision harvesting systems |
| Increased labor productivity | up to 2-3 times | Automation of routine tasks |
| Reducing the cost of agrochemicals | up to 20-25 % | Optimizing resource usage |
| Increased profitability | up to 15-20 % | Overall economic efficiency |
| Reduce time to complete tasks | up to 50 % | Fast execution of routine operations |
| Improving product quality | up to 10-15 % | Minimizing damage to plants and fruits |

Despite the benefits, the development and implementation of robotic technology in agriculture faces a number of challenges. Firstly, significant initial investment can be a barrier for many farmers, especially small and medium sized farms. The cost of purchasing and maintaining high-tech robots can be prohibitive, requiring the development of flexible financial instruments and support programmes for farmers.

Secondly, there is the problem of integrating new technologies into existing agricultural processes. This requires highly skilled personnel capable of managing and maintaining robotic systems. The need for training and retraining of personnel is also an important aspect that requires attention.

The third challenge is the need to develop and implement standards and regulations to ensure the safety and efficiency of robots in agriculture. This includes both technical standards and legal regulations governing the use of autonomous machines in the fields.

However, the outlook for the development of agricultural robots is quite encouraging. Every year, the technologies become more accessible and effective, contributing to their widespread use. Innovations in artificial intelligence, machine

learning and sensor technologies are opening up new possibilities for automating various agricultural processes [5].

The future of agriculture with robotic technologies looks very promising. The introduction of robots and automated systems can significantly increase the efficiency and productivity of agricultural work, reduce costs, improve product quality and minimise the negative impact on the environment. Robots can perform routine and labour-intensive tasks such as planting, weeding, watering, harvesting and monitoring crop health. This frees farmers from physically demanding tasks and allows them to focus on strategic aspects of farm management.

In addition, robotic technologies are opening up new horizons for the development of precision farming, enabling the optimisation of resource use and the minimisation of losses. This is particularly important in the context of the world's growing population and the need to ensure food security.

In the long term, automation and robotics in agriculture will contribute to the sustainable development of the sector, improving the quality of life of farmers and protecting the environment. Investment in research and development, government support and international cooperation will play a key role in realising this potential.

The future of robotic agriculture promises to be high-tech, efficient and environmentally sustainable, opening up new opportunities for the development of the agricultural sector and ensuring food security on a global scale.

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# COMFORT AND SAFETY TECHNOLOGIES IN THE SMART HOME SYSTEM

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**Abstract.** The article explores the prospects and key trends in the development of smart homes, considering the examples of NEST, PHILIPSHUE and RING companies. Special attention is paid to such aspects as the integration of artificial intelligence and machine learning, the Internet of Things, strengthening data security measures, increasing energy efficiency, improving voice assistants and the introduction of augmented and virtual reality technologies. The main directions and innovations defining the future of smart homes and creating more comfortable, safe and environmentally friendly housing are considered.

**Keywords:** smart homes, artificial intelligence, internet of things, data security, energy efficiency, voice assistants, augmented reality, virtual reality.

# ТЕХНОЛОГИИ КОМФОРТА И БЕЗОПАСНОСТИ В СИСТЕМЕ «УМНЫЙ ДОМ»

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**Аннотация.** В статье исследуются перспективы и ключевые тенденции развития умных домов, рассматриваются примеры компаний NEST, PHILIPSHUE и RING. Особое внимание уделяется таким аспектам, как интеграция искусственного интеллекта и машинного обучения, Интернет вещей, усиление мер безопасности данных, повышение энергоэффективности, совершенствование голосовых ассистентов и внедрение технологий дополненной и виртуальной реальности. Рассматриваются основные направления и инновации, определяющие будущее умных домов и создающие более комфортное, безопасное и экологически чистое жилье.

**Ключевые слова:** умные дома, искусственный интеллект, Интернет вещей, безопасность данных, энергоэффективность, голосовые ассистенты, дополненная реальность, виртуальная реальность.

The concept of smart homes and buildings represents one of the most significant trends in the development of modern technologies, with the objective of enhancing the level of comfort, safety and energy efficiency of residential and commercial premises. Integrated automation systems are utilised in smart homes to regulate a multitude of domestic parameters, including lighting, heating, ventilation, air conditioning, security and other functions. Such systems can be controlled and managed remotely via smartphones, tablets or computers, thereby affording users a high level of convenience and control over their homes.

The fundamental concept of a smart home is to create an environment that can adapt to the needs and preferences of its occupants while ensuring optimal utilisation of resources. For example, smart thermostats such as the Nest Thermostat are capable of automatically adjusting the temperature within a domestic setting in accordance with the time of day, the presence of occupants, and meteorological conditions. This enables considerable energy savings and a reduction in heating and cooling costs. The implementation of smart lighting systems, such as the Philips Hue system, enables users to personalise their domestic lighting to align with their emotional state or activity, and to regulate it remotely. This provides an additional layer of convenience and security.

Security is a further crucial element of smart homes. The Ring Video Doorbell, which incorporates video cameras and remote control functionality, enables homeowners to oversee their front door and receive notifications of any suspicious activity, thereby significantly enhancing the level of home security. Such systems can be integrated with other smart devices, including smart locks and security systems, in order to create a comprehensive home security solution.

The concept of the smart home has its origins in the mid-20th century, with the advent of the first automatic devices and control systems. However, the most significant advancement has occurred in recent decades, largely due to the advent of the Internet, wireless technologies, and the Internet of Things (IoT). These technologies have facilitated the creation of more sophisticated and integrated systems that can interact with one another and with external services, such as weather forecasts or energy management systems.

One of the principal factors propelling the evolution of smart homes is the increasing emphasis on energy efficiency and sustainability. The implementation of smart energy management systems serves to diminish energy consumption, whereby the optimisation of resource utilisation and the reduction of the carbon footprint are facilitated. This is particularly pertinent in the context of global climate change and the concomitant rise in energy prices.

In addition to enhancing energy efficiency and security, smart homes also present numerous opportunities to improve the quality of life for residents. For instance, home automation systems may comprise features for controlling multimedia devices, voice assistants, water management systems, and a plethora of other

capabilities. Collectively, these contribute to a more comfortable and convenient living and working environment.

The concept of smart homes and buildings represents a significant advancement in the field of modern technology, with the potential to enhance the comfort, safety and energy efficiency of residential and commercial premises. The integration of diverse smart devices and systems enables the creation of adaptive and optimised environments that can markedly enhance the quality of life and reduce the environmental impact [1].

One of the most well-known and widely used smart thermostats on the market is the Nest Thermostat (Figure 1), developed by Nest Labs. Since its introduction in 2011, the Nest Thermostat has transformed climate control in residential and commercial spaces, offering users distinctive automation and energy efficiency capabilities. This smart thermostat not only ensures a comfortable temperature in the home, but also helps to significantly reduce energy consumption and, therefore, heating and cooling costs.

Figure 1. Nest Thermostat Interface

One of the principal characteristics of the Nest Thermostat is its capacity to learn autonomously. In the initial period following installation, the device monitors the routines and preferences of users, noting the temperature they prefer in different rooms and at varying times of day. Based on the aforementioned data, the thermostat generates bespoke heating and cooling schedules, automatically adjusting the temperature within the domestic environment to achieve optimal comfort and energy efficiency. For instance, if the typical departure time for work is 8 a.m. and the return time is 6 p.m., the Nest Thermostat has the capacity to reduce the temperature while the occupants are absent and subsequently elevate it prior to their return, thus creating a comfortable environment and reducing energy expenditure. The device is equipped with motion and geolocation sensors that enable it to detect when the house is unoccupied and automatically transition to energy-saving mode. This is particularly beneficial for homeowners who frequently neglect to adjust the thermostat before

leaving the residence. Furthermore, the thermostat is capable of integrating with other smart devices within the home, such as smart locks or security systems, in order to more accurately detect the presence or absence of occupants and adjust the temperature accordingly.

Additionally, the Nest Thermostat offers users the ability to control their thermostat settings remotely via a mobile application. Consequently, users are able to monitor and adjust the temperature of their domicile from any location worldwide via their smartphones or tablets. This is particularly beneficial in instances where users return home at an earlier or later time than anticipated, or wish to prepare their residence for their return following an extended absence. Furthermore, the app furnishes comprehensive energy consumption reports, thereby enabling users to monitor their expenditure and identify potential avenues for additional cost savings [2]. You can learn more about the Nest thermostat on the company's official website.

The Nest Thermostat serves as an exemplar of the ways in which contemporary technology can enhance the quality of life, offering comfort and convenience while simultaneously contributing to substantial energy savings and cost reductions. The thermostat's self-learning, automation, and remote control features enable users to optimise their home climate according to their needs and preferences, while simultaneously reducing their environmental impact.

Philips Hue (Figure 2) represents one of the most innovative and popular systems for the control of lighting currently available on the market.


Figure 2. Philips Hue smart bulbs and control unit

The system, developed by Philips, enables users to exercise complete control over the lighting in their domicile via their smartphone, tablet or computer. It offers unparalleled customisation, automation and integration with other smart devices. In addition to enhancing comfort and convenience, the Philips Hue system also facilitates energy savings and the creation of distinctive ambiences in any given space.

One of the principal characteristics of the Philips Hue system is the capacity to regulate the lighting via a mobile application. The application enables users to control the lighting in their domicile by activating or deactivating the lights, modifying the

brightness, altering the hue of the light, and establishing different lighting scenarios. As an illustration, one may choose to establish a lighting ambience that is conducive to relaxation in the evening, characterised by a soft, warm glow, or alternatively, a bright, cool lighting scheme that is optimal for tasks such as reading or working. Furthermore, the application enables the user to save and rapidly transition between disparate lighting scenarios, thereby adapting the illumination to their emotional state or the task at hand.

The extensive range of colours and shades supported by the Philips Hue system provides a vast array of possibilities for the creation of a distinctive ambience within the domestic environment. The system comprises bulbs, LED strips and lamps that are capable of reproducing up to 16 million colours. This affords users the opportunity to experiment with lighting, creating a festive or romantic ambience, emphasising interior design solutions or simply adding bright accents to everyday life. For instance, one may adjust the lighting to align with the colour scheme of a social gathering or create a sunset effect in the bedroom prior to retiring for the night.

Another significant feature of the Philips Hue system is its capacity for lighting automation. The user is able to create schedules and timers that will cause the lights to turn on and off automatically at a specified time. This is particularly beneficial for individuals who frequently neglect to extinguish the lights or desire for their residence to appear occupied when they are absent. To illustrate, the user may elect to have the lights in the kitchen activate prior to breakfast and deactivate in the bedroom before retiring for the night. Furthermore, automation facilitates energy conservation by ensuring that the lights are only activated when necessary.

Philips Hue is compatible with numerous smart devices and platforms, including Amazon Alexa, Google Assistant, and Apple HomeKit. This enables users to control their lighting via voice commands. This provides convenience, as users are able to control the lighting by issuing verbal commands, including turning the lights on or off, adjusting the brightness, and changing the colour. As an illustration, one may issue a command such as “Alexa, turn on the living room lights” or “Hey Google, brighten the kitchen lights,” and the system will respond accordingly [3]. You can find out more about Philips Hue on the company’s official website.

The Ring Video Doorbell (Figure 3) represents a significant advancement in the field of smart home technology, offering a comprehensive solution to enhance security and convenience. It is a smart doorbell equipped with a video camera that enables users to monitor and interact with visitors at the door through a mobile app. The Ring Video Doorbell’s array of features and capabilities markedly elevate the level of home security and provide a range of conveniences for its users.


Figure 3. Streaming images from Ring Video Doorbell to your smartphone

One of the key features of the Ring Video Doorbell is its real-time video surveillance capability. The device features a high-quality, wide-angle camera that transmits a clear image directly to the user's smartphone. This allows you to always know who is at the door, whether you are home or not. Even if you are at work, on vacation, or just in another room, you can quickly and easily check who has arrived and take appropriate action.

The Ring Video Doorbell camera supports HD resolution, which ensures high-quality images. Built-in infrared LEDs allow you to see visitors even in the dark, making it an effective 24-hour security solution. The ability to record video allows you to save all events that occur at the door for later review. This can be especially useful in the event of incidents or suspicious activity, as you will always have access to video recordings for analysis or transmission to law enforcement.

The Ring Video Doorbell also features two-way audio, allowing users to not only see but also hear and speak to visitors. This is especially useful for those who frequently receive packages or guests, as you can give instructions to the delivery person or greet guests without opening the door. For example, if you are busy or away from home, you can ask the delivery person to leave a package at the door or tell a friend that you will be back soon. Two-way audio can also deter potential intruders, as they will know that they are being watched and can be contacted at any time.

Another important feature of the Ring Video Doorbell is the ability to send notifications to your smartphone when motion is detected. The device is equipped with motion sensors that can be set to detect activity in specific zones. When the sensors detect movement, you receive an instant notification on your smartphone, allowing you to quickly respond to potential threats or simply stay informed about what is happening at your door. Setting up motion detection zones helps avoid false alarms, such as from passing cars or animals [4]. You can find out more about Ring Video Doorbell on the company's official website.

The prospective evolution and future trajectory of smart home development portend substantial shifts in the manner by which we live, work, and interact with our residences. The prevalence of smart homes is increasing, and they are not merely a transient phenomenon; rather, they represent a sustainable trend that is gaining significant traction. In the forthcoming years, it is anticipated that a number of pivotal developments will occur, which will have a considerable impact on the future of smart homes.

One of the most significant trends is the integration of artificial intelligence (AI) and machine learning into smart home systems. The application of AI will enable smart devices to not only execute commands, but also to anticipate the needs of users, adapt to their habits and preferences. For example, smart thermostats will be capable of regulating temperature with greater precision, taking into account the time of day, weather conditions and the preferences of residents. Similarly, smart lighting will be able to adapt automatically to the daily routine and mood of the occupants of the home. This will result in the creation of a more comfortable and personalised environment, which will best meet the needs of each user.

Another significant trend is the advancement of the Internet of Things (IoT) and the concomitant increase in the interconnectivity of devices. It is anticipated that in the future, an increasing number of smart devices will operate within a unified ecosystem, facilitating seamless integration and interaction. This will facilitate the development of sophisticated automation systems, wherein disparate devices will operate in unison to attain a unified objective. To illustrate, in the event of movement being detected at the front door, a smart security system can initiate the activation of outdoor lighting, commence video recording, and transmit a notification to the user's smartphone. The integration of these devices will enhance the security, convenience, and energy efficiency of a smart home.

The protection of data and privacy will also be a priority for smart homes. As the number of connected devices continues to grow, so too does the risk of cyber attacks and data breaches. It is therefore to be expected that manufacturers will devote greater attention to the development of reliable encryption, authentication and data protection systems. The public will be able to rely on a greater degree of privacy and security when utilising smart devices, which will enhance their trust in smart home technologies.

The development of smart homes will continue to prioritise energy efficiency and sustainability. In light of the growing awareness of the necessity to conserve natural resources and reduce carbon footprints, it is anticipated that smart homes will be equipped with increasingly efficient energy management systems. The operation of smart thermostats, lighting, and appliances will be conducted in an energy-saving mode, thereby optimising the utilisation of resources and reducing utility costs. It seems reasonable to posit that the future will see an increase in the number of advanced renewable energy systems, such as solar panels and wind turbines, integrated into smart home infrastructure.

Furthermore, the advancement of voice assistants and the enhancement of their functionalities are noteworthy developments. The use of voice commands is becoming increasingly intuitive and natural, thereby facilitating interaction with

smart devices. In the future, voice assistants will be capable of comprehending context and more sophisticated commands, thereby enhancing the convenience and efficacy of smart home control. For instance, a command may be given in the following format: upon uttering the command “I’m going to bed,” the smart home system will automatically initiate a sequence of actions, including the deactivation of lighting, the closure of access points, the adjustment of the thermostat to a comfortable temperature, and the activation of the security system.

It is evident that the advent of augmented and virtual reality (AR and VR) technologies will have a significant impact on the evolution of smart homes. Such technologies may be employed in the creation of interactive interfaces for the control of smart devices, as well as in the design and planning of interiors. One can envisage a scenario in which a virtual reality headset is used to visualise and personalise a smart home, selecting optimal locations for device installation and modifying their settings within a virtual environment [5].

The prospective developments and future trends in smart home technology hold the promise of significant enhancements in the comfort, safety and energy efficiency of our domestic environments. The integration of AI, increased connectivity of devices, enhanced data security measures, the advancement of energy-efficient technologies, the enhancement of voice assistants and the utilisation of AR and VR will facilitate the creation of smart homes that align with the needs and expectations of users.

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# ASSESSMENT OF THE IMPACT OF FAULTY ROLLING STOCK ON THE RAILWAY TRACK AND THE CONTACT NETWORK

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**Abstract.** Assessing the impact of faulty rolling stock on the railway track and the contact network is an urgent task, since the serviceable condition of the track and network ensures traffic safety, reduces the cost of repair and maintenance of infrastructure. This article examines the main factors affecting the deterioration of the technical condition of the railway track and the contact network due to faulty rolling stock, and presents methods for assessing the impact of faulty rolling stock on the railway track and contact network.

**Keywords:** railway track, contact network, load, rolling stock, safety.

# ОЦЕНКА ВЛИЯНИЯ НЕИСПРАВНОГО ПОДВИЖНОГО СОСТАВА НА ЖЕЛЕЗНОДОРОЖНЫЙ ПУТЬ И КОНТАКТНУЮ СЕТЬ

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**Аннотация.** Оценка влияния неисправного подвижного состава на железнодорожный путь и контактную сеть является актуальной задачей, так как исправное состояние пути и сети обеспечивает безопасность движения, снижает затраты на ремонт и обслуживание инфраструктуры. В данной статье рассмотрены основные факторы, влияющие на ухудшение технического состояния железнодорожного пути и контактной сети из-за неисправного подвижного состава, и представлены методы оценки влияния неисправного подвижного состава на железнодорожный путь и контактную сеть.

**Ключевые слова:** железнодорожный путь, контактная сеть, нагрузка, подвижной состав, безопасность.

Railway infrastructure plays a key role in the economy of many countries, providing fast and reliable transportation of goods and passengers. However, the operation of the railway system is associated with a number of technical and operational difficulties, one of which is the impact of faulty rolling stock on the track and the contact network. Improper functioning of parts of rolling stock, such as wheelsets and auto couplings, can lead to significant negative consequences, including accelerated wear of rails, increased dynamic impacts on the track, deterioration of current collection quality and even accidents. In this paper, we will focus on studying these factors and propose measures to reduce their impact on the operation of railway lines.

Rolling stock malfunctions can be divided into two main groups: structural and operational. Structural failures occur at the design and production stage of rolling stock, and they are caused by design errors, poor-quality manufacturing and assembly. Operational malfunctions occur during operation and are associated with violation of operating rules, wear of parts and improper maintenance.

**Factors influencing faulty rolling stock**

One of the main factors affecting the condition of the railway track and the contact network is the vertical and horizontal dynamics of the rolling stock. Uneven distribution of the axle load, improper installation of wheelsets, inconsistency of the size and weight of wagons and locomotives with the requirements of regulatory documents lead to an increase in dynamic loads on the track, which causes its accelerated wear and reduces its reliability.

Uneven load distribution on the contact suspension and violations of the rules of operation of the contact network can lead to premature wear and a decrease in its reliability. In addition, vibrations and acoustic waves propagating through the contact network from the rolling stock can cause additional loads on the contact suspensions and cause their wear.

The main operational malfunctions of rolling stock for railway tracks are malfunctions of wheelsets and trolleys (cracks, fractures, etc.) serviceability of the wheelset. The main operational faults of the rolling stock for the contact network are the malfunction of the locomotive in terms of the current collector (wear) and the electric motor [1].

**Consequences of the influence of faulty rolling stock**

The consequences of the influence of faulty rolling stock are presented in Table 1.

Table 1 – Consequences of the influence of faulty rolling stock on the contact network and railway track

| Contact network | Railway track |
|---|---|
| Contact wire wear and damage: faulty current collectors and traction motors can cause excessive wear and damage to the contact wire, which can lead to breakages and other problems. | Rail damage: the wheels of defective wagons can create excessive loads on the rails, which leads to their wear and deformation [2]. |
| Insulator damage: a faulty braking system can cause the insulators to spark and damage, which can cause short circuits and other hazards. | Sleeper damage: excessive loads can also damage the sleepers on which the rails are laid. |

| Contact network | Railway track |
|---|---|
| Contact wire wear and damage: faulty current collectors and traction motors can cause excessive wear and damage to the contact wire, which can lead to breakages and other problems. | Destruction of the ballast structure: the crushed stone on which the rail grating is located can be damaged by faulty wagons, which leads to a decrease in the bearing capacity of the track. |
| Mechanical damage: mechanical failures, such as derailed wagons, can cause damage to the supports of the contact network and other structures. | Derailment: faulty rolling stock may derail due to faulty wheelsets and bogies. Gatherings can lead to serious accidents and interruptions in traffic. |
| Delays and cancellations: damage to the contact network can lead to delays and cancellations of trains, which can cause inconvenience to passengers and losses to railway operators. | *Note: The first three factors are directly related to the calculation of the path for strength: if abnormal loads are placed on the path, then the path may fail before its calculated time (life cycle).* |
| Safety hazards: a damaged contact network may pose a safety hazard, causing electrical arcs and other dangerous situations. | |
| Increased operating costs: faulty rolling stock and a damaged contact network can lead to increased operating costs for railway operators [3]. | |

**Assessing the impact of faulty rolling stock**

To determine a faulty rolling stock, it is necessary to make sure that there is a malfunction or the results of malfunctions on the track or contact network: when rolling stock moves along a railway track, a wheelset runs out, etc.; when rolling stock moves, electric arcs and characteristic short-circuit sounds occur (which in turn can lead to an accident or failure of electrical equipment).

In order to assess the impact of faulty rolling stock, it is also necessary to take into account not only obvious mechanical and electrical deficiencies, but also their consequences for the overall safety and efficiency of rail transport. If the faulty train continues to move, this can lead to serious accidents, due to the possibility of a break in the contact network or damage to the track. In such cases, the speed and responsiveness to such incidents are of critical importance.

In addition to physical damage, rolling stock malfunctions can cause emotional stress for drivers and passengers. Constant rumors about safety problems negatively affect the public perception of rail transport. Thus, regular maintenance and monitoring of the condition of rolling stock is not just a formality, but a necessity to ensure public safety and confidence in transportation.

**Methods for assessing the impact on the railway track and the contact network**

1. Determination of the result of a malfunction: it includes the establishment of specific malfunctions in parts of rolling stock (for example, pantographs, contact network, traction motors, trolleys, wheelsets, etc.) [4].

2. Fault detection for the operation of the contact network and track: when determining a fault, it is necessary to understand how this fault affects the operation

of other devices, systems and structures directly related to the contact network and the railway track.

3. Analysis of possible consequences of a malfunction: it is necessary to assess what consequences may arise as a result of a malfunction for the track, the contact network and other devices and systems (for example, a malfunction may lead to a decrease in voltage in the contact network, cracks in the rails, etc. This malfunction, in turn, can affect the operation of traction motors and traffic safety).

The above methods imply the following:

- ensuring the safety of train traffic, that is, preventing the occurrence of events, violations of technological processes, technological maps, etc.;
- ensuring compliance with the interaction of the train and the track (ensuring compliance with design loads on the track, etc.);
- ensuring compliance with the interaction of the train and the contact network;
- monitoring the state of the infrastructure [5];
- optimization of train schedules [6];
- training and professional development of employees;
- introduction of new technologies and equipment.

These methods help to maintain the serviceable condition of the railway track and the contact network for a longer period of use, that is, to increase the service life.

For a more in-depth analysis of methods for assessing the impact of faults on the railway track and contact network, as well as for the safety and reliability of railway transport, the following aspects can be considered:

1. Fault identification: the use of diagnostic equipment (e.g. ultrasonic and magnetic flaw detectors).

This stage includes the use of special tools and equipment to identify hidden defects and malfunctions in the structure of the rolling stock. An ultrasonic flaw detector is used to detect internal cracks and other damages in metals without destroying the material. The magnetic flaw detector is used to search for surface and subsurface defects such as microcracks, hairline cracks, non-welding and other weld defects.

2. Current collector testing: assessing the condition of current collectors, including their mechanical condition and the effectiveness of contact with the contact network.

When testing current collectors, their ability to efficiently transfer energy from the contact network to the traction equipment of the train is checked. The main aspects of testing include an assessment of the mechanical condition of the pantograph, including the presence of deformations, wear or damage, as well as an assessment of the quality of contact between the pantograph and the contact wire. This is important to ensure stable power transmission and to prevent energy losses due to poor contact.

3. Checking traction motors: analysis of condition and performance, including analysis of their thermal condition and checking for current leaks.

Checking traction motors is necessary to ensure their reliable and efficient operation. Their thermal condition is analyzed to identify possible overheating or

malfunctions in the cooling system. It is also checked for current leaks, which may indicate problems with insulation or connections in the electrical system of the engine. In conclusion, faulty rolling stock poses a serious threat not only to the state of the railway infrastructure, but also to the overall safety of the transport industry. Understanding and identifying problems related to wheel sets, pantographs and other components of rolling stock is the key to effective operation of railways. Each of the noted factors – from accelerated wear of rails to failure of the contact network – requires careful analysis and timely intervention.

It is necessary to increase efforts to introduce modern technologies for diagnosing and monitoring the condition of rolling stock, regular maintenance and strict compliance with operational standards. This will help to prevent negative consequences and minimize the risks associated with malfunctions.

Only joint actions of all participants in the process, including manufacturers, operators and regulatory authorities, will be able to ensure the reliability and safety of the railway.

One of the important aspects in solving the problem of faulty rolling stock is to improve the skills and motivation of personnel involved in maintenance and operation. Training in modern diagnostic and repair methods will not only speed up troubleshooting processes, but also significantly improve the overall maintenance culture. Regular trainings and seminars on new technologies, as well as the exchange of experience between specialists from various enterprises, will create an atmosphere conducive to innovation.

In addition, attention should be paid to the importance of public monitoring of the condition of rolling stock. The openness of data on maintenance and identified problems will allow passengers and the public to better understand the situation on the railways and increase the level of confidence in rail transport. This is an important step towards improving the overall safety and reliability of the transport system.

It should also be borne in mind that the development of infrastructure and rolling stock requires significant financial investments. Efficient use of resources and active cooperation with private investors can be the key to a successful system upgrade. Without this, it is impossible to ensure long-term security.

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# PATENT LANDSCAPE ANALYSIS AND INTELLECTUAL PROPERTY PROTECTION AS A WAY TO MITIGATE STARTUP RISKS IN THE MARKET ENTRY STAGE

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**Abstract.** This article raises the problem of analyzing the patent landscape and intellectual property protection in emerging technology start-up companies. The authors consider the main key aspects of why startup teams do not pay enough attention to this aspect, and examine a real case of applying analytical methods and forming a strategy for intellectual property protection. A parallel is drawn between risks and ways to mitigate them. Finally, the authors formulate an algorithm that can be used by teams on similar projects to analyze and develop strategies for the legal protection of intellectual property.

**Keywords:** patent landscape, intellectual property protection, risk mitigation, startup, market, risk management, strategy.

# АНАЛИЗ ПАТЕНТНОГО ЛАНДШАФТА И ЗАЩИТА ИНТЕЛЛЕКТУАЛЬНОЙ СОБСТВЕННОСТИ КАК СПОСОБ МИТИГАЦИИ РИСКОВ СТАРТАПОВ НА ЭТАПЕ ВЫХОДА НА РЫНОК

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**Аннотация.** В статье рассматривается проблема анализа патентного ландшафта и защиты интеллектуальной собственности в зарождающихся технологичных компаниях – стартапах. Авторы представили ключевые моменты того, почему команды стартапов не уделяют достаточного внимания данному аспекту, а также реальный кейс применения методов анализа и формирования стратегии защиты интеллектуальной собственности. Проводится параллель с рисками и способами их митигации. В завершение авторы формируют алгоритм, который может быть использован командами подобных проектов для проведения анализа и разработки стратегии правовой охраны интеллектуальной собственности.

**Ключевые слова:** патентный ландшафт, защита интеллектуальной собственности, митигация рисков, стартап, рынок, управление рисков, стратегия.

Not many startup founders consider protecting their intellectual property after launching a project. Even fewer of them, if at all, think about it during the product design phase, when they have a minimum viable product (MVP) or some idea of future development potential. The authors of this paper acknowledge that this approach may be justified by fierce competition, uncertainty, and the fact that the team's workload is often distributed among 3-7 or fewer people, leaving little time for strategic thinking. However, can this approach affect the viability of a project? And does it lead to a high rate of startup failure? This paper aims to answer these questions.

In the realm of scientific inquiry, the issue of safeguarding the intellectual property rights of emerging businesses has received insufficient attention. Our investigation commenced by exploring the available resources on the Google Scholar platform, as well as the databases of the Elibrary and Elsevier libraries. Our findings indicate that the majority of research efforts are focused on MIPs (micro-innovative enterprises), which are typically established in collaboration with or even within the framework of universities. A. S. Nikolaev and N. N. Kirillov, in their work, identified one of the key drivers behind this interest. They found that "researchers view universities as potential hubs for technology transfer" [1, p. 16]. The reason for this is the presence of a crucial resource – highly engaged human capital, comprising students, educators, and staff. However, in this instance, as correctly pointed out in the same research [1, p. 24], it is not uncommon to create something that already exists and lacks originality on a global scale. Furthermore, the generally inadequate disclosure of intellectual property management practices in startups is evident, particularly in the context of creative industries [2].

The lack of attention to the safeguarding of intellectual property rights for startups may also be attributed to the fact that startups, by their very nature, are often hidden from the public eye. This is because many teams undertake such projects in their spare time, as a form of personal enrichment. A startup can be defined as a collaborative effort of a small group of individuals with specialized expertise in various fields of professional activity. Their goal is to enhance the quality of any process related to the development of a novel technology or a fresh approach to an existing one. This approach aims to address the significant pain points of a specific consumer group and, in a relatively short period, recoup the initial investment.

Regarding the statement "enabling you to recoup your initial investment in a brief time for further gain", it is important to clarify that a brief period should be understood as the time that has elapsed since entering the market and making the initial sale, until the full reimbursement of the funds invested. This period may be restricted to one year.

A startup is a potentially high source of income for an investor who has invested in the project team. Potentially high income obviously leads to potentially high risk of losing invested funds. Statistics show that only 1 % of startups become commercially successful and survive in the market. Traditionally, a lot of emphasis has been placed on determining the real needs of the client, i.e., its validation through using various methods to study the client and evaluate the possibility of meeting this need in the best way possible with existing alternatives.

According to analytics provided by the MTS telecommunications company in 2023, about 24 % of startups have a finished product and mass sales, 33 % have launched a prototype (previously mentioned MVP) and almost half were at the stage of development or idea [3]. In addition, there is still a trend towards using a bright and catchy idea that can be conveyed to the investor [4]. And finally, among the most common reasons for the closure of startups are exhaustion of funds (38 %), lack of interest from investors (27 %) and legal problems (16 %), including and problems related to the protection of intellectual property [5]. Therefore, it can be concluded that the focus on the investor's interest, the lack of funds and the inability to start generating profits are becoming one of the key factors that make it necessary to postpone the solution of the strategic objectives of the project.

The project team consists of specialists from different fields, as a rule, with significant professional experience, which allows them to identify pain points and then eliminate them through the launch of a new product. At the same time, it is often possible to create new products or services that did not exist before, or to find new ways to use technology that seemed to have already been exhausted.

So, the main focus on real pain and the consumer, a high degree of dependence on external financing and significant market competition lead to the fact that, in an attempt to create a product, a team actually creates something that has already been created before by someone else or creates something fundamentally new which is then copied by other market participants. This foreshadows the imminent demise of the startup. And, in this case, one of the circumstances leading to this is lack of a strategy for legal protection of the obtained results.

Studying various acceleration programs – programs aimed at supporting startups and aspiring entrepreneurs, allowing them to accelerate business development or identify its weaknesses and helping to eliminate them, we can see that many of these do not generally contain an educational component aimed at developing the appropriate competencies for ensuring legal protection of the product. Venture capitalists also most often focus on the potential return on investment rather than how the existence of the project will be ensured – this conclusion is supported by the experience of the authors in participating in various pitch events aimed at identifying and promoting the most successful startup projects and their teams (Startup Nights of ITMO University, the accelerator of social initiatives RAICE, the public protection of projects through the release of programs such as "Above the Dream" and similar projects). The methodological framework also pays little attention to this aspect. And at the same time, startups very often generate potential objects of legal protection. This makes the possession of such competencies by project team members a vital necessity. For this reason, in favor of ensuring the technological sovereignty of the Russian Federation, the formation of skills aimed at building patent landscapes and ensuring appropriate protection of intellectual property are essential for the success of projects [6].

Timely analysis of the patent landscape and development of a strategy for legal protection of intellectual property can ensure reduction or elimination of a number of risks that affect the viability of startups. Firstly, this allows you to understand existing solutions in the field and their essence. Secondly, it allows you to build on existing

solutions and create a future patent project for a startup product. Thirdly, this helps you understand which aspects to pay attention to when creating a legal protection strategy overall.

A. V. Sennikova comes to a similar conclusion in her research, which analyzes the role of management of creation and legal protection of innovations in startups [7]. However, in the work, the author points out that the team must constantly keep in touch with the patent specialist, which is not always correct. Of course, the presence of an area specialist allows you to reduce the risks in the field of intellectual property protection to zero, but at the same time, remembering that startup teams rarely have enough money, ensuring the availability of a specialist can be unbearable for him. The authors of this paper believe that it is possible to provide a similar degree of protection at the expense of their own resources.

Given that, as a rule, the activities of startup participants are settled by oral agreements, conflicts may arise after the launch on the basis of uneven distribution of income received relative to each participant, which creates the need for mandatory written fixation of the agreements reached. However, it is worth returning directly to the analysis of the patent landscape, which is a systemically structured work on the research and evaluation of existing patent solutions through the study of domestic and international patent databases on a specific topic or within the framework of a technological direction to identify key players, trends in technology development, identify potential risks and opportunities for current and future innovative research. Today, there are a sufficient number of tools that can be used to perform an initial search for the closest to the solution being developed.

However, a startup's activity is not always limited to the development of a new product that is subject to patent rights. This is especially common in the fields of Edtech, IoT (Internet of Things) and others, where the product is presented as an object of copyright and/or related rights, as well as in matters of trademark registration, the need for which arises already at the time of creation of the MVP product [8]. At the same time, the key risk that can be blocked is the misuse of intellectual property objects, and in some cases the loss of a legitimate "monopoly" on the use of the object.

In order to derive a schematic and understandable algorithm for actions that will allow the startup team to conduct primary analytics to form a patent landscape and develop a legal protection strategy, a real project with prospects for development on the startup path will be considered.

The project team is developing an online course that contains a unique element in the form of AI (artificial intelligence). It is associated with this and trained in a special way, and is able to calculate an individual psychological profile for each participant based on their actions during the seminar and generate a pool of recommendations for improving the processes related to self-realization. The project team has also formed a plan for commercializing the results of their intellectual activity. This is shown in Figure 1 below.

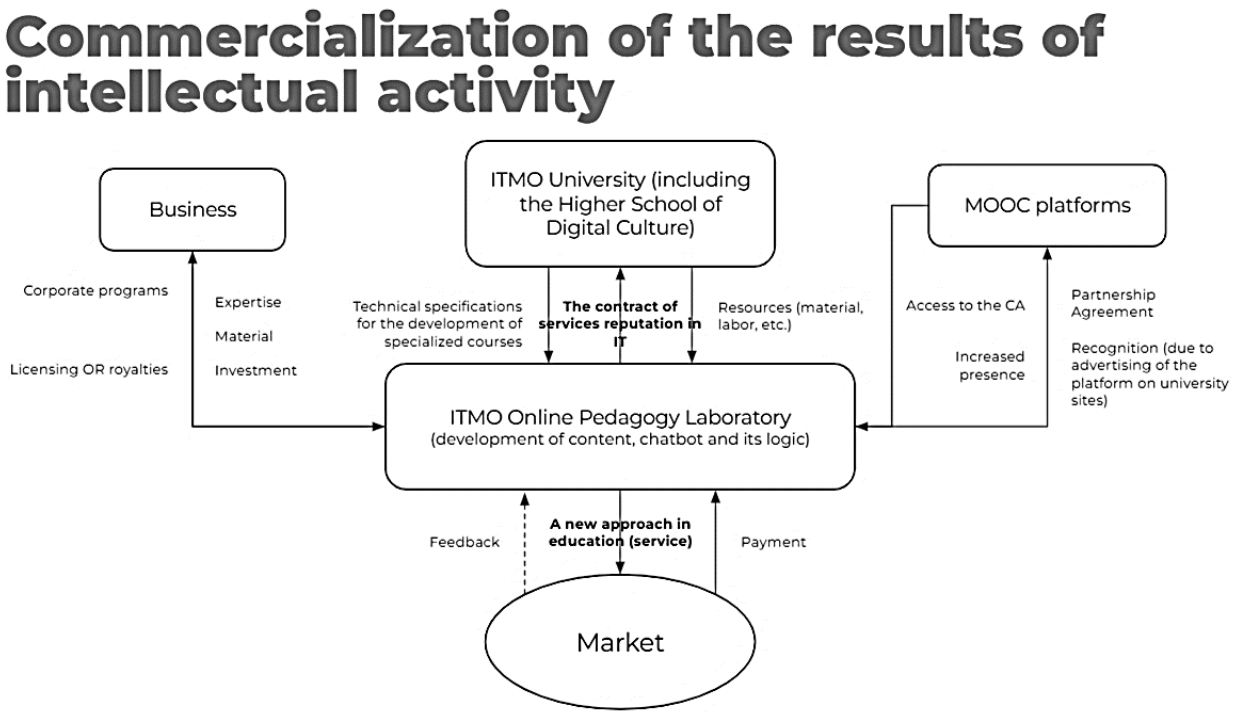


Figure 1. The scheme of commercialization of the results of intellectual activity within the online course (prepared by the authors)

It can be seen from the diagram above that the beneficiaries of the project implementation are a wide range of various entities involved in certain stages in the mutual exchange of specific resources. The results of the intellectual activity commercialization strategy allow you to form a pool of potential subjects who will be interested in solving the problem and, at the same time, understand who can use the solution for their own purposes.

The online course primarily relates to copyright in terms of content and course content, but at the same time, it assumes new mechanisms, as well as ways to process the results of classic psychometric tests and a user's digital footprint. To form a legal protection strategy, the project team conducted a patent search through Rospatent databases and databases available on the Internet, identifying the most closely related patented objects.

The same should be done with regard to the trademark. These steps will help to avoid unnecessary costs associated with both re-filing applications for the issuance of a certificate and possible litigation, compensation payments, etc. Based on this data, the team has formed the primary structure of the legal protection strategy for their product or IP strategy, which is shown in Figure 2 below.

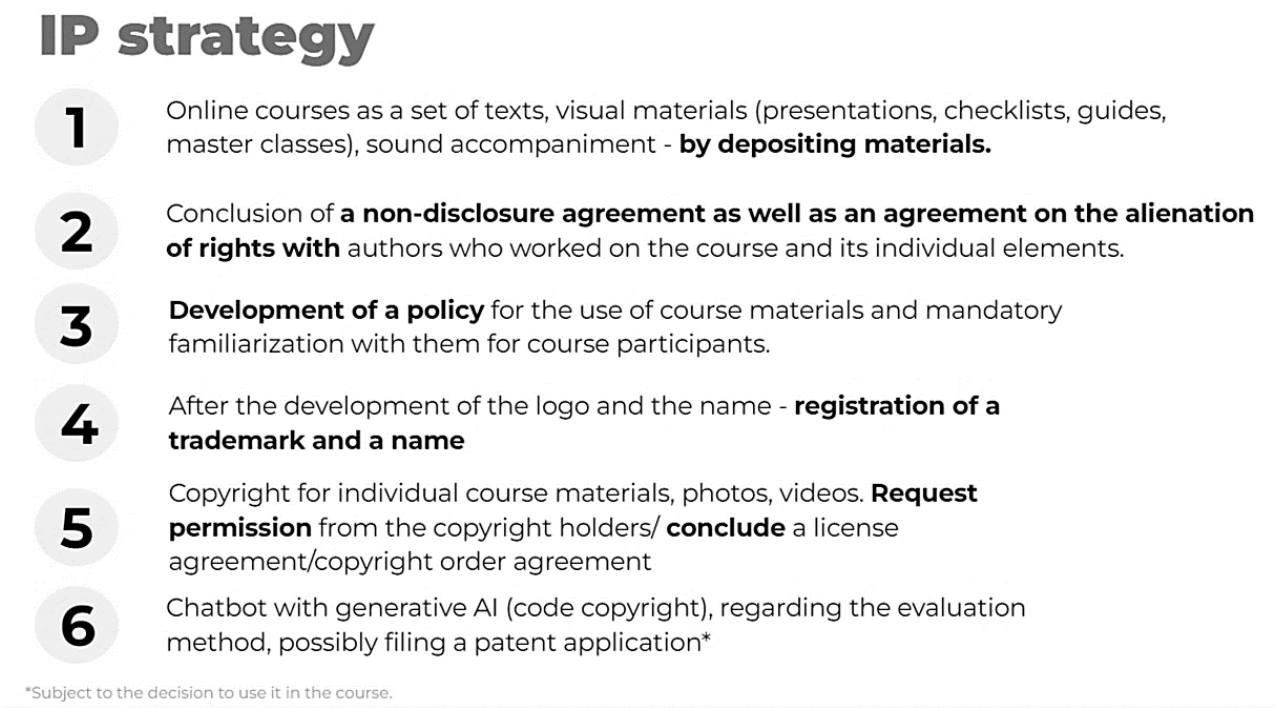


Figure 2. An IP strategy prepared by the team taking into account the analysis carried out

It can be seen from the strategy that the key element of this online course lies within the framework of a chatbot based on artificial intelligence. The project team has also decided to protect the development of the course by filing an application for the registration of a patent for their invention.

Then, taking into account the above, the authors of this work can propose the following algorithm for developing a strategy for legal protection of the intellectual property of startups:

1. Conduct an internal audit of the product/service for the allocation of intellectual property objects. There are 17 such objects in Russian law, and when analyzing your product, you should focus on the list of them, which is publicly available on the Internet.

2. If objects of patent law (invention, utility model, industrial design) are identified, search relevant databases for similar technologies and understand how they are described.

3. Analyze trademark databases and search for all possible phrases, taking into account various spellings and spellings. If there is a computer program, register it.

4. Formalize relations in written contracts and agree on use of intellectual property.

5. Create a plan for commercializing the result of intellectual activity, understand who will be users, identify those capable of developing or copying software.

6. To form a final strategy for legal protection in order to mitigate possible risks in the field of intellectual property.

7. If objects of patent law (inventions, utility models, industrial designs) are identified, search relevant databases for similar technologies and understand how they are described.

8. Analyze trademark databases and search for all possible variations, taking into account different spellings. If there is a computer program, register it.

9. Formalize all relationships in written contracts and agree on the use of intellectual property.

10. Create a plan for commercializing the result of intellectual activity, understanding who the users will be and identifying people who can develop similar software or copy it.

11. Form a final strategy for legal protection to minimize possible risks in intellectual property protection.

The implementation of these steps will allow us to form a viable intellectual property protection strategy at the early stages of startup development by members of its team, and will also allow us to gain a primary understanding of the patent landscape for the future product. This approach becomes especially relevant during the market launch stage, when it is essential to ensure stable and rapid growth in sales of the product. Although the authors of this article omitted several legal aspects and nuances related to each individual recommendation, even so, this approach remains useful. In addition, it helps to eliminate key risks in this area.

In future works, the authors will study the problem of intellectual property protection for startups in more depth, in order to develop a more fundamental approach to solving this problem and provide a methodological basis for developing a strategy for protecting such property without the involvement of external specialists.

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**УДК 698**

# LASER SCANNING OF CONSTRUCTION OBJECTS USING DRONES

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**Abstract.** The article discusses the evolution of technologies in construction. Laser scanning with drones is a revolutionary approach that allows one to quickly and accurately collect data about the terrain and objects. The use of this technology opens up new horizons for architects, engineers and builders, providing the opportunity to create detailed three-dimensional models and optimize processes at all stages of construction. The article also discusses the advantages and challenges of introducing laser scanning with drones in various industries, emphasizing its importance for the future of the construction industry.

**Keywords:** drones, construction, laser radiation, design.

# ЛАЗЕРНОЕ СКАНИРОВАНИЕ СТРОИТЕЛЬНЫХ ОБЪЕКТОВ С ПОМОЩЬЮ ДРОНОВ

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**Аннотация.** В статье рассматривается эволюция технологий в строительстве. Лазерное сканирование с помощью дронов представляет собой революционный подход, который позволяет быстро и точно собирать данные о местности и объектах. Использование этой технологии открывает новые горизонты для архитекторов, инженеров и строителей, обеспечивая возможность создания детализированных трехмерных моделей и оптимизации процессов на всех этапах строительства. В статье также обсуждаются преимущества и проблемы внедрения лазерного сканирования с помощью дронов в различных отраслях, подчеркивается его важность для будущего строительной индустрии.

**Ключевые слова:** дроны, строительство, лазерное излучение, проектирование.

Traditional construction methods based on manual measurements and simple tools have given way to high-tech solutions that significantly increase the precision

and effectiveness of design and work execution. Laser scanning with drones (unmanned aerial vehicles) is a cutting-edge technology that greatly enhances the processes of data collection and monitoring in construction. This method is a high-tech approach that integrates the capabilities of UAVs with laser technology to produce accurate three-dimensional models of landscapes and objects. The primary technology employed in this process is known as LiDAR (Light Detection and Ranging). LiDAR is based on the use of laser light to measure distances and generate high-precision three-dimensional models of objects and terrain. The operation of LiDAR involves several key steps:

1. Laser pulse emission: a laser scanner mounted on a drone emits short pulses of light that are directed at objects on the ground. These pulses can be directed in different directions to cover a large area.

2. Reflection and reception: when a laser beam collides with a surface, it is reflected back to the scanner. The receiver records the time it takes for the laser pulse to return. This time allows you to calculate the distance to the object using the formula= $\frac{c \cdot t}{2}$, where c is the speed of light and t is the flight time of the pulse.

3. Creating a point cloud: as a result of scanning, a point cloud is created – an array of data representing the three-dimensional coordinates of all reflected points. Each point contains information about its position and the intensity of the reflected light.

4. Data processing: the received data is processed using specialized software to create 3D models of the terrain or objects. These models can be used for analysis, planning and monitoring.

5. Integration with GNSS and INS: to improve accuracy, drone position data is collected using global navigation satellite systems (GNSS) and Inertial Navigation System (INS), which allows you to accurately determine the coordinates of the scanned objects [1].

Drones used for laser scanning pick up a signal for control using radio frequency communication. This communication is carried out between an unmanned aerial vehicle (UAV) and its control panel or other device that sends commands and receives data on the status of the drone. Drones usually use radio frequencies (RF) to transmit data between themselves and the control panel. These signals can operate at different frequencies, depending on the drone model and the technology used. The control panel sends commands to the drone using radio signals. The drone accepts these commands and performs actions such as takeoff, landing, or changing flight direction. At the same time, the drone sends back data about its status, such as battery level or current location. Many drones also use GPS (Global Navigation Satellite System) to determine their location. This allows them to perform tasks with high accuracy, such as automatically returning to the starting position or completing predefined routes. To ensure reliable communication, some modern drones use anti-interference technologies, such as automatic frequency switching in case of interference detection. This allows you to maintain a stable connection even in difficult conditions.

Laser scanning with drones is among the most advanced technologies in construction, greatly enhancing the quality and efficiency of design and building processes. This method merges the high precision of laser scanning with the mobility of drones, enabling the resolution of numerous tasks on construction sites. Consequently, the use of drones in construction offers a variety of benefits:

- High accuracy: laser scanners mounted on firewood are capable of creating detailed three-dimensional models of objects with millimeter accuracy. This is especially important for architectural measurements and quality control.
- Fast data collection: drones can quickly survey large areas, which reduces the time required to perform topographic work and monitor the progress of construction. Modern drones are able to capture millions of points per second, which makes the data collection process more efficient.
- Access to hard-to-reach places: drones can take pictures in conditions inaccessible to humans, such as steep slopes or dangerous areas. This significantly expands the possibilities of geodetic works and increases safety.
- Cost-effectiveness: the use of drones for laser scanning reduces the cost of surveying, reducing the need for a large number of personnel and expensive ground equipment.

Despite the many advantages, the use of drones also has its drawbacks:

- Limited flight time: drones have limited battery life, which may limit the number of tests performed at a time.
- Problems with weather conditions: drones may be ineffective in bad weather (rain, strong wind), which may affect the work schedule.
- The need for operator training: for effective use of drones, operator training is required, which may require additional time and financial costs.
- Legal restrictions: in some countries, there are strict rules on the use of drones, which may limit their use in certain areas or conditions [2].

Application of the technology:

- Creation of 3D models: laser scanning allows you to create accurate digital models of objects and terrain that can be used for design and planning of construction. These models help architects and engineers visualize the project and take into account all the necessary parameters.
- Monitoring the progress of construction: drones with laser scanners allow you to quickly track the progress of work on construction sites. This helps to identify deviations from the design documentation and make the necessary adjustments during the construction process.
- Quality control: laser scanning can be used to monitor the quality of work performed, identifying defects or non-compliance with standards.

Laser scanning using drones is used in various industries, except construction. Here are the main ones:

1. Oil and gas industry

Drones with laser scanners are used to monitor drilling rigs, patrol main pipelines and monitor leaks. This allows you to effectively manage resources and ensure security in remote and hard-to-reach areas.

2. Electric power industry

In this industry, drones help in monitoring power lines by providing timely information about the condition of wires and insulators. This allows you to quickly respond to damage and prevent unauthorized access to objects.

3. Agriculture

Laser scanning helps in precise planning of agricultural activities, such as determining the required number of fertilizers and monitoring the condition of crops. This technology allows you to create topographic maps of fields and optimize farming processes.

4. Environmental monitoring

Drones are used to assess the condition of reservoirs, analyze pollutants, as well as for rapid fire detection and biodiversity monitoring. This is especially important in a difficult climate and large territories.

5. Urban planning

Laser scanning allows you to create three-dimensional models of the urban environment, which helps in the inventory of urban property and monitoring the work of contractors. This improves the management of urban infrastructure.

6. Archaeology and restoration of monuments

In this field, laser scanning is used to create accurate digital models of historical sites, which is critical for their preservation and restoration.

7. Geodesy and cartography

Laser scanning is used to create high-precision terrain maps, which simplifies the process of land surveying and allows you to identify violations of the land cadaster [3].

Laser scanning using drones is widely applied in various countries due to its high accuracy, speed and efficiency. Below are the countries that are most actively using this technology in various industries.

1. USA

The United States is at the forefront of utilizing drones and laser scanning technologies. This technology finds extensible application in sectors such as construction, geodesy, agriculture, and environmental monitoring. American companies leverage Lidar to generate three-dimensional models of landscapes and structure, as well as to oversee the condition of infrastructure.

2. Canada

Canada is also actively using laser scanning with drones, especially in the mining and forestry industries. Drones help in mapping large areas and monitoring natural resources, which makes it possible to effectively manage natural resources.

3. Australia

In Australia, laser scanning with drones is used for environmental monitoring, including ecosystem assessment and land management. The technology is also used in construction and infrastructure projects.

4. Great Britain

In the UK, drones with laser scanners are actively used in architecture, construction and geodesy. They allow you to create accurate models of buildings and carry out inspections of complex objects such as bridges and power lines.

5. Germany

Germany uses laser scanning with drones to monitor infrastructure, including railways and highways. The technology is also used in the field of environmental protection to assess the condition of forests and reservoirs.

6. New Zealand

In New Zealand, laser scanning with drones is used in agriculture and forestry, where it is used to assess the condition of crops and manage forest resources.

7. Italy

Italy is actively implementing laser scanning technologies in architecture and cultural heritage. Drones help in documenting historical sites and conducting archaeological research [4].

Laser scanning using drones offers numerous advantages across various industries by enhancing data accuracy, accelerating data collection, and lowering operational costs. This technology is increasingly recognized as a vital tool for efficient resource management and facility condition monitoring across diverse sectors. The combination of laser scanning with other digital technologies opens up new possibilities for optimizing construction processes and project management. While there are some drawbacks, the benefits of this technology render it an essential asset in contemporary construction, significantly improving the quality of design and execution.

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# HOW CHANGING LIFESTYLES AFFECT DESIGN DEVELOPMENT

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**Abstract.** Every year society changes faster, the pace of life continues to grow and influence not only people's lifestyles but also their needs. Designers respond to these demands by planning and creating solutions that can fit into the changing system and influence it. The number of vacancies and new types of designers is steadily growing, today their contribution is required in almost every field.

**Keywords:** design, lifestyle, comfortable environment, service industry, market development, new technologies.

# КАК ИЗМЕНЕНИЕ ОБРАЗА ЖИЗНИ ЛЮДЕЙ ВЛИЯЕТ НА РАЗВИТИЕ ДИЗАЙНА

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**Аннотация.** С каждым годом общество меняется все быстрее, темп жизни продолжает расти и влиять не только на образ жизни людей, но и на их потребности. На запросы реагируют дизайнеры, планируют и создают такие решения, которые смогут вписаться в изменчивую систему, повлиять на нее. Число вакансий и новых видов дизайнеров неуклонно растет, сегодня их вклад требуется практически во всем.

**Ключевые слова:** дизайн, образ жизни, комфортная среда, сфера услуг, развитие рынка, новые технологии.

Modern young people do not have the opportunity to go to the country, they spend their weekends walking in public places, so the demand is growing not only for the quantity of places for rest and leisure, but also for quality. Previously, a public place could be a table and a bench on a playground near houses, where people met each other, chatted, and played board games. But at the moment, there is one trend in society. People in general have become lonelier, it is more difficult for them to trust others and start communication. Therefore, now there is a need to create places where a person can sit alone and communicate as desired and have activities for one.

After conducting the analysis, it is possible to identify certain trends that can be detected now, as well as those that are expected in the future. For example, the development of green technologies and spaces, which began around 2010 and is still

growing. Now people can be among nature not only by going out of town, but also on various terraces, gardens, roofs, in the middle of restaurants and in many other places.

Every year the functions of public space are expanding. With the development of technology, more and more people have the opportunity to work remotely. They are spending whole days on the Internet, increasingly feeling lonely, unable to concentrate at home or have a need to change their surroundings. These problems are solved by activity centers, coworking areas and even restaurants. They can provide not only a place to work, but also libraries, modern computers, technologies, and cafes. And since a person often spends more time in such spaces than at home, the demand for comfort is huge. Designers are constantly working and developing here, using new materials, ergonomic standards in public spaces and monitoring changes in society, responding to them. More and more often you can see how companies use the idea of coworking in advertising, for example, arranging them on the first floors of their offices (Figure 1). This fact leads to the theory that design will soon undergo major changes. Modern people, accustomed to ignoring huge streams of visual noise, advertising, signs, no longer perceive classic graphic design. A good website or interior in a cafe attracts more people than banners and flyers. In developed countries, advertising through social media is becoming increasingly popular. There people can rate places and read reviews, which saves time.

The most striking example of change in design is the trend towards simplification. When the first smartphones appeared, their interface imitated a push-button telephone, it was a necessity of that time. And if the external simplification of such icons some time ago was a natural process of getting rid of the unnecessary, now designers are simplifying everything as much as possible. This is a consequence of human information overload.

Figure 1. The colorful Dublin offices have plenty of space for employees to relax and work (Photo by Avery Hartmans)

The rhythm of life is accelerating, and the amount of what needs to be seen, read, remembered and analyzed also increases. Just a couple of decades ago, a person

went to work by tram, watched billboards and managed to read store signs. But over time, transport goes faster, the information on the phone becomes more interesting than outside the window, and there is no time to read the signs. All this acceleration has led to total simplification, up to getting rid of text completely. Nowadays, designers can work even with just one color. For example, for delivery services, where couriers do not always even need to have a brand identity on their clothes, people are able to recognize it just by color.

However, even in this case, it does not always save a person from brain overload. It is not surprising that minimalism is extremely popular in the modern world. It allows the head to rest from the visual noise and bustle of the city. However, classic minimalism, which has recently emerged, has already turned out to be too lifeless for people. It has been replaced by a more functional and pleasant “soft” version. It combines the best of minimalism – lots of light, space and cleanliness with warmth and comfort. Such an interior has more soft materials, textiles and a variety of decor. To make a minimalist design more lively, it is worth abandoning smooth surfaces in favor of more textured materials: use large knits, natural fabrics, wood. These facts remind us of the “green” trend. In the world of technology and information, people are really tired of everything artificial. Therefore, modern users have a craving for the presence of “green” spaces and the introduction of natural patterns into home interiors. It can be considered that with the development of the Internet and the expansion of culture, people are moving further and further away from the position of “mine and someone else’s” and think more about the general. Now the comfort of the home is not enough, it is also required outside, but without harming nature. Someone tries to preserve history and does not go towards changes in the world. However, the biggest trend at the moment is mixing. And this applies not only to styles in clothing and interior (Figure 2). This is probably due not only to the availability of information about other countries, but also to the fact that it is becoming increasingly difficult to come up with something new, and creating something from things that already exist comes to the rescue.

Figure 2. Japandi has been around for decades (Photo by Jenna Peffley)

The phenomenon of mixing the borders of the real and the virtual is interesting. It is not even about virtual reality, but about less noticeable forms that work in both directions. A striking example is books. At first, there were only paper ones, then they began to be converted to electronic format. This caused a lot of debate about which is better. But now few people notice the reverse process, when e-books and comics are adapted and published in printed format. This can also be found in the field of games, music, hence the new wave of popularity of vinyl records, etc.

If we consider the field of design in the world in general before and now, we can notice incredible growth:

1) 93 % of all our communication is carried out visually [1].
2) 75 % of customers evaluate the credibility of a business based on its web design.
3) About 50 % of content creators create visual content at least five hours a week.
4) 56.6 % of companies were forced to change their visual content strategy due to the pandemic.
5) Every year, 23,900 new vacancies for designers appear [2].
6) 94 % of people will leave a site if it has a bad design [3].
7) The global graphic design industry is valued at $43.4 billion. [4].
8) 87 % of SMBs state that graphic design is at least slightly important for business success [5].

You cannot talk about design without touching on social changes. Not only is the rhythm of life changing, but also the way of life. Great changes have occurred in the social and economic status of women. The older generation witnessed the time when one husband could provide for the whole family, while the woman took care of the house and children, but now it is difficult to find such a picture. Some time ago, the percentage of economically active girls was quite low, women did not often use certain things and benefits. And the development of such did not take into account the female audience and anatomy when creating. Such are, for example, cars. The percentage of girls from all drivers is approaching 50 %. It is not surprising that there are also requests for cars that take into account their physiology. Only in 2022, a female dummy for testing was presented in a Swedish testing laboratory under the direction of Astrid Linder, Director of Road Safety at the Swedish National Road and Transport Research Institute, which is extremely important, since according to NHTSA statistics, women are 73 % more likely than men to receive serious injuries in accidents [6]. And this is just one of the representatives of new industrial design.

More and more often you can find discussions of the problem that things “for women” should not just be painted pink, but take into account the female anatomy. Nevertheless, studies have shown that so far very many things are uncomfortable for half of humanity. In the presence of pregnancy, such inconveniences are several times greater. One of the main influences of young people on design is that they began to raise such topics and problems, creating requests.

Such changes in society have affected not only women, but also entire families. Statistics show that every year fewer of them are created, especially with children.

This is connected not only with economic processes, but also with the growth of the standard of living. If literally the previous generation of people could grow up walking in the streets, coming home only to eat, and the school did all the teaching, now such parents are considered to be unable to cope with their responsibilities. It is all about the growth of the level of education. Now the efforts and means for raising one child are more than previously could be enough for the whole family. Therefore, it is not surprising that every year the demand for better conditions for children's growth is rising. For example, playgrounds consisting of stairs, slides and swings no longer cover the needs of children. Modern psychologists have come to the conclusion that children need more abstract elements, and not just those involving physical abilities. They need not only to run, jump, but also to use their imagination. Nowadays, on playgrounds you can increasingly find buildings with tunnels and caves, entire ships and towers, where children can come up with their own stories and use their imagination. The sphere of children's clothing and toys is also actively changing, even designers are increasingly working on them. Both themes and materials have changed. Bright, multi-colored plastic toys that children used to play with are now considered unsafe. Even here, the trends for minimalism and natural patterns can be seen. Absolutely everything for children is now being created from cotton, wood, and other hypoallergenic and non-toxic materials. Human health in the modern world is protected as never before. And the responsibility on parents is as huge as it has never been before.

This has become one of the leading reasons for a new trend for humanity. A view of life in which people prefer to live alone or with pets is gaining popularity. Dogs have been good companions before, but caring for them has grown to a new level. Many people care about dogs as if they were their own children, so it is not surprising that the term "dog friendly" has appeared, denoting places where you can spend time with your dog, as opposed to the old system where the dog had a place only on the street. Moreover, now there is a growing popularity of medium and small breeds that can happily live in an apartment. Since animals have become constant companions of people in public spaces, fashion for pets has become more sought-after. That is, now people try to dress beautifully not only themselves and their children, but also their dogs. At the moment, there is a rapid growth of dog designer clothing, the emergence of trends and various new elements, accessories and devices. A real boom is happening in the field of food, toys and even transport. More and more often you can find dog versions of human food. And not even just birthday cakes, but instant noodles, fast food, beer and much more for pets. In these cases, designers have a big task: to make everything as similar to human food as possible, but immediately distinguishable, to avoid confusion. This is a completely new, but rapidly gaining momentum, sphere, as well as various kinds of accessories: not only raincoats, automatic feeders, smart collars, but also more specific ones, for example, a stroller in which you can roll your pets around the city, car seats for the safety of your pet, keyboards for communication, etc. One part of society is not yet fully accustomed to close communication with dogs, another part demands better conditions, in such cases good design is necessary.

An example is dog booths in front of the entrance to stores and shopping centers. Such places are sometimes called dog parking. They are most often made closed, with ventilation, to protect the pet not only from weather conditions, but also to prevent their theft. In such houses, dogs will also not harm others. Often, such places have electronic locks with access to the network. Strangers will not open it, and the fee, if any, will be written off automatically. Another interesting idea is a cart with a compartment for dogs. Adding a special compartment solves many problems at once. The pet will not jump on the goods, spoil them, will not eat anything extra, and will not come into contact with the food area, which is a good solution from a hygiene point of view. And when moving, it will not stumble and fall. Such carts are usually marked, and people who do not like dogs or have allergies will not come into contact with anything that someone else's pet could touch. And of course, it is the owner, who can make purchases without worrying about the condition and location of their pet (Figure 3) [7, pp. 279-281].


Figure 3. Carts for dogs in Elba stores in Italy (Photo from bestlj.ru)

Having studied the topic, one can come to the conclusion that changes in people's lifestyles have a cardinal effect not only on science and technology, but also on art – what people do, how they look and where they live. Many believe that innovative solutions in this area are the engine of progress. But everything turns out to be more complicated. Each era has its own face, which is not a reflection of reality, but shows the needs and aspirations of the youth of a given time. Even each generation of people has its own features, and when new ones come, the concepts of good design are turned upside down. In fact, it is not designers and agencies that influence people by creating new collections, products and trends, but quite the opposite. Outstanding design differs from ordinary design in that the latter reflects changes in society, and the former anticipates these changes.

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# MARKETING BUDGET: HOW TO CALCULATE AND PLAN

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**Abstract.** In a modern market characterized by high competition and rapid changes in consumer preferences, effective management of marketing resources is becoming a key factor in the success of any organization. The correct calculation and allocation of financial resources for marketing activities can significantly increase the effectiveness of advertising campaigns and, as a result, contribute to sales growth and strengthen the company's position in the market.

**Keywords:** marketing budget, marginality, consumer, demand, sales funnel.

# МАРКЕТИНГОВЫЙ БЮДЖЕТ: КАК РАССЧИТАТЬ И ПЛАНИРОВАТЬ

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**Аннотация.** В условиях современного рынка, характеризующегося высокой конкуренцией и быстрыми изменениями потребительских предпочтений, эффективное управление маркетинговыми ресурсами становится ключевым фактором успеха любой организации. Правильный расчет и распределение финансовых средств на маркетинговые мероприятия способны значительно повысить эффективность рекламных кампаний и, как следствие, способствовать росту продаж и укреплению позиций компании на рынке.

**Ключевые слова:** маркетинговый бюджет, маржинальность, потребитель, спрос, воронка продаж.

A marketing budget is often understood as a cost plan for advertising a company, brands, or individual products, but actually marketing budget is a financial expenditure plan for all marketing purposes of a company [1, p. 32]. It includes expenses not only on communication and customer acquisition, but also on research, product testing, and branding.

Marketing goals are directly related to business goals. As a rule, the company's long-term goals, mission and strategy are formed first. Then goals are set for the next year or two: sales growth, increased profits, and entry into the top companies in their industry. Goals are already being formed for them in functional areas, including marketing. Marketing goals are related to promotion, pricing, product and sales.

When drawing up a marketing budget for a company, a marketer should focus on these main points of expenditure [2, p. 2]:

– **Online maintenance** of a website and social networks.

– **Direct advertising** – the promotion of a company outside the Internet: in magazines, on television and radio, on billboards.

– **Event marketing** – organization of events to expand the customer base and attract the interest of existing customers.

– **Printing** – brand promotion through products with original logos and stylistics.

– **Research** – analysis of interaction with the target audience: surveys, focus groups, review of reviews and the "mystery shopper" format.

– **Employees** – payment for the work of full-time or freelance specialists, expenses for training and professional development of staff.

– **External consultants** – payment for the services of specialists who establish business processes and solve problems related to the development and positioning of the company.

– **Branding** – defining the unique image of the brand and its values, thanks to which the company will be able to stay on the market for a long time.

There are four popular budget planning techniques:

**1. Based on a share of revenue**

Most often, companies plan a marketing budget based on a sales plan – revenue expected in the next year or two. However, this approach does not take into account market changes, such as inflation, procurement or logistics problems.

**2. From competitor analysis (benchmarking)**

Marketers use several approaches to analyzing colleagues in the market:

- Competitor analysis through services, wherein the costs of marketing through benchmarking are determined based on analytics or insider information about budgets, advertising volume, turnover and profits from competitors.
- Competitive parity, which involves dividing marketing costs by market share. When choosing this method, qualitative differences between the company and the competitor and different target priorities do not come into view. A competitor may have internal expenses that do not go public. For example, he invests money in the development of a modern mobile application, which the market will only know about after its launch.

**3. On the amount of funds that the company is willing to invest in marketing**

This method is used by startups or companies without a historical base related to the development of marketing, which do not have large budgets and plan from the

funds that they currently have. In conditions of a limited budget, it is important to clearly build an action plan, select several advertising channels and test their effectiveness.

**4. From goals and objectives**

The method focuses on evaluating the necessary resources of the company. The budget is formed through the sum of all pre-calculated costs after completing marketing tasks. This approach to budget creation is considered the most effective and complete.

In order to correctly determine the marketing budget, you need to understand how the economy of a company or product develops. For this, unit economics calculations, margin determination, share of advertising expenditure and understanding of the sales funnel are used.

**Unit-economics**

A unit is a unit of goods or services that a company produces and sells. Unit economics is the calculation of the difference or ratio of revenue and expenses for a product, customer or user (Figure 1).

**The cost of attracting a client=**(Average check-The average cost of the buyer right)* Repeat purchases

Figure 1. The formula of the cost of attracting a client

It is considered at the business planning stage to predict sales, and after its launch to track possible problems. Weekly analysis allows you to evaluate the indicators and understand what can be changed and improved.

**Marginality**

In an ideal world, the budget for marketing, including advertising, should be included in the cost of production. This budget can fall into variable or fixed costs. It depends on the company's decision. But it often happens that advertising costs are not included in the cost of a product or service at all. Then they are covered from the margin. Margin is the difference in rubles between the cost and the final price. The company makes a profit from the margin. Marginality is the percentage difference between the cost and the final price.

**Share of advertising expenses**

The share of advertising expenses (SAE) reflects what percentage of the money earned was spent on advertising, that is, how much money it took to earn 1 ₽ (Figure 2) [3, p. 67]:

**SAE** = (advertising expenses : advertising revenue) * 100%

Figure 2. The formula of the SAE

**Sales funnel**

In order to determine the share of expenses within the marketing budget, you need to understand the goals at each stage of the sales funnel (Figure 3) [4, p. 121].

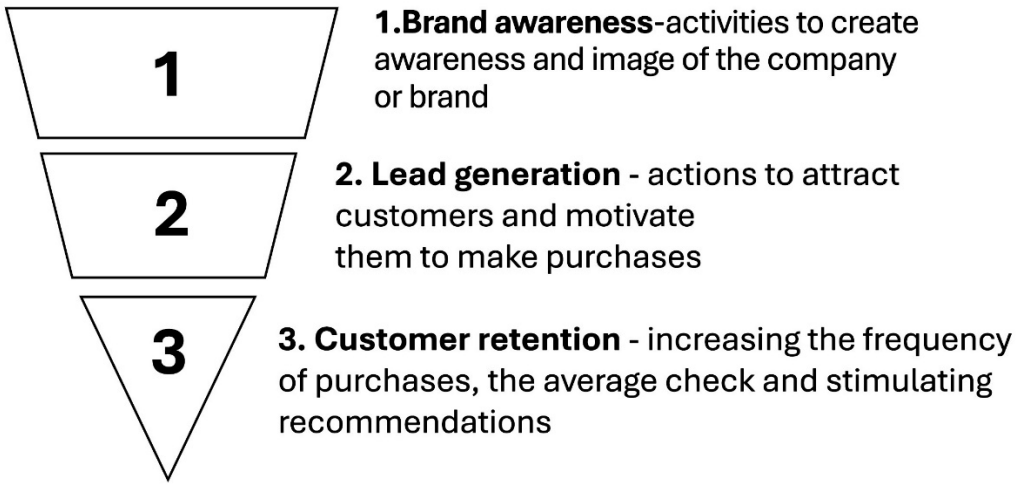


Figure 3. A detailed model of consumer and consumer behavior

A marketing budget is effective if the cost of it pays off. Here are the factors that are important to consider when planning a budget [5, p. 43]:

– **Seasonality of demand.** This is relevant for companies that depend on seasonal fluctuations in demand for their goods, for example, some food or beverages.

– **The capacity of the sales and production department.** Will the company cope with a large flow of customers and will it be able to manufacture products or provide a service on time?

– **Channels that will be used for advertising.** The choice of advertising channels is related to the sales funnel and business goals.

– **Cash flow**, cash gap control (temporary problems with financing budget expenditures) and realistic installment payment opportunities.

It is important to understand that a marketing budget is a dynamic tool that requires constant monitoring and adaptation to changing market conditions and the needs of the target audience. In conclusion, it can be noted that effective planning and management of the marketing budget is a key factor for achieving success in any marketing strategy. This article can be used as a starting point for developing your own marketing budget, allowing you to create a more targeted, effective and measurable marketing strategy.

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# SOLAR SAIL TECHNOLOGY FOR MOVING IN SPACE

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**Abstract.** This article provides an overview of the technology of using solar sails in space exploration. Solar sails are an innovative technology that uses the pressure of sunlight to move spacecraft. The concept, first proposed in the 1920s, is based on the principle that photons reflected from the mirror surface of the sail create thrust, allowing the ship to move without the need for traditional fuel. Solar sails provide light and continuous thrust, making them ideal for long-duration space missions, especially within the Solar System, where sunlight is abundant.

**Keywords:** solar sail, photons, momentum, space exploration.

# ТЕХНОЛОГИЯ СОЛНЕЧНЫХ ПАРУСОВ ДЛЯ ПЕРЕМЕЩЕНИЯ В КОСМИЧЕСКОМ ПРОСТРАНСТВЕ

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**Аннотация.** Данная статья посвящена обзору технологии применения солнечных парусов для исследования космоса. Солнечные паруса представляют собой инновационную технологию, которая использует давление солнечного света для перемещения космических аппаратов. Данная концепция, впервые предложенная в 1920-х годах, основывается на принципе, согласно которому фотоны, отражаясь от зеркальной поверхности паруса, создают тягу, позволяющую кораблю двигаться без использования традиционного топлива. Солнечные паруса обеспечивают легкую и непрерывную тягу, что делает их идеальными для длительных космических миссий, особенно в пределах Солнечной системы, где солнечный свет доступен в изобилии.

**Ключевые слова:** солнечный парус, фотоны, импульс, космические исследования.

Since ancient times, people have looked up at the night sky, admiring the stars and trying to unravel their mysteries. The stars served not only as navigational

landmarks, but also as objects of deep philosophical reflection. Over time, with the development of science and technology, people began to invent new tools and methods for exploring space and neighbouring planets. Telescopes, satellites and space probes have become important steps in understanding our place in the universe. Today, science does not stand still: every year new technologies appear that open up wider horizons for us. One such amazing achievement is solar sails.

These innovative devices use solar radiation as a source of energy to travel in space, opening up new opportunities for exploring the far corners of our galaxy. Solar sails are a unique technology that uses the pressure of photons emitted by the Sun to move in space. This concept allows spacecraft to travel without the need for conventional fuel, making them particularly effective for long-term interplanetary missions.

The solar sail works on the basis of Newton's third law, which states that for every action there is an equal and opposite reaction. When a photon of light hits the surface of the sail, it transmits an impulse to it. Although each individual photon has a very small pulse, with a large number of photons (e.g. over an area of one square kilometre), the total pressure can reach significant values. However, this information is not fully understood and has open questions [1].

To achieve maximum efficiency, solar sails should have the following properties:

- minimal mass of the sail material;
- a large surface area needed to capture a large number of photons;
- high reflective properties to maximize the transmission of momentum from photons.

Solar sails are ideal for exploring the inner planets of the Solar System, such as Europa and Enceladus. It is estimated that a 100 kg solar sail can reach Europe in just 1-4 years, and Enceladus in 3-6 years. This makes them an excellent choice for missions to search for extraterrestrial life.

There are several types of solar sails, each with its own unique characteristics and operating principles:

- The square sail is the most common type of solar sail, which has been used in projects such as the Japanese IKAROS probe. It has a square shape and is made from lightweight materials such as polyester or polypropylene, with a reflective coating to increase efficiency.
- Heliogiro is a type of solar sail that consists of narrow "blades" or ribbons, which can be long (up to hundreds of meters) and have a small width. The heliogiro allows you to control the direction of movement more effectively by rotating individual belts. An example of using this type is the Ultra Sail project.
- Rotary solar sail consists of several blades stretched on a frame. Each blade acts as a membrane, and their movement allows the pressure of sunlight to be used to create thrust. This type of sail can be made of lightweight synthetic materials and is designed for stable deployment in space [2].

In modern history, there have already been real launches of this technology. For example, "Znamya-2": the first Russian experiment with a solar sail, conducted in

1993. It confirmed the possibility of deploying the sail in space and its stability (Figure 1).

Figure 1. “Znamya-2”: the first Russian experiment with a solar sail

The project “LightSail-2”, launched by the Planetary Society in 2019, demonstrated the practical application of solar sail technology (Figure 2).

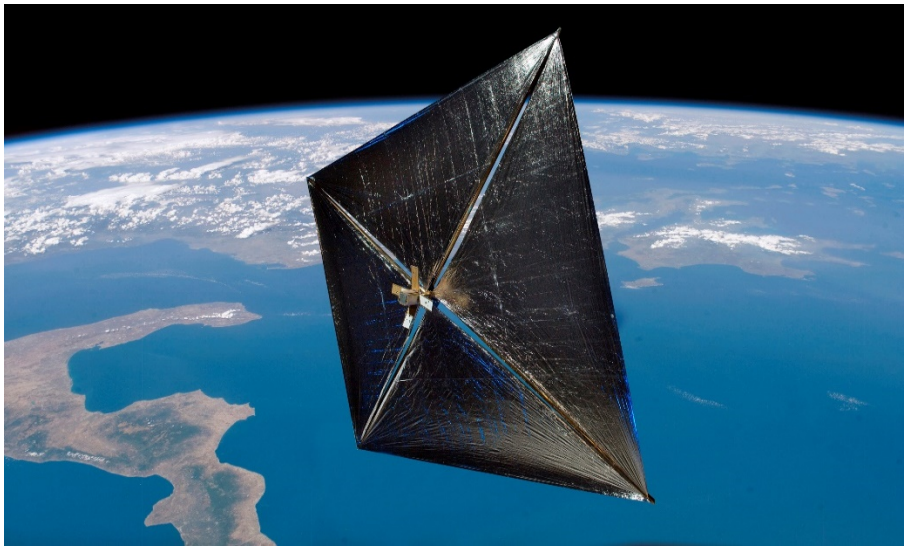

Figure 2. LightSail-2

So why do we need solar sails when we already have familiar rocket technologies and spacecraft? Comparing the efficiency of solar sails with traditional rocket engines shows that each technology has its own unique advantages and disadvantages that make it suitable for different space missions.

One of the advantages of solar sails is the lack of fuel: this technology does not require fuel storage, which allows you to reduce the weight of the device and increase the payload. They use solar radiation as an energy source, making them environmentally friendly.

Another advantage is continuous acceleration: solar sails can provide constant, albeit slight acceleration over a long period of time. This allows them to accumulate speed, reaching significant values that can exceed those of traditional rocket engines.

Thirdly, low mechanical loads can be mentioned: solar sails experience lower mechanical and thermal loads compared to rockets, which increases their lifetime [3].

Unfortunately, solar sails also have disadvantages, the first one being low maximum speed, which is significantly lower compared to rocket engines, especially ion or thermonuclear ones. For example, a solar sail can reach speeds of up to 100 km/s after a long acceleration, while rockets can reach much higher values in a short time. Another disadvantage is dependence on sunlight: the efficiency of solar sails decreases in interstellar space due to the lack of a strong light source. This limits their use for deep space missions.

Scientists are currently trying to solve the problem of the low speed of solar sails. The theoretical speed that solar sails can reach is ~ 120,000 km/s (or 40% of the speed of light) under ideal conditions, which is significantly higher than the speeds of traditional rocket engines. This is possible due to the constant exposure to solar photons, which provide continuous acceleration.

The currently recorded maximum speed achieved by spacecraft with solar sails is significantly lower. For example, the IKAROS spacecraft reached a speed of about 1,410 km/h (or 0.39 m/s) during its mission (Figure 3).

Figure 3. IKAROS is a Japanese spacecraft with a solar sail

Another device, LightSail 2, was able to increase its speed to 549 km/h (or 0.15 m/s) during the month of flight due to constant exposure to sunlight.

Solar sails are capable of accumulating speed for a long time. For example, if a solar sail vehicle receives an acceleration of 1 mm/s2, it will be able to gain a speed of about 15.5 km/s in six months of continuous acceleration.

The speed of the solar sail also depends on the distance to the Sun. The closer the sail is to the Sun, the more photon pressure it receives. For example, at a distance of 37 million kilometers from the Sun, the pressure can increase by 16 times compared to the Earth’s orbit.

Controlling the orientation of the solar sail is a key aspect of its operation, since it determines the effectiveness of using solar pressure to maneuver the

spacecraft. There are several methods and systems that can be used to change the angle of the sail and, accordingly, direct its movement.

1. Changing the angle of the sail: the orientation of the solar sail relative to the flow of sunlight can be changed by changing the angle of inclination. This allows you to adjust the force and direction of the thrust created by the light pressure. For example, if the sail is turned at an angle to the Sun's rays, this will change the direction of the transmitted pulse and, as a result, change the trajectory of the device.

2. Active Orientation Control Systems (ACS): special orientation control systems are installed on spacecraft with solar sails. These systems allow you to adjust the tilt of the sail depending on its orbital trajectory and provide zero net torque for a stable position of the device.

3. Using of inertial wheels: some designs, such as the LightSail-2, use inertia wheels to control orientation. They help the device to make turns and maintain the desired angle of inclination of the sail.

4. Changing the reflectivity of the surface: orientation control can also be carried out by changing the reflectivity coefficient of the sail surface. This allows you to adjust the effect of sunlight on different sides of the sail, thereby changing its response to light pressure. However, this information is theoretical, not used in practice [4].

Thus, solar cell technology can become the foundation of a new era in space exploration. Research shows that the use of solar panels can significantly reduce the flight time to remote planets and objects of in the Solar System. However, in practice, their maximum speed remains well below theoretical limits due to the limitations of modern technology and working conditions in space. This opens up opportunities for improving this technology and further using it for more ambitious missions to explore extraterrestrial life and other planetary systems. Solar sails are therefore a promising technology for future space exploration, enabling long-duration flights without the need for traditional fuel and opening up new opportunities for exploring the farthest corners of our Solar System.

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**УДК 621.31**

# CARBON NANOTUBE-BASED TECHNOLOGIES

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**Abstract.** Carbon nanotubes are unique nanoscale structures with exceptional mechanical and electrical properties. They demonstrate high strength with low weight and are capable of conducting electric current at a level comparable to traditional conductors. In recent years, various methods for the synthesis of carbon nanotubes have been developed, which has made them more accessible for industrial applications. This opens up new horizons for the creation of wires and cables with improved characteristics that can significantly surpass existing metal counterparts.

**Keywords:** nanotubes, energy, wires, alternative materials.

# ТЕХНОЛОГИИ НА ОСНОВЕ УГЛЕРОДНЫХ НАНОТРУБОК

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**Аннотация.** Углеродные нанотрубки представляют собой уникальные наноразмерные структуры, обладающие исключительными механическими и электрическими свойствами. Они демонстрируют высокую прочность при малом весе и способны проводить электрический ток на уровне, сопоставимом с традиционными проводниками. В последние годы разработаны различные методы синтеза углеродных нанотрубок, что сделало их более доступными для промышленного применения. Это открывает новые горизонты для создания проводов и кабелей с улучшенными характеристиками, которые могут значительно превзойти существующие металлические аналоги.

**Ключевые слова:** нанотрубки, энергетика, провода, альтернативные материалы.

In recent decades, the world has seen significant changes in the field of wire and cable production technology, traditionally based on the use of various metals such as copper and aluminum. These materials have proven themselves due to their

high conductivity and durability, but their use is associated with a number of limitations, including high cost and significant weight. In response to these challenges, scientists have begun to actively explore alternative materials, among which carbon nanotubes (CNTs) attract special attention.

The main materials used to make wires and cables at the moment are:

1. Copper

Copper has high electrical conductivity, which makes it an ideal material for conductors. The resistivity of copper is approximately 0.017-0.018 μom·m, which ensures low energy losses during the transmission of electricity. It is more ductile than aluminum, which makes it possible to create flexible cables and wires capable of withstanding significant mechanical loads and bends.

2. Aluminum

Aluminum is significantly cheaper than copper and lighter, making it a popular choice for some applications. However, its resistivity is higher (about 0.0271 ohms · sq.mm/m), which limits its use in wires with a small cross section. Aluminum wires are more fragile and prone to breakage, especially when bending, so their use is limited.

3. Lead

Lead is not used for conductive conductors, but is used to create a protective shell of wires, especially in aggressive conditions (for example, in the ground or under water) due to its high ductility and corrosion resistance [1].

Of course, they all have their advantages and disadvantages, but with the development of technology, a new opportunity has appeared for the production of wires and cables, namely the use of CNTs.

CNTs are unique nanoscale structures with outstanding electrical, mechanical and thermal properties. These characteristics make them promising for use in the production of wires and cables with high conductivity.

1. Electrical conductivity of carbon nanotubes

CNTs have high electrical conductivity, which allows them to be used as substitutes for traditional conductors such as copper and aluminum. This is due to their structure, which ensures the efficient transfer of electric charges. In particular, single-layer nanotubes can exhibit conductivity comparable to copper, but at the same time have significantly less weight and volume.

Advantages of using CNTs in wires and cables:

- Lightness and strength: CNTs are significantly lighter than traditional materials, which allows you to create lighter and more durable wire structures.
- Corrosion resistance: due to its chemical stability, carbon nanotubes are not susceptible to corrosion, which increases the service life of wires and cables.
- Flexibility: CNTs can be used to create flexible conductors, which is especially important in modern electronic devices.

2. Technological aspects of production

The production of CNT-based cables requires the development of new technologies for their uniform distribution in a matrix of polymers or other materials. This may include the use of various composite manufacturing methods such as extrusion or injection molding. It is also important to take into account that the uniform distribution of CNTs in the material is critically important to achieve the claimed electrical properties [2].

The prospects for the development of technologies using CNTs look very promising due to their unique properties and wide range of applications.

Carbon nanotubes are actively used to create polymer nanocomposites. The development of a new method for producing such composites using briquettes from compacted CNTs can significantly reduce production costs and improve the characteristics of the final product, such as electrical conductivity and thermal conductivity. This can accelerate the development of the composites industry and lead to a wider introduction of CNTs into everyday life. CNTs are also used in the production of flexible and transparent electronics such as solar cells, LEDs and touchscreens. In addition, they can be used in hydrogen batteries and other energy storage devices, which can facilitate the transition to more environmentally friendly energy sources. In medicine, carbon nanotubes can be used to deliver drugs, create implants, and develop new diagnostic methods. Their unique properties make it possible to develop highly effective means of combating various diseases. According to forecasts, the market for carbon nanotubes will continue to grow, due to an increase in their use in various industries, including automotive, aviation and electronics. It is expected that new technologies for the production and application of CNTs will help reduce the cost of materials and expand their use. Thus, carbon nanotubes have the potential to become a key element in the development of high technologies, providing new solutions for a variety of industrial and scientific tasks.

Production stages

1. Growing carbon nanotubes

The most common methods include chemical gas phase deposition (CVD), where carbon nanotubes are formed on catalysts at high temperatures (600-1200 °C) using gases such as acetylene ($C_2h_2$) and methane ($ch_4$).

The use of various catalysts, such as Fe/Ti or Co/TiN, allows you to control the orientation and density of nanotubes

2. Creating composites

CNTs can be mixed with other materials to create composites, which increases strength and conductivity. For example, studies show that adding CNTs to polymer matrices significantly improves their mechanical properties.

3. Wire forming

To form wires from CNTs, the winding or extrusion method is used, where the resulting nanotubes are assembled into filaments or fibers. This may include mixing CNTs with other polymer or metal components to improve the properties of the final product.

It is important to ensure the uniform distribution of nanotubes in the matrix in order to avoid the formation of defects that can reduce the strength of the wires [3].

Carbon nanotubes (CNTs) have a number of significant advantages over traditional materials such as copper and aluminum, which are commonly used for the production of wires and cables. These advantages include:

- Corrosion resistance: CNTs are not subject to corrosion, which significantly increases the service life of wires and cables. Unlike copper and aluminum, which can be oxidized, carbon nanotubes retain their properties even under aggressive conditions.
- Flexibility and miniaturization capability: CNTs can be used to create flexible conductors, which is especially important for mobile devices and wearable electronics. This opens up new possibilities for designing compact and lightweight electrical components.
- Improvement of thermal properties: carbon nanotubes have high thermal conductivity, which allows efficient heat dissipation in electrical systems. This can reduce the risk of overheating and improve the reliability of the devices.
- Environmental safety: compared to traditional metals, CNT production can be less energy-intensive and more environmentally friendly, which makes them attractive for sustainable technology development.

The use of carbon nanotubes (CNTs) in electronics is associated with a number of problems that must be considered for the successful integration of these materials into existing technologies. The main problems include:

- Technological difficulties of integration: the integration of carbon nanotubes into mass-produced electronic devices faces production and processing difficulties. This is due to the need to develop new technologies that will ensure a stable and high-quality connection of CNTs with other materials such as silicon or metals.
- Adhesion of nanotubes: CNTs tend to stick together to form agglomerates, which makes it difficult to use them as a homogeneous conductor. This can lead to heterogeneity of electrical properties and a decrease in overall efficiency.
- High contact resistance: when connecting carbon nanotubes with metal elements, the problem of high contact resistance arises, which leads to significant energy losses. This prevents the creation of efficient and reliable electrical connections.
- Environmental and toxicological issues: the potential toxic effects of carbon nanotubes on human health and the environment are also of concern. Studies show that some types of CNTs can cause negative biological reactions, which requires additional research to assess their safety.
- High production cost: although the cost of carbon nanotubes is decreasing, it still remains higher compared to traditional conductors such as copper. This may limit their use in the mass production of electronics [4].

The use of carbon nanotubes in the production of wires and cables opens up new horizons for the creation of highly efficient, lightweight and durable electrical systems. These advantages make CNTs an important direction in the development of

new materials for electronics and energy. Despite the outstanding electrical and mechanical properties of carbon nanotubes, their use in electronics requires solving a number of technological, environmental and economic problems. The production of heavy-duty carbon nanotube wires requires an integrated approach to the selection of methods for their cultivation, processing and formation. Given the unique properties of CNTs, such wires can significantly change the approaches to creating new materials in various industries. Successful overcoming of these obstacles will open up new horizons for the use of CNTs in various fields of electronics and nanoelectronics.

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# REVIEW OF EQUIPMENT FOR CLEANING EMISSIONS FROM HYDROCHLORIC ACID VAPORS AT THE PRODUCTION OF MCC

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**Abstract.** The article examines methods and equipment for cleaning emissions from hydrochloric acid (HCl) vapor. Mechanical purification and absorption are considered as the methods of gas purification. The paper also analyses a complex of purification equipment, including a filter and scrubber. The principles of operation and advantages of the installations are given.

**Keywords:** emissions, hydrochloric acid, mechanical cleaning, filter, wet gas cleaning, scrubber.

# ОБЗОР ОБОРУДОВАНИЯ ДЛЯ ОЧИСТКИ ВЫБРОСОВ ОТ ПАРОВ СОЛЯНОЙ КИСЛОТЫ ПРИ ПРОИЗВОДСТВЕ МКЦ

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**Аннотация.** В статье рассматриваются методы и оборудование для очистки выбросов от паров соляной кислоты (HCl). В качестве методов очистки газа приводятся механическая очистка и абсорбция. Также в работе рассмотрен комплекс очистного оборудования, включающий в себя фильтр и скруббер. Анализируются принципы работы и преимущества установок.

**Ключевые слова:** выбросы, соляная кислота, механическая очистка, фильтр, мокрая очистка газов, скруббер.

The most common method of producing microcrystalline cellulose (MCC) is hydrolysis of raw materials in the presence of hydrochloric acid and at high temperatures. Hydrolysis is carried out by the action of 41 % hydrochloric acid at a temperature of 150-170 °C, which is above the boiling point of the acid and leads to its evaporation.

Hydrochloric acid vapors pose not only a danger to human health but also a significant risk to the environment. These vapors can corrode and damage

ecosystems, contaminating soil and water bodies. Once in the atmosphere, they can initiate chemical reactions leading to the formation of acid rain, which harms vegetation and animals. Therefore, it is crucial to implement measures to purify and remove hydrochloric acid vapors to minimize its negative impact on nature and preserve the ecological balance. Ensuring safe handling practices for this chemical is an important task for environmental protection. To ensure safety, production emissions of hydrochloric acid vapor must be cleaned up.

Equipment for cleaning hydrochloric acid (HCl) vapor emissions must meet several basic requirements to ensure efficient, safe and environmentally friendly operation.

Hydrochloric acid vapors are highly corrosive and can damage metal structures, equipment and building materials, therefore, equipment used to treat gas from hydrochloric acid vapors should be made of corrosion-resistant materials such as stainless steel with high toxic resistance, polymeric and composite materials capable of withstanding the aggressive conditions caused by HCl vapor. The equipment must be capable of operating under varying temperatures and pressures, as well as changes in the composition of the emissions. The equipment should minimize the generation of secondary pollutants and safely dispose of by-products from the cleaning process.

The system of hydrochloric acid emissions purification, which includes mechanical (filter) and physical-chemical (absorber) purification stages, is a reliable way to reduce the concentration of hazardous emissions into the atmosphere and protect the environment.

Mechanical cleaning of hydrochloric acid vapor emissions using filters is one of the important steps in pollution control systems. This process aims to remove droplets containing hydrochloric acid. The essence of the filtration process in the capture of acid droplets from vapors by a filter is that because of a surface, screen filtration mechanism on the membrane, the captured aerosol droplet formation occurs and the formed droplets flow back inside the container [1].

Filters are mechanical and carbon filters. Mechanical filters use physical barriers such as meshes or textile membranes to separate particles from gas streams. These filters are effective at trapping large and medium-sized particles. The activated carbon in carbon filters is capable of adsorbing chemicals and can be used to remove hydrochloric acid residues and other volatile organic compounds if they are present in the emissions [2].

The advantage of mechanical filters is that they can be easily cleaned or washed and do not require regeneration of the filter media after each filtration cycle like carbon filters. This advantage allows for increased operational efficiency and reduces the cost of chemicals used for regeneration.

One type of mechanical filter is mist eliminators (Figure 1).

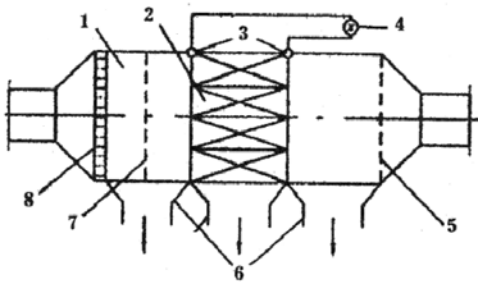


Figure 1. Mist eliminator:
*1* – housing; *2* – electrode block; *3* – high-voltage electric insulators with terminals; *4* – voltage source; *5* – drop catcher; *6* – funnel; *7* – grid; *8* – distribution grid

Mist eliminators are fiber filters used to capture liquid droplets larger than 10 microns. The filtering partition in them is a packed material made of polymer fibers. During the operation of the apparatus, the structure is saturated with liquid, and then gravity droplets remove it. The cleaning efficiency of mist eliminators is 90-99 %.

Many mist eliminators are easy to operate and maintain, and are also highly energy efficient, which reduces energy consumption during their operation

Acid aerosol trap filters are also an effective solution. Aerosol trap filters work by several key mechanisms in which the droplets contained in gases are captured. The first mechanism is surface filtration wherein the gas containing acid aerosols passes through a filter element. The surface of the filter membrane retains the particles and droplets that adhere to it. This stage allows even small droplets of aerosols to be effectively trapped. The second mechanism is screen filtration wherein a screen mechanism is used for larger particles and droplets. As the gas flow moves through the pores of the filter (membrane), aerosol droplets collide with the holes and cannot pass through them, settling on the surface [3]. Cleaning efficiency of the filter-catcher of acid aerosols can reach 96-99 %.

The advantage of these filters is that both the polyethylene housing and the PTFE filter element provide resistance to chemical attack, allowing the filter to operate effectively in high acidic environments. In addition, whole filters or their replaceable parts require minimal maintenance.

After the hydrochloric acid, vapors have been captured and partially cleaned, wet gas cleaning must be performed. Wet gas cleaning is based on the absorption process. The method of cleaning emissions from hydrochloric acid (HCl) vapor using absorption is one of the most common and effective ways to remove the pollutant from gas streams. An absorbent (liquid), which can be an aqueous solution of an alkali such as sodium hydroxide (NaOH), is introduced into the system. The gas passes through contact devices. In these devices, intensification of the gas-liquid interaction is carried out. This can be achieved by breaking the gas into small bubbles and providing sufficient contact time with the liquid. Such a process can be realized in a scrubber with fixed nozzles. A scrubber is a device designed for continuous contact between gas and liquid, creating conditions for absorption and chemical reaction.

One type of scrubber suitable for reagent scrubbing is the foam scrubber. A foam scrubber is a liquid plate absorption filter for effective cleaning of industrial

emissions from a wide range of gaseous, vapor-aerosol and micromechanical impurities (Figure 2). The principle of operation consists in passing the polluted flow through the working chamber, in which perforated trays are installed in tiers, one above the other. During parallel irrigation of the plates, the passage of the gas phase through the perforations creates a dense layer of foam in which technologically undesirable, toxic or ballast compounds are captured. The foam, capturing pollutants, collapses into a liquid and is discharged from the working area through an open or semi-closed circuit into a container via an overflow system [4].

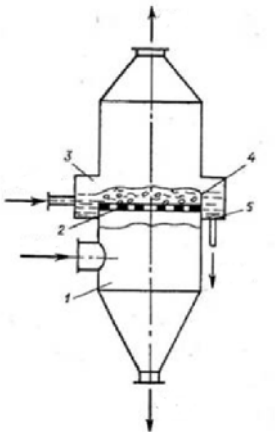

Figure 2. Foam scrubber:
*1* – body; *2* – perforated plate; *3* – receiving box, *4* – threshold; *5* – drain box

The foam scrubber removes contaminants from the gas-air mixture with a size of 5 microns or larger, has compact dimensions and a high purification rate of 99 %.

Effective cleaning can also be achieved with the use of a nozzle scrubber. In nozzle scrubbers, the column cross-section is filled with a nozzle on which the liquid flows down in the form of a film. The gas fed to the bottom of the column flows countercurrently to it [5]. The wetted surface of the nozzle is the surface of phase contact (Figure 3).

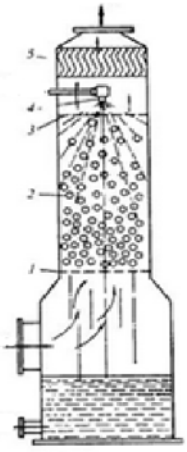

Figure 3. Scrubber with movable ball nozzle:
*1* – support plate; *2* – ball nozzle; *3* – restrictive plate; *4* – irrigation device; *5* – drift eliminator

The main advantages of this method are high cleaning efficiency and the use of inexpensive reagents, but the salts formed in the neutralization process may require additional treatment and disposal, which may lead to additional costs.

Based on the studied materials, it can be concluded that the use of an integrated treatment strategy based on a combination of mechanical filtration and absorption scrubber cleaning is the most reliable and effective approach. First, mechanical cleaning using filters allows the capture of liquid droplets in the gas stream, which effectively reduces aerosol concentrations. This preliminary step eliminates a variety of potential contaminants and reduces the burden on subsequent purification steps. Second, absorption scrubber cleaning provides chemical recycling of the remaining hydrochloric acid vapors, converting them into less hazardous compounds. Scrubbers use liquids, usually with neutralizing agents added, to absorb and dissolve the acid vapors, preventing them from being released into the atmosphere. The synergy of these two techniques – mechanical and absorption scrubbing – allows for a high level of pollutant removal, ensuring environmental safety.

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**УДК 336.051**

# THE FINTECH INDUSTRY ON THE EDGE: NARRATING THE TRENDS AND FIGURES STEALING THE FINANCIAL REVOLUTION

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**Abstract.** This paper discusses the driving factors and trends of the Russian financial technology industry. The digital payments, online lending platforms, cryptocurrency, robo-advisory and AI-driven investment management, blockchain and other drivers of innovation in Russia's fintech landscape are considered. Further, the research analysis looks into how consumers' rates of adoption in Russia and explores social and economic reasons that impact the acceptance of financial technologies in the country.

**Keywords:** fintech industry, digital payments, artificial intelligence, digital lending, robo-advisors, cryptocurrency.

# СЕКТОР ФИНАНСОВЫХ ТЕХНОЛОГИЙ НА ПЕРЕВОРОТЕ: ТЕНДЕНЦИИ И ДАННЫЕ, ФОРМИРУЮЩИЕ ФИНАНСОВУЮ РЕВОЛЮЦИЮ

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**Аннотация.** В данной статье рассматриваются движущие факторы и тенденции развития российской индустрии финансовых технологий. Затрагиваются цифровые платежи, платформы онлайн-кредитования, криптовалюта, роботизированное консультирование и управление инвестициями на основе искусственного интеллекта, блокчейн и другие движущие силы инноваций в сфере финансовых технологий в России. Кроме того, были проанализированы темпы внедрения финансовых технологий потребителями в России, а также социальные и экономические причины, влияющие на принятие финансовых технологий в стране.

**Ключевые слова:** финтех-индустрия, цифровые платежи, искусственный интеллект, цифровое кредитование, роботы-советники, криптовалюта.

These days, financial technologies are becoming an integral part of all types of financial services: lending, payments and remittances, savings, investment,

insurance, etc. They transform business models and enhance their customer focus. Both large financial organizations, such as banks, and specialist fintech companies offering a narrow range of services have introduced various fintech solutions [1]. In the past few years, the financial technology (fintech) industry has experienced tremendous growth, changing the way consumers and businesses handle, save, invest and spend their money. Reaching a size of around $699 billion by 2030, it is no surprise that fintech is continuously transforming the financial status of the regions across the globe. But how many numbers do we have in the case of such a trend that encourages the growth of financial technologies? Let us find out some statistics that raise the century old industry craze.

Fintech growth has been phenomenal. In fact, the current market size of the global fintech market is found to be USD 260,7 billion in 2022. Other research forecasts predict that this figure will generate returns with prevailing rates of 14 % CAGR (Compound annual growth rate) over the coming ten-year period; the market size is therefore expected to be close to 990 billion dollars by 2030 [2]. As for Russian fintech industry growth, it is reported that the revenue of Russian fintech companies for 2023 grew by 20 %. The total revenue of the 100 largest fintech companies in Russia for 2023 amounted to 223.8 billion rubles – this is 19.8 % more than a year earlier, according to a new Smart Ranking market review.

Causal factors for such growth include many factors, firstly, a rise in the usage of smartphones. There were about 4.8 billion smartphone users across the globe in the year 2024 (which is 60 % of the overall population) and the number is still increasing. According to the statistics there are 104 million of the smartphone users in Russia. The second factor is the increase in supply of customer and business banking online and electronic payment systems. Thirdly, higher spread of use of digital technologies by improving sectors can be mentioned, more so emerging markets.

The rise of digital payments takes place these days, addressing the journey towards a cashless society. Within the financial technology, or fintech, sector, it is safe to say that digital payments are one of the elements that is growing at a rapid rate. As of 2022, the overall value of the digital payments market through the systemically important payment system of the Bank of Russia (PS BR), 5.0 billion money transfers were carried out in the amount of 3342.4 trillion rubles (an increase of 1.9 times in quantity and 1.7 times in volume compared to 2021). On average daily 16.1 million transfers worth 13.5 trillion rubles were carried out through the BRPS. Well-known digital payment services that include the likes of YooMoney, Evotor, and Banki.ru have reported unprecedented levels of engagement during the recent past. To put this growth into perspective again, here are some figures that are sure to raise some eyebrows: in 2023, the share of Russians who use cash in everyday transactions decreased to 24 %. What is more, most Russians prefer non-cash payment methods. Most often, people pay with a bank card (75 %), mobile transfers and online banking are in second place in popularity (48 %), and the Faster Payment System is in third place (28 %) [3]. Moreover, the payment service YooMoney in 2023 increased net profit under RAS (Russian Accounting Standards) by 31.7 % – up to 2 billion rubles, compared to 1.51 billion rubles in 2022, as follows from the reporting of YooMoney.

In 2019-2021, thanks to the pandemic, according to Rosstat, 3.9 % of retail turnover came from online sales, while before the pandemic it was 2 %; due to the pandemic, this figure almost doubled. Export of goods through online services also increased by 42 % [4]. This explains why managing finances seems to be more consumer oriented for the most part for instance the management of payments embraces a lot of speed and efficiency in the processes.

Digital lending is yet another thriving niche within the fintech revolution and the reason behind the popularity of these services is the high speed of processing and accessing money. In 2022, microfinance organizations (MFOs) issued 22 % more loans than a year earlier. Most of the growth occurred in the second half of the year. In particular, the volume of loans issued to small and medium-sized businesses increased: 60 billion rubles were issued to entrepreneurs, which is 19 % more than in 2021 [5]. The market share for digital lending across the globe is expected to grow every year by 11.9 % due to the growing trend acceptance of nonbank financial services to consumers by many people. The digital lending market size is estimated at US$ 453.32 billion in 2024 and is expected to reach US$ 795.34 billion by 2029 [6]. Taking into account the mentioned consideration, digital loans, despite the benefit they offer, come under the scrutiny of regulators because of the dangers posed by the potential increase in default following a speedy approval process.

The demand for fast and easy loans has contributed to an immense growth of the online lending market in Russia. The emergence of digital lending platforms that have the public's attention can be said to have introduced competition to banks. The average time for content approval in a Russian digital lending platform is less than an hour whereas, in traditional banks, days and even weeks are expected. These platforms particularly attract younger Russians who value convenience and least time. These claims can be proved by the statistics, provided by analytical center NAFI, which states that over the past 5 years in Russia, the share of those who use mobile banking for financial transactions has doubled from 34 % in 2018 to 70 % in 2023. 2.5 times more Russians made certain transactions through Internet banking (17 % in 2018, 43 % in 2023) [7].

The emergence of Artificial Intelligence (AI) has changed the face of investing making it commonplace and cheap. In 2023, investors' assets in robo-advisors worldwide amounted to $2 trillion which is a significant increase from $987 billion in 2019. By the year 2025, assets under robo-advisory management (AUM) in this segment will likely reach $4.3 trillion. The investment sector in Russia is being changed by AI and robo-advisory services. Using AI technologies, the process of credit scoring is simplified, fraud detection is more effective and customer service is more efficient providing Russian clients with personalized financial services. AI-driven robo-advisors are also becoming popular, but at a primary level compared to the western countries. As per predictions, by 2025 robo-advisory AUM in Russia will grow to considerable amounts, indicative of the vacuum for automated investments. Ater running a research, an article in Financial Times was published, stating that GPT (Generative pre-trained transformer, a type of artificial intelligence language model) comfortably dominates the average financial analyst's performance in forecasting earnings [8].

Robo-advisors provide investors with numerous benefits, such as lower costs (generally not exceeding 0.25 %–0.50 % of the market value of funds under management) and more efficient means of investing where one can commence engagement with little or no capital. The minimal resource requirement for such service has enhanced the traditional way of investing where more resources are required especially with the youths of the millennial generation and those of the generation Z who would otherwise remain aloof from the financial markets. Customers will appreciate these services since these are low cost and algorithmic in nature and do not require physical advisors. Also, the adoption of AI for customer service offers a potential opportunity for growth. In 2023, for instance, chatbots powered by artificial intelligence solutions addressed 62 % of customer requests in Romanian online banks, responding quickly and solving problems efficiently which reduce cost of operation. In addition to this, AI plays a role in enhancing the experience of the users as it looks at trends so as to provide the most appropriate financial services to the user. The combination of such customization and quick service completion without any human intervention is also expected to enhance customer experience and loyalty in the fintech industry.

'Buy Now, Pay Later' services (BNPL) have gained popularity in the whole of Russia, especially within the younger audience that is looking for options out of conventional credit cards. Russian fintech companies are launching BNPL format at leading retail chains, enabling the customers to make payments in parts. This financing model allows even a casual buyer to make a high-value purchase, as it motivates expenditure and offers a simple timetable for repayments. On the one hand, the Russian Bureau of Natural Law has a rather slow evolving market perspective. Still, its expansion is supported by the demand for easily accessible payment methods. Yet, it is important to note that, BNNL can encourage overspend behaviors particularly with consumers who have other plans and are expected to pay other purchases. In Russia, financial specialists have begun advising consumers on the BNPL system hoping to limit the risks of excessive leverage restraint, to keep track of their expenses.

The involvement of Russia with the technology known as blockchain can be numerous, including usage which is not limited to digital currencies. Although quite a number of people in Russia are known to be cryptocurrency patrons, the usage of blockchain technology is also extending to other sectors such as agriculture infrastructure management, property management, and even Corporate Health Services. Policies that outline the use of such technologies are still in development, with the authorities in the country working out how best to utilize the technology without losing grip on virtual currencies.

Cryptocurrency markets have suffered periodic bottlenecks but interest in this technology remains robust in Russia. This country belongs to the group of several countries with the best percentage of the population using blockchain wallets while the existing cryptocurrency market in the region is expanding. In light of developing the regulatory and legislative structures, the economic impact of blockchain technologies in Russian Federation is expected to be tangible and growing, with

figures accordingly suggesting additional 1.76 trillion rubles contribution to GDP by the year 2027.

Artificial intelligence and machine learning remain an integral part of the innovative transformation of the fintech ecosystem in the Russian Federation. By the end of 2023, revenues from utilizing AI technologies in financial institutions in Russia had reported the highest figures ever, with the expectations of further increase up to 2030. Russian companies in the field of financial technology are also using AI, for example, to increase the level of service for customers by personalization or providing protection against fraud.

Indeed, AI-based tools are fundamental in risk management. AI is integrated into the operational practices of approximately 75 % of Russian banking and financial institutions to analyze the history of transactions, evaluate the risks of fraudulent activities, and adhere to the legal requirements. Moreover, the Russian society seems to embrace the concept of AI in the financial sector, with 57 % of the population being comfortable with AI applications taking control of some of their finances.

Similarly, Russian financial sector participants such as banks and fintech companies are implementing AI-based predictive analytics which allows them to make more realistic forecasts and develop service offerings that fit the customer needs. Those technologies are expected to help the fintech firms to stay afloat by providing efficient services that utilize data and are sufficiently fast, safe and convenient for the consumers.

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# ANALYSIS OF DIFFERENCES IN STANDARDS APPLIED TO GRAPHIC DESIGN DOCUMENTS OF ESKD AND ASME

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**Abstract.** This article is devoted to a comparative analysis of the requirements for the design of the graphic part of engineering and design documents in the Russian Federation and the countries of America. The paper discusses in detail the general provisions and standards governing the creation, design and presentation of drawings, diagrams and other graphic materials, and their application in the engineering model of a given country. Specific examples are provided for clarity and better understanding.

**Keywords:** system of standards, graphic design documents, design rules.

# АНАЛИЗ РАЗЛИЧИЙ В СТАНДАРТАХ ЕСКД И ASME ПРИМЕНИТЕЛЬНО К ГРАФИЧЕСКИМ КОНСТРУКТОРСКИМ ДОКУМЕНТАМ

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**Аннотация.** Настоящая статья посвящена сравнительному анализу требований, предъявляемых к оформлению графической части инженерно-конструкторских документов в Российской Федерации и странах Америки. В работе подробно рассматриваются общие положения и стандарты, регламентирующие создание, оформление и представление чертежей, схем и других графических материалов, их применение в инженерной модели данной страны. Для наглядности и лучшего понимания представлены конкретные примеры.

**Ключевые слова:** система стандартов, графические конструкторские документы, правила оформления.

ESKD (Unified System of Design Documentation) is a set of interstate standards that establish interrelated rules, requirements and norms for the development, execution and circulation of design documentation [1, 2].

ESKD is developed by Gosstandart with the support of state-accredited organizations.

ESKD establishes uniform standards for the execution and design documentation. ESKD ensures uniformity of execution of design documents, the ability to automate the processing of design documents, it eliminates discrepancies in technical documents as well [3].

ASME (The American Society of Mechanical Engineers) is an American society of mechanical engineers. ASME regulates industrial safety and is engaged, among other things, in the development of standards for the execution of drawings in various industries. Unlike the Russian set of ESKD standards, which is mandatory for all participants in the technical development market, ASME standards are developed for a specific customer and are not mandatory for other market participants [4, 5].

Despite the absence of a national standard for drawing up drawings in the USA, there are still generally accepted norms for drawing up design documents.

Let us try to compare these norms with the rules established in the Unified System for Design Documentation (ESKD).

We will make a comparison using a simple example shown in Figure 1. On the left side of the figure, there is a drawing made according to the ESKD standard, on the right side the drawing is made according to the ASME recommendations [5].

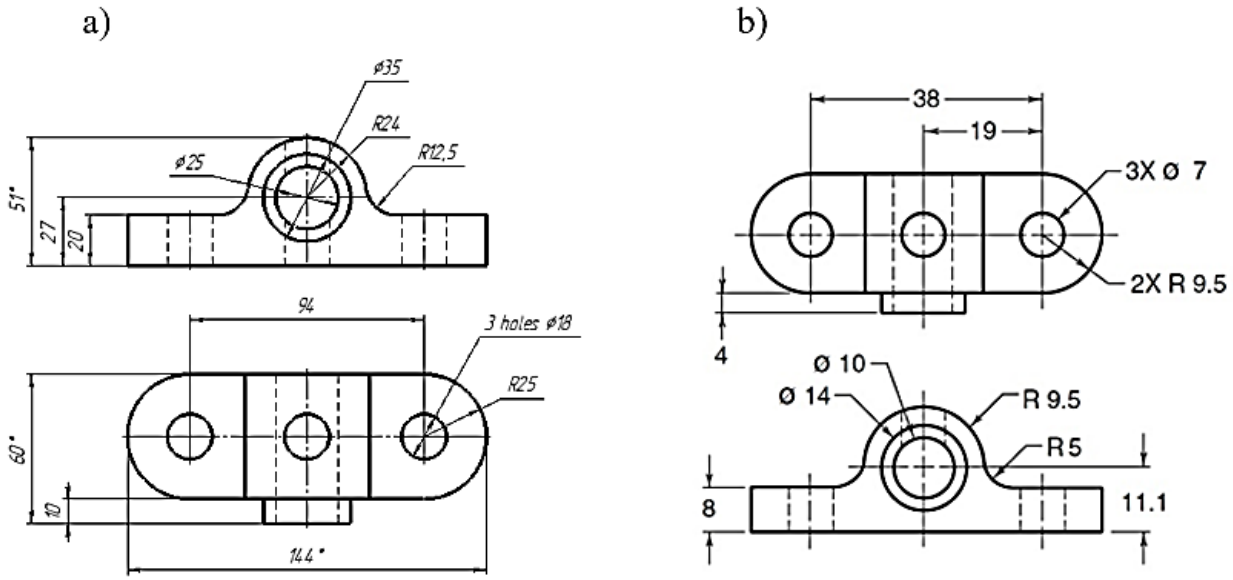


Figure 1. Example of a drawing:
a) according to the ESKD standards, b) according to the ASME standards

Let us analyze the differences. The first thing that catches the eye is the difference in the placement of views. The difference is due to the location of the object relative to the projection planes. In the ESKD system, the object is placed between the observer and the projection planes, in the first coordinate angle, while the observer looks through the object, the projection is performed on the plane behind the object (Figure 2). As a result, we have the top view located under the object, and the bottom view located on the plane above the object (Figure 3).

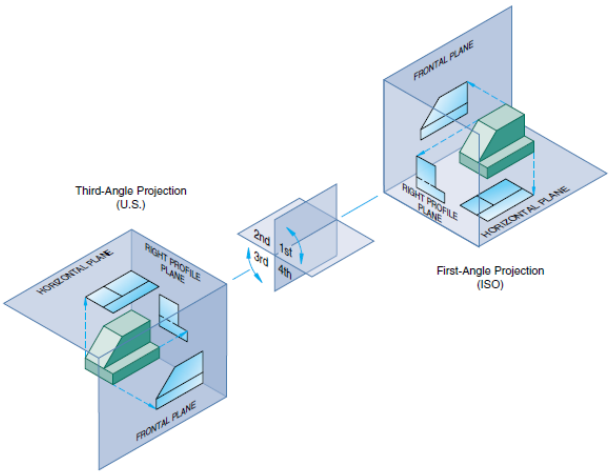


Figure 2. Projection of the first and third angles

In the ASME system of standards, the object is located in the third coordinate angle, behind the projection planes (Figure 2). When projecting, the projection planes stand between the object and the observer. This means that the top view is obtained by projecting onto the plane located above the object, and the bottom view is obtained by projecting onto the plane below it (Figure 4).

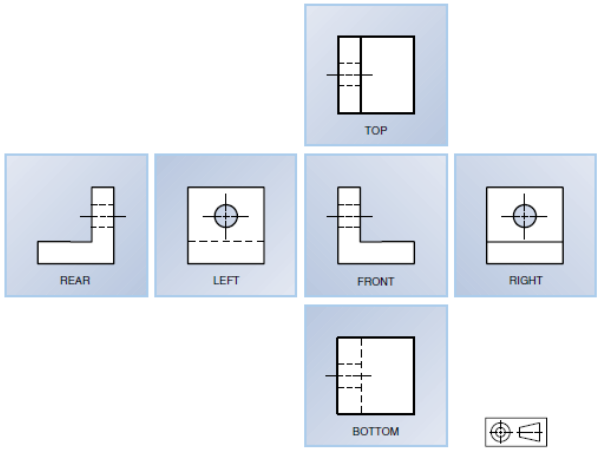


Figure 3. Standard layout of views for the ASME system

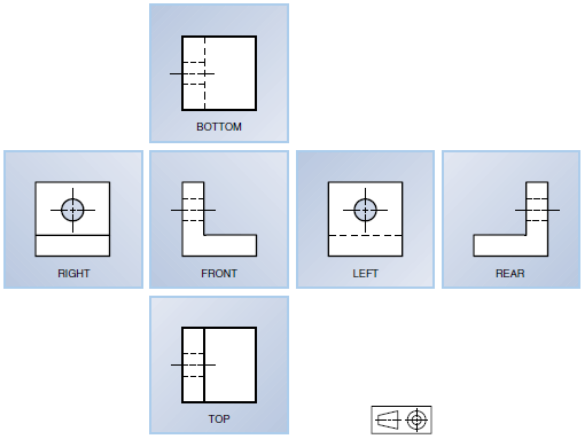


Figure 4. Standard layout of views for the Unified System for Design Documentation (ESKD) system

Returning to the analysis of the drawing presented in Figure 1, we can note other differences:

**Units of measurement**

In ASME, dimensions on drawings are specified in inches, in ESKD, dimensions on drawings are specified in millimeters.

**Dimension number position**

In ESKD, dimension numbers are placed above the dimension lines. In ASME, dimensions are specified in a break in the dimension line, always horizontally.

**Extension lines**

Extension lines in ESKD are drawn directly from the outline of the drawing, without a gap. In ASME, extension lines are drawn with an indent of 1-2 mm from the visible outline lines (Figure 5).

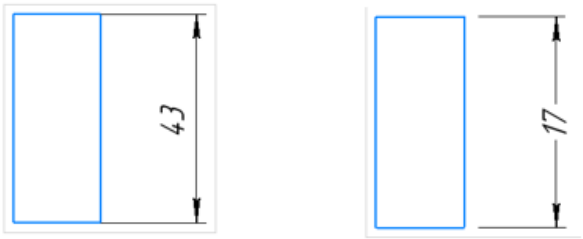


Figure 5. Rule for drawing extension lines

**Diameters of holes**

In the Unified System for Design Documentation (ESKD), diameters are usually indicated by lines with two arrows resting on the contour of the circle or on extension lines. It is allowed to break off the diameter dimension line beyond its center. The text part of the dimension is placed on the dimension line, on its extension or on the extension shelf (Figure 5).

In ASME, the diameter is shown by a dimension line extending from the center of the circle with a single arrow. The text part of the dimension is placed horizontally or vertically behind the extension shelf, with centre alignment (Figure 5).

In the Unified System for Design Documentation (ESKD), for several identical cylindrical holes, the following notation is used: “3 holes Ø 18”. In ASME, the notation is different, “3XØ7” (Figure 6).

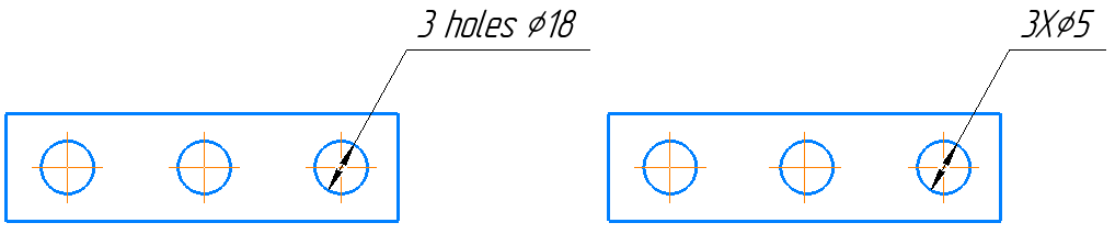


Figure 6. Rule for applying hole sizes

In the Unified System for Design Documentation (ESKD), the quantity of identical elements is recorded only for holes and chamfers. Other dimensions of identical elements are indicated without specifying their quantity, for example, the

radius of rounding R25 in Figure 1 or R12.5 in Figure 7. In ASME, the quantity can be specified for any identical elements, see Fig. 6, size 2XR5.


Figure 7. Rule for applying dimensions to identical elements

The analysis of the two images shown in Figure 1 allowed us to identify only some differences in the drawing systems, but even in such a small fragment we were able to identify six differences. When analyzing full-fledged design documents, the total number of differences will probably be several times greater.

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# GUARDIANS OF THE IONOSPHERE: A NEW ERA IN THE STUDY OF NEAR-EARTH SPACE

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**Abstract.** The launch of the Ionosphere-M satellites represents a significant breakthrough in Russian cosmonautics, as they form the country's first system for monitoring the heliogeophysical situation ("space weather"). This is a great achievement for the development of domestic space technologies and the expansion of scientific knowledge about near space. The article is devoted to the latest Russian Ionosphere-M satellites launched as part of the Ionosonde project. The material considers the key features of these spacecraft, their scientific tasks and their importance for the study of near-Earth space. Special attention is paid to the analysis of the advantages and potential limitations of Ionosphere-M satellites.

**Keywords:** space, heliogeophysical environment, space satellites, spacecraft.

# СТРАЖИ ИОНОСФЕРЫ: НОВАЯ ЭРА В ИЗУЧЕНИИ ОКОЛОЗЕМНОГО ПРОСТРАНСТВА

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**Аннотация.** Запуск спутников «Ионосфера-М» представляет собой значительный прорыв в российской космонавтике, так как они формируют первую в стране систему наблюдения за гелиогеофизической обстановкой («космической погодой»). Это является большим достижением для развития отечественных космических технологий и расширения научных знаний о ближнем космосе. Статья посвящена новейшим российским спутникам «Ионосфера-М», запущенным в рамках проекта «Ионозонд». В материале рассматриваются ключевые особенности этих космических аппаратов, их научные задачи и значение для изучения околоземного пространства. Особое внимание уделяется анализу преимуществ и потенциальных ограничений спутников «Ионосфера-М».

**Ключевые слова:** космос, гелиогеофизическая обстановка, космические спутники, космические аппараты.

In ancient times, people could only predict the weather by watching the stars and natural phenomena. However, science does not stand still, and today we have the opportunity to use high technology to study the world around us in depth. One of the most striking examples of such achievements is the launch of the Ionosphere-M satellites, which represents an important development in the field of space research. Ionosphere-M satellites No. 1 and No. 2, launched on November 5, 2024, became the basis of Russia's first heliogeophysical monitoring system called Ionosonde (Figure). This system is designed for continuous monitoring of the state of the Earth's ionosphere and studying the processes occurring in it under the influence of both natural and anthropogenic factors.

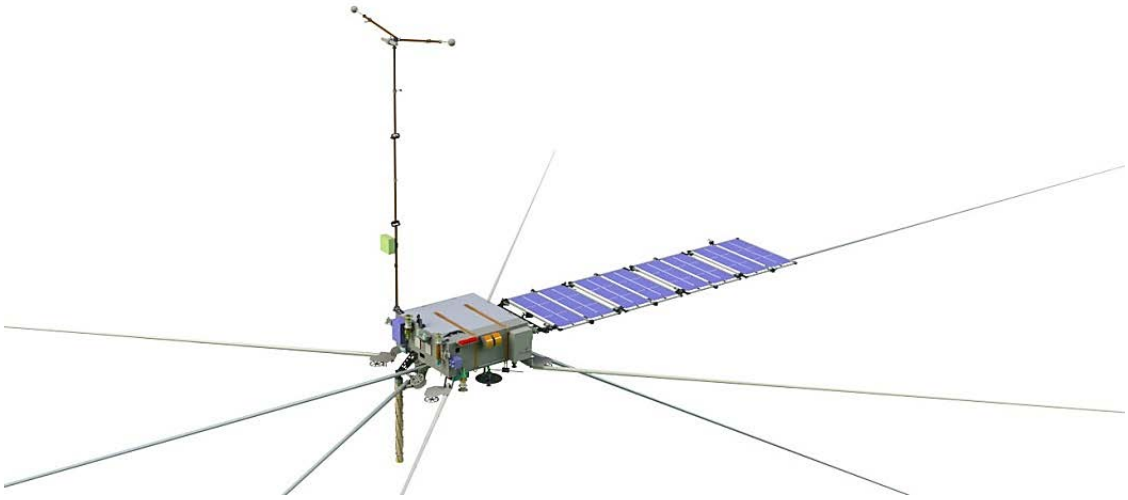

Figure. The first Russian system for monitoring the heliogeophysical situation “Ionozond”

The development of Ionosphere-M satellites includes unique scientific equipment that allows global sensing of the ionosphere in a wide frequency range. The data obtained will help scientists to better understand the impact of the space environment on the processes taking place on Earth, as well as on the operation of modern technological systems. Ionosphere-M satellites have several key objectives aimed at studying and monitoring the ionosphere and space weather:

The main objectives of the Ionosphere-M satellites:

1. *Ionosphere observation.* Satellites are designed to study physical phenomena in the Earth's ionosphere, including changes caused by both natural and anthropogenic factors.

2. *Space weather monitoring.* They will collect data on the state of near-Earth space, which will make it possible to predict the propagation conditions of radio waves and navigation signals, affecting the accuracy of navigation systems.

3. *The study of electromagnetic fields.* Satellites will be equipped with devices for measuring electromagnetic fields, which will help in understanding the processes occurring in the ionosphere and their impact on radio communications.

4. *Space radiation research*. The devices will analyze the level of cosmic radiation, which is important to protect both ground systems and spacecraft from the negative effects of solar activity.

5. *Study of the ozone layer.* The project also provides for a study of the distribution of ozone in the upper atmosphere, which is of practical importance for assessing the effects of solar radiation on human health.

*6. Fundamental research.* Satellites will contribute to solving scientific problems related to understanding processes in the high-latitude ionosphere and other aspects of heliogeophysics [1].

The Ionosonde project includes the creation of a constellation of four Ionosphere-M satellites and one Zond-M satellite. They are expected to be launched in two phases: the first two satellites have already been launched on November 5, 2024, and the next two are planned for 2025.

The Ionosphere-M satellites are two heliogeophysical devices designed to study space weather and monitor the Earth's ionosphere. These satellites were delivered to the Vostochny cosmodrome and are at the stage of preparation for launch.

Main Features:

Purpose: to study space weather and ionospheric dynamics.

Number: two satellites – Ionosphere-M №1 and № 2.

Ionosphere-M satellites will collect data on the state of the ionosphere, which will help in forecasting space weather. This is especially important to protect satellite systems and ground infrastructure from the negative effects of solar activity, such as solar flares and coronal emissions [2].

At the moment, the satellites are at the stage of integration and preparation for launch. They are expected to be launched from the Vostochny cosmodrome in the near future, which will be an important step for Russian cosmonautics in the field of space environment research. The main data that will be collected by the ionosonde:

1. *Electron concentration*: measurement of the concentration of electrons at various altitudes in the ionosphere, which allows you to estimate its density and structure.

2. *Electromagnetic field:* monitoring changes in electromagnetic fields in near-Earth space, which is important for understanding the interactions between the solar wind and the Earth's atmosphere.

3. *Cosmic radiation:* measurements of cosmic radiation levels, including solar proton and electron fluxes, as well as galactic cosmic rays.

4. Atmospheric parameters: studying the distribution of ozone in the upper atmosphere using spectroscopic measurements of reflected ultraviolet radiation from the Sun.

5. *Plasma spectra:* measurement of the differential energy spectra of ionospheric plasma, which makes it possible to study its dynamics and physical processes.

6. *Magnetic fields:* registration of magnetospheric phenomena and monitoring of the magnetic field in near-Earth space.

7. *Optical characteristics of the atmosphere*: study of the optical properties of the Earth's upper atmosphere, including spectroscopic measurements of ultraviolet radiation.

8. *Observations of solar activity:* collection of data on solar flares and other phenomena affecting space weather, including the construction of maps of the Sun [3].

The collected data will be used for:

– building a three-dimensional model of the Earth's ionosphere;

– conducting fundamental research of processes in the ionosphere;

– monitoring changes caused by both natural phenomena and anthropogenic activities;

– supporting scientific research in the field of heliogeophysics and space meteorology.

The Ionosphere-M satellites represent an important step in the development of the Russian space program and the space weather monitoring system. So, we can consider their advantages and disadvantages. The advantages are as follows:

1. *Improved forecasting.* Satellites will make it possible to more accurately predict the impact of solar activity on the Earth and its magnetic field.

2. *Integrated monitoring.* A system of four satellites (two have already been launched, two more are planned to be launched in 2025) will provide comprehensive monitoring of the Earth's ionosphere.

3. *Communication support.* Data from these devices will help improve global communications and satellite navigation.

4. *Scientific potential.* Satellites will provide valuable information to study the impact of space conditions on the Earth's climate.

5. *International cooperation.* The launch of Ionosphere-M was accompanied by the launch into orbit of 53 small satellites, including foreign ones, which demonstrates Russia's capabilities in the field of international space cooperation.

The disadvantages are:

1. *Limited quantity.* The system consists of only four satellites, which may limit the coverage and continuity of observations.

2. *High cost.* The development, launch and maintenance of such specialized satellites require significant financial investments.

3. *Dependence on ground infrastructure*. For the full operation of the system, a well-developed ground infrastructure for receiving and processing data is necessary.

4. *Vulnerability to space debris.* At an altitude of 820 km, where these satellites operate, there is a risk of collision with space debris.

5. *Limited service life*. Like all satellites, Ionosphere-M has a limited service life, after which replacement will be required [4].

The Ionosonde system represents an important step in the development of Russian science and technology, allowing not only to solve practical problems, but also to deepen understanding of processes in the Earth's atmosphere. Despite some disadvantages, Ionosphere-M satellites are an important tool for studying near-Earth space and improving space weather forecasting, which is of great importance for various spheres of human activity. This underlines the importance of the Ionosonde system as a tool for scientific research and practical application in the field of monitoring space weather and the state of the Earth's atmosphere.

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**УДК 316.42**

# MOTIVATION AND INVOLVEMENT IN PROJECT WORK

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**Abstract.** The article examines the issues of motivation and involvement in project work, focusing on the theoretical foundations and practical aspects of managing these factors. The factors influencing the level of employee engagement are considered, among which a special place is occupied by the meaning and value of the project, opportunities for professional development, relationships within the team, fair recognition and control over the work process. In addition, the article suggests methods to increase engagement through employee participation in decision-making, the use of feedback systems, encouraging teamwork and conducting regular project evaluations.

**Keywords:** projects, motivation, engagement, effective management, goal.

# МОТИВАЦИЯ И ВОВЛЕЧЕННОСТЬ В ПРОЕКТНУЮ РАБОТУ

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**Аннотация.** В статье описываются вопросы мотивации и вовлеченности в проектную работу, акцентируя внимание на теоретических основах и практических аспектах управления этими факторами. Рассматриваются факторы, влияющие на уровень вовлеченности сотрудников, среди которых особое место занимают смысл и ценность проекта, возможности для профессионального развития, отношения внутри коллектива, справедливое признание и наличие контроля над процессом работы. Кроме того, статья предлагает методы повышения вовлеченности через участие сотрудников в принятии решений, использование систем обратной связи, поощрение командной работы и проведение регулярных оценок проекта.

**Ключевые слова:** проекты, мотивация, вовлеченность, эффективное управление, цель.

In the modern world, project work is becoming an increasingly common form of labor organization. Projects require a high degree of responsibility, flexibility and readiness for change from the participants. The success of the project largely depends on how motivated and involved employees are in the work process. In this article, we will look at various aspects of motivation and engagement in project activities, as well as discuss the main theories of motivation that can be useful for improving the effectiveness of teamwork.

Motivation is an inner desire for action that pushes a person to achieve the goals of the project. It is determined by the personal values, interests, desires and goals of each participant.

Engagement is an active and conscious participation in a project, manifested in a willingness to invest your efforts, ideas and time in its success. The involved participants feel responsible for the result and strive for the common good.

Despite the close relationship, motivation and engagement are not the same thing. Motivation is an internal factor, and engagement is an external manifestation of motivation in work. For example, a person may be motivated for a project, but due to external circumstances (lack of tools, unclear tasks) may not be involved in it.

The main task of creating a motivation system for the project team is to create the most comfortable working conditions for employees and stimulate them to increase their performance. Each employee has different intellectual abilities, markers of progress, a set of professional and personal qualities, therefore, the most important principle of creating a competent mechanism is personification, as well as a unified work scheme. Understanding the mechanisms of motivation and engagement is extremely important for effective project management. Firstly, high motivation and engagement contribute to increased productivity and quality of work. Secondly, these factors reduce the risk of employee burnout and reduce staff turnover. Finally, a successful project requires the coordinated interaction of all participants, which is impossible without a proper level of motivation and engagement [1, 2].

One of the popular theories of motivation is Maslow’s theory of needs (Figure 1), according to which human needs are divided into five levels: physiological needs, security, belonging and love, respect and self-realization. This theory emphasizes that in order to maintain motivation, it is necessary to take into account different levels of employee needs. For example, at the initial stage, basic needs such as wages and safe working conditions are important, whereas at higher levels recognition and the possibility of personal growth become more important.

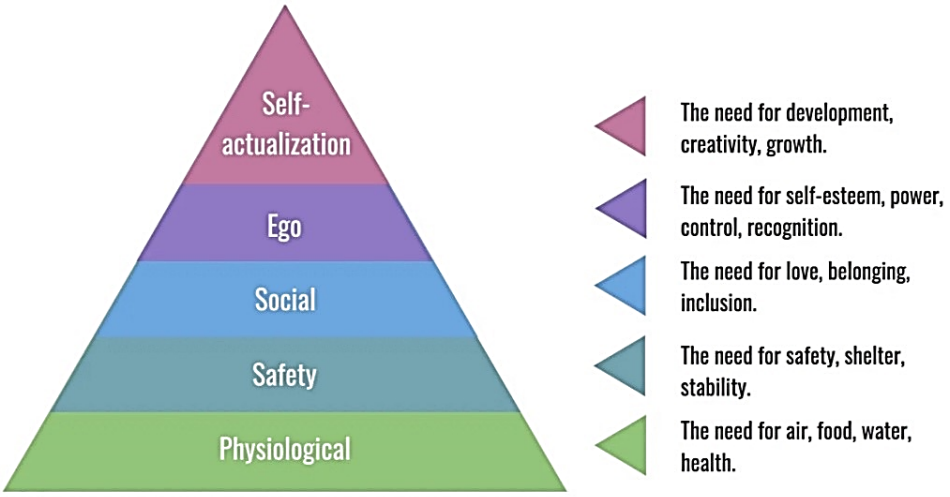


Figure 1. Maslow's hierarchy of needs

Another well-known theory is the Hertzberg theory of two factors (Figure 2), which identifies hygienic factors (working conditions, salary, company policy) and motivating factors (achievements, recognition, growth). According to this theory, the absence of hygienic factors causes dissatisfaction, but their presence does not necessarily lead to high motivation. Real motivation arises only in the presence of motivating factors.


Figure 2. Herzberg's two-factor theory

In addition, there is Vroom's theory of expectations (Figure 3), which states that motivation depends on three variables: valence (reward value), instrumentality (expectation that a certain action will lead to the desired result) and expectancy (probability of achieving the desired result). If at least one of these variables is missing, motivation decreases.


Figure 3. Vroom's Expectancy Theory

As for the factors influencing engagement, there are several key aspects. Firstly, this is the meaning and value of the project. When employees realize that their work has real meaning and contributes to achieving meaningful goals, they become more involved. Secondly, opportunities for learning and growth also play an important role. If a project provides a chance to develop professionally and acquire new skills, it motivates employees to participate in it more actively. Another factor is the relationship in the team. Harmony and mutual assistance within the team create a favorable atmosphere for work. Cooperation, support and mutual respect strengthen the team and increase overall engagement. Fair assessment and recognition are also important. An objective assessment of work and recognition of merit, whether it is a financial reward or a simple "thank you", significantly increase the motivation and involvement of employees.

Finally, control and autonomy are an important element. It is essential for project participants to have a certain level of independence in making decisions and choosing working methods. Autonomy promotes the development of a sense of responsibility and engagement, as the employee feels like an important link in the overall process [3].

Having considered the factors influencing engagement, we can conclude that in order to strengthen it, it is necessary to take into account such aspects as the meaning and value of the project, opportunities for learning and growth, team relationships, fair assessment and control. All these elements create the foundation for the active participation of employees in the project. Now, based on this foundation, you can move on to strategies to increase motivation.

Let us start by setting clear goals and objectives. When employees know exactly what is required of them and how their work affects the overall result, they begin to perceive their activities as something meaningful. This is especially important in conditions of long deadlines and difficult stages. Specifying goals and

breaking them down into subtasks helps employees see progress and feel moving forward.

The next step is to create a positive working atmosphere. A comfortable and friendly workplace environment promotes better communication and collaboration. It is important that employees feel like part of a unified team, know that their opinions are respected, and can freely discuss any issues. Such a manner reduces stress levels and contributes to a more effective solution to emerging problems.

Providing feedback and recognition is equally important. Regular feedback helps employees understand how they are coping with tasks and gives them the opportunity to adjust their actions. Recognition of merit, both tangible and intangible, motivates you to continue working and strive for even better results. Even small praise can have a huge impact on the team's morale [3, 4].

It is also worth paying attention to the development of skills and competencies. Training and professional development of employees motivate them to do better work. The new knowledge and skills gained during the project will stay with them for a long time and can be used in the future. In addition, such development strengthens employees' self-confidence and increases their loyalty to the company. Finally, it is very important to provide employees with autonomy and independence. When they get the right to make decisions and choose their working methods, they feel more responsible for the result. This encourages them to take the initiative and look for creative solutions, which has a positive effect on the quality of work [4].

Now let u s move on to the methods of increasing engagement. The first of them is the inclusion of employees in the decision-making process. When project participants have the opportunity to influence the course of events, they feel like an important part of the team. This creates a sense of belonging and increases the level of responsibility for the result. Taking into account the opinions and suggestions of employees also contributes to the development of trusting relationships within the team. Another method is to create a feedback system. Open communication and the exchange of ideas help to identify problems at an early stage and quickly find a solution. This not only improves workflows, but also strengthens trust between team members. The feedback system should be two-way so that everyone can express their opinion and get a response. It is also useful to encourage teamwork and collaboration. Joint activities, such as brainstorming sessions, help to establish interaction between employees and develop a sense of community. A team that works together and supports each other achieves better results and solves difficulties faster. Organizing team-building events also has a positive impact. Team building and corporate events outside the work context bring employees closer together and improve their relationships. Such events contribute to the formation of a trusting and open atmosphere, which subsequently affects the effectiveness of joint work [5].

And finally, we should mention regular assessments of the project and engagement. Periodic monitoring of the progress and level of employee engagement allows timely identification of possible problems and taking measures to eliminate

them. Feedback from participants helps to understand what needs to be changed or improved to increase their motivation and engagement.

To summarize, we can say that motivation and engagement are two inextricably linked characteristics that ensure the success of project work. By applying the proposed strategies and methods, it is possible to create conditions in which employees will work with full dedication and interest. It is important to remember that each person is unique, and an individual approach to motivation and engagement can bring the greatest benefits.

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# USING BLOCKCHAIN TO AUTOMATE SUPPLY CHAINS IN PHARMACEUTICALS

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**Abstract.** The article discusses the application of blockchain technology to automate logistics processes in the pharmaceutical industry. It discusses the importance of blockchain for pharmaceuticals, the supply chain problems that can be solved using this technology, and existing blockchain-based solutions. Examples are given of projects that demonstrate how blockchain can improve transparency, security and efficiency of logistics processes. The advantages and disadvantages of implementing blockchain in pharmaceutical logistics are discussed, as well as the prospects and anticipated trends in the development of this technology in the industry.

**Keywords:** blockchain, pharmaceutical logistics, transparency, drug authenticity, supply chain, process automation.

# ИСПОЛЬЗОВАНИЕ БЛОКЧЕЙНА ДЛЯ АВТОМАТИЗАЦИИ ЛОГИСТИЧЕСКИХ ЦЕПОЧЕК В ФАРМАЦЕВТИКЕ

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**Аннотация.** В статье рассматривается применение блокчейн-технологий для автоматизации логистических процессов в фармацевтической отрасли. Обсуждаются значимость блокчейна для фармацевтики, проблемы логистических цепочек, которые могут быть решены с помощью этой технологии, и существующие решения на базе блокчейна. Приводятся примеры проектов, которые демонстрируют, как блокчейн может повысить прозрачность, безопасность и эффективность логистических процессов. Рассматриваются преимущества и недостатки внедрения блокчейна в фармацевтическую логистику, а также перспективы и предполагаемые тенденции развития этой технологии в отрасли.

**Ключевые слова:** блокчейн, фармацевтическая логистика, прозрачность, подлинность лекарств, цепочка поставок, автоматизация процессов.

A blockchain is a distributed database or registry that maintains a list of records called blocks. These blocks are linked and secured using cryptographic methods. Each block contains a timestamp and a reference to the previous block, making it immutable and tamper-proof. The basic principles of blockchain include decentralization, transparency and immutability. Unlike traditional centralized systems, blockchain operates on the basis of a distributed network where each participant (node) keeps a copy of the entire database. Blockchain transparency means that all transactions are publicly available and can be verified by any participant in the network. Data immutability provides a high degree of security and trust, as once data is entered into the blockchain, it cannot be changed or deleted.

The pharmaceutical industry faces many challenges, including counterfeit drugs, complex supply chains and the need for strict regulatory compliance. Blockchain can offer solutions to ensure drug authenticity, improve supply chain management and regulatory compliance. With blockchain, every shipment of drugs can be tracked from the manufacturer to the end user, reducing the risk of counterfeiting. The decentralized and transparent nature of blockchain allows for better visibility and control throughout the supply chain. Blockchain provides a secure and immutable record of all transactions, making it easier to audit and comply with regulatory standards [1].

One of the most serious problems in the pharmaceutical industry is counterfeit drugs. Counterfeit drugs can be ineffective or even dangerous to health. Blockchain makes it possible to track every batch of drugs from production to the end user, which significantly reduces the risk of counterfeiting. Pharmaceutical supply chains often involve multiple actors: manufacturers, distributors, pharmacies and healthcare providers. This creates complexity in managing and tracking shipments. Blockchain provides transparency and allows all participants to see up-to-date information on the status of shipments. Inefficient logistics management can lead to delays in deliveries, which is especially critical for drugs with limited shelf life. Blockchain can automate many processes and improve coordination between supply chain participants. Some drugs require strict storage conditions, such as a certain temperature. Blockchain, combined with IoT devices, can accurately track and record storage conditions at every stage of the supply chain [2].

There are various blockchain-based solutions for automating pharmaceutical logistics processes. For example, the MediLedger project (Figure) uses blockchain to ensure the authenticity and traceability of pharmaceuticals. The MediLedger project aims to create a secure and transparent system for tracking and authenticating pharmaceuticals. The goal of the project is to ensure the authenticity of medicines and improve the transparency of supply chains.

Figure. “MediLedger”, an open network for the pharmaceutical supply chain

Key MediLedger features include origin tracking, authentication and process automation. Origin tracking records all stages of drug production and movement on the blockchain. Authentication verifies the authenticity of drugs, and process automation through smart contracts simplifies operations.

MediLedger has several advantages. First, it ensures transparency by providing access to up-to-date information for all participants in the supply chain. Second, the high level of data protection guarantees the safety of information. Third, the use of blockchain reduces the risk of counterfeit drugs appearing on the market. Finally, the project helps with regulatory compliance.

The statistics and results of the MediLedger project are impressive. The implementation of the system has led to a 30 % reduction in the number of counterfeit medicines on the market. In addition, the time to perform logistics operations was reduced by 20 %.

A manufacturer creates a shipment of drugs and records information about it on the blockchain. A distributor receives the shipment and updates the blockchain with information about its movement. The pharmacy, upon receiving the shipment, verifies its authenticity using the blockchain. The patient, in turn, can verify the authenticity of the medicine by scanning the unique identifier on the package. The MediLedger project is a prime example of how blockchain technology can improve transparency, security and efficiency of supply chains in the pharmaceutical industry [3].

There are advantages and disadvantages to implementing blockchain in pharmaceutical logistics. The advantages include transparency and traceability, data security, process automation and reduced risk of counterfeiting. Blockchain provides a complete and transparent record of all transactions, which allows tracking of each batch of drugs. Cryptographic methods and the decentralized nature of the blockchain provide a high level of data security. Smart contracts allow the automation of many processes such as payment and delivery confirmation. The ability to trace the origin and path of each shipment of drugs reduces the risk of counterfeiting. However, there are disadvantages such as high initial costs, integration complexity, scalability issues and regulatory barriers. Implementing blockchain technology may require significant investment in infrastructure and staff training. Integrating blockchain with existing systems can be complex and require significant effort. Some blockchain platforms face scalability issues, which may limit their use in large systems. In some countries, legislation and regulatory requirements may restrict the use of blockchain.

Prospects and anticipated trends for blockchain in the pharmaceutical industry include increased pilots and implementations, development of standards and regulations, integration with other technologies, increased awareness and trust, and impact on global supply chains. More companies in the pharmaceutical industry are beginning to experiment with blockchain technology, leading to an increase in the number of pilot projects and real-world implementations. As the technology evolves and its use increases, it is likely that new standards and regulations will be developed for the use of blockchain in the pharmaceutical industry. Blockchain will increasingly be integrated with other advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and machine learning to create more comprehensive and efficient solutions. With the increasing number of successful blockchain use cases, confidence in the technology will grow, which will encourage its wider adoption in the pharmaceutical industry. Blockchain has the potential to significantly change global supply chains, making them more transparent, secure and efficient, which is particularly important for the pharmaceutical industry [4].

Blockchain technologies offer many opportunities to improve pharmaceutical supply chains. They provide transparency, security and immutability of data, addressing issues such as drug counterfeiting, complexity of logistics management and the need for strict regulatory compliance. Existing blockchain-based solutions such as MediLedger, IBM Blockchain and Chronicled are already demonstrating successful use cases in the pharmaceutical industry. However, blockchain adoption also comes with challenges such as high upfront costs, integration complexity and regulatory barriers. Prospects for blockchain in pharmaceuticals include increasing the number of pilot projects, developing standards and regulations, integrating with other advanced technologies, and increasing confidence in the technology. Ultimately, blockchain has the potential to significantly change global supply chains, making them more transparent, secure and efficient, which is especially important for the pharmaceutical industry.

The regulatory and legal aspects of using blockchain technology in pharmaceutical logistics are key to ensuring security, transparency and compliance. Blockchain can offer unique solutions for tracing the origin of medicines, verifying their authenticity and controlling their movement in the supply chain. However, its effective implementation requires consideration of existing legal frameworks, data exchange standards, patient privacy requirements and other regulations governing the pharmaceutical industry. Before looking at the specific regulatory and legal aspects of using blockchain in pharmaceutical logistics, it is important to realize that they cover a wide range of requirements and standards, from legislative frameworks to storage standards. These aspects play a crucial role in integrating blockchain technology into pharmaceutical supply chain processes. For clarity and a better understanding of the key aspects that need to be considered when implementing blockchain in pharmaceutical logistics, let us summarize them in the form of Table.

Table – Key regulatory and legal aspects of using blockchain in pharmaceutical logistics

| Aspect | Description |
|---|---|
| Legislative framework | Includes national and international regulations governing the manufacture, distribution and quality control of pharmaceutical products. |
| Data exchange standards | Define the format and structure of information to be communicated between supply chain participants, e.g. GS1 standards for unique product identification. |
| Protection of personal data | Includes requirements to ensure the privacy and security of patient information, e.g. GDPR in the European Union. |
| Pharmacovigilance | Requires tracking side effects and monitoring drug safety, which can be facilitated by blockchain. |
| Anti-counterfeiting measures | Blockchain helps in the fight against counterfeiting as it provides a reliable mechanism to authenticate products at every stage of the supply chain. |
| Storage and transportation standards | Standards and regulations that ensure proper storage and transportation conditions, including temperature and humidity control. Blockchain can provide continuous and immutable logging of all stages of transportation and storage. |

The implementation of blockchain in pharmaceutical logistics requires careful analysis of these aspects and their compliance with applicable legislation. It is important to ensure that the use of blockchain systems will not conflict with privacy laws and that it will improve product safety and efficiency in the pharmaceutical supply chain. It is also important to consider the industry's readiness for technological change and the ability to integrate new systems with existing information platforms. Properly implemented, blockchain can significantly increase consumer confidence in pharmaceutical products and improve quality and safety control throughout the supply chain.

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**УДК 676.2**

# ECO-FRIENDLY CLEANING OF COATED PAPER: NEW APPROACHES TO REDUCING ENERGY CONSUMPTION AND RECYCLING

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**Abstract.** The article discusses a promising technology for cleaning coated paper from toner prints to reduce energy costs and negative impact on the environment. By using pulsed light exposure to various types of coated paper (glossy, satin, matte), the efficiency of toner removal was studied depending on the density and optical properties of the paper.

**Keywords:** toner removal, intense pulsed light, coated paper, eco-recycling, paper recycling**.**

# ЭКОЛОГИЧНАЯ ОЧИСТКА МЕЛОВАННОЙ БУМАГИ: НОВЫЕ ПОДХОДЫ К СНИЖЕНИЮ ЭНЕРГОЗАТРАТ И ПЕРЕРАБОТКЕ

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**Аннотация.** В статье рассматривается перспективная технология очистки мелованной бумаги от отпечатков тонера для сокращения энергозатрат и уменьшения негативного воздействия на окружающую среду. За счет использования импульсного светового воздействия на различные типы мелованной бумаги (глянцевую, сатиновую, матовую) была изучена эффективность удаления тонера в зависимости от плотности и оптических свойств бумаги.

**Ключевые слова:** удаление тонера, интенсивный импульсный свет, мелованная бумага, экологическая переработка, повторное использование бумаги.

Optical toner removal is a promising technology that can reduce the environmental impact and energy costs of recycling coated paper. The existing methods of traditional paper recycling are associated with high energy costs and significant emissions, which makes alternative approaches highly demanded. This work is aimed at studying the efficiency of optical toner removal from various types

of coated paper, including glossy, satin and matte, and assessing the possibility of applying this technology to materials of different densities. For the experiments, samples with pre-applied black toner stripes were used, and flash lamps of different power served as the source of light energy. This approach allows us to analyze how the parameters of the paper and the light source affect the cleaning result and how effectively this technology can replace or complement traditional methods.

To evaluate the efficiency of the optical toner removal technology, as well as to study its applicability to other types of coated paper, several different types of paper were used, namely: glossy and satin UPM Finess, and matte paper Mondi Color Copy. Each type of paper includes several samples of different weight: 120; 160; 300 g/m² for matte paper, 130; 170; 300 g/m² for satin and glossy paper. On the ECOSYS M2540dn digital printing machine shown in Figure 1, a complete set of toner cartridges was used to print a prepared document, which consisted of black stripes measuring 180 mm by 32 mm and a distance between stripes of 23 mm.


Figure 1. MFP ECOSYS M2540dn

A Falcon Eyes SS-250BJ xenon studio flash lamp with a pulse energy of 250 J was initially used as a source of broad-spectrum pulsed light (Figure 2). However, the diameter of the flash reflector is 80 mm, and the area of the light spot with direct contact of the flash reflector with the paper is 50.24 cm², the pulse energy density at full power is 4.97 J/cm². According to the data provided by M. Jha [1], the mode of complete toner removal with a single pulse requires an energy density of 12.5-13.5 J/cm², and the partial removal mode – 7.5 J/cm². Experimental data confirm that the pulse energy density of this lamp is not enough even for the partial removal mode.

Figure 2. FalconEyesSS-250BJ flash lamp

A possible solution to this problem could be to make an additional reflector from a sheet of aluminum foil with a hole of the required area. It was assumed that part of the pulse energy passing through the hole in the reflector would directly hit the paper sample, and the remaining part would be reflected from it, which would ultimately lead to the passage of all the energy through the hole. Several reflector samples were made with a hole area of 20, 25, and 4 cm², and a calculated energy density of 12.5 and 62.5 J/cm², respectively (Figure 3) [1].

Figure 3. Sample after a single lamp pulse through an aluminum reflector with an opening area of 20.25 $cm^2$

However, during the experiment, even the partial toner removal mode was not achieved, since it was found that the aluminum foil did not have sufficient reflective properties, so a significant part of the pulse energy was absorbed by the reflector itself. This occurred even though the second sample of the reflector was designed for an energy density passing through the hole several times greater than that required to achieve the full toner removal mode. For further experiments, the built-in xenon flash lamp of the Nikon D3000 digital SLR camera was used (Figure 3) [2]. The manufacturer did not specify the flash power in the camera specifications, but it was later approximately calculated. The camera was installed and fixed on a tripod so that the plane of the lamp reflector was parallel to the plane of the sheet, and the distance between them was regulated and was 1 and 2 mm. The flash mode was switched to

manual with the maximum pulse energy set. These parameters remained unchanged during all experiments.


Figure 4. Built-in flash of the Nikon D3000 digital SLR camera

Each test sample was exposed to a single pulse of light, after which it was wiped with a paper napkin moistened with isopropyl alcohol. The use of isopropyl alcohol instead of ethanol did not cause any change in the efficiency of toner removal from paper. Also, its use without the use of pulsed light did not lead to any changes in the surface of the paper and toner. The degree of toner removal was assessed visually, as well as by measuring the lightness value with an efi ES-2000 spectrophotometer (Figure 4) [3]. Measurements were made on areas of clean paper, on a print of black toner without the effect of pulsed light, and in the area of the pulse at five different points, after which the average value was found.


Figure 5. Spectrophotometer efiES-2000

The best degree of toner removal was achieved on glossy paper: toner was removed almost completely from samples of all densities (Figures 6–8).

Figure 6. Sample of glossy paper UPMFiness130 g/m$^2$

Figure 7. Sample of glossy paper UPMFiness170 g/m$^2$

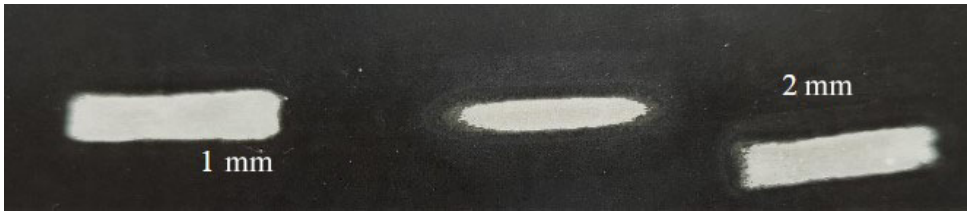

Figure 8. Sample of glossy paper UPMFiness300g/m$^2$

This is confirmed by measurements of lightness on cleaned areas of paper (Figure 9): 1 mm, 2 mm, 1 mm, 2 mm.

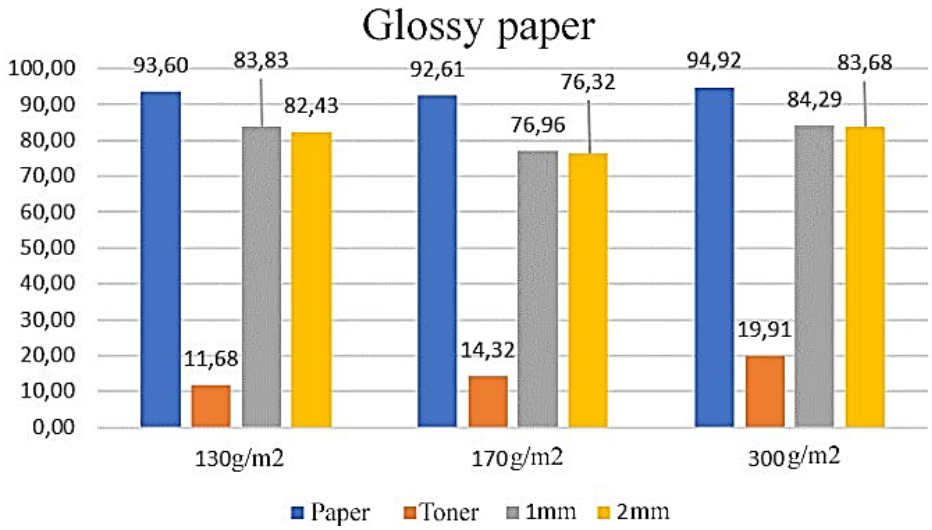

Figure 9. Lightness index for different areas of glossy paper samples

A slight decrease in the lightness value on 170 g/m² glossy paper is caused by contamination of the flash protective glass, which occurs as a result of toner particles settling on it. This is due to the small distance between the sample and the lamp. Comparing the results of 130 and 300 g/m² samples, it can be noted that the paper density does not affect the degree of toner removal; the same can be said about the

distance from the sample to the lamp. The toner removal area from a distance of 1 mm is slightly larger, which is due to the increase in the area of the light spot. The print was removed from satin paper in the partial removal mode. The effect of the square meter weight of the paper on the degree of cleaning is observed: the greater it is, the more toner remains on the paper surface (Figures 10–13).

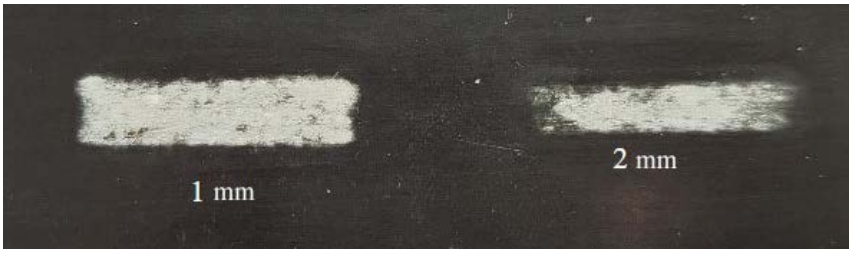


Figure 10. Sample of satin paper UPMFiness130 g/m$^2$


Figure 11. Sample of satin paper UPMFiness170 g/m$^2$


Figure 12. Sample of satin paper UPMFiness300 g/m$^2$

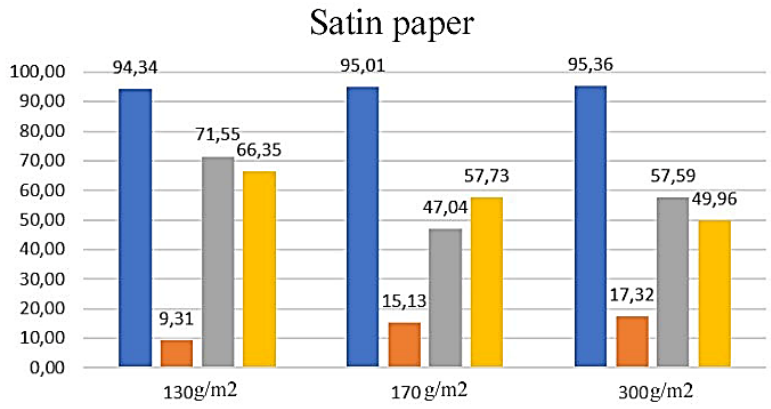


Figure 13. Lightness index for different areas of satin paper samples

Increasing the energy density during toner removal on satin paper should improve the cleaning efficiency and lightness values. Toner removal on matte paper was only partial, with a change in the colour of the substrate being observed (Figures 14–16).


Figure 14. Sample of matte paper MondiColorCopy 120 g/m$^2$


Figure 15. Sample of matte paper MondiColorCopy 170 g/m$^2$


Figure 16. Sample of matte paper MondiColorCopy 300 g/m$^2$

Lightness measurement confirms visual observations (Figure 17).

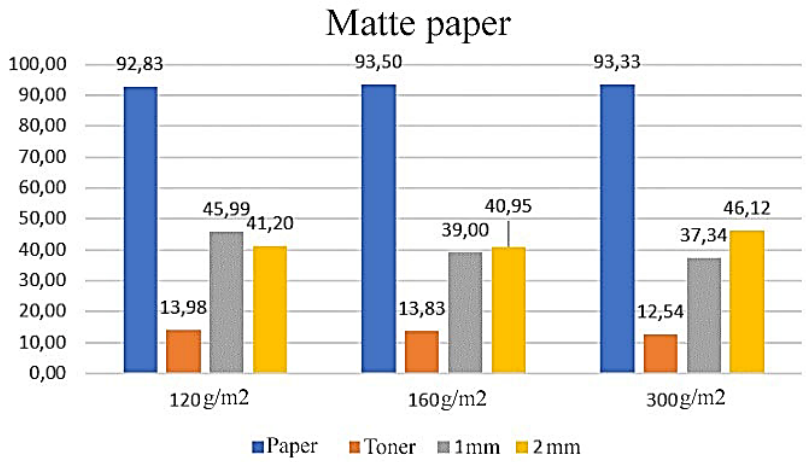


Figure 17. Lightness index for different areas of matte paper samples

It is likely that further increase in energy density will not result in complete removal of toner, since the surface of matte paper, unlike the other tested samples, does not have a sufficient degree of light reflection. An additional experiment is needed to unambiguously confirm this theory. An additional experiment was conducted to verify whether the mass of a square meter of paper affects the degree of

its cleaning. New samples were used, the pulse energy density remained unchanged, and the distance from the lamp to the surface was 3 mm. The results of the lightness measurements for each sample are presented in Figure 18.

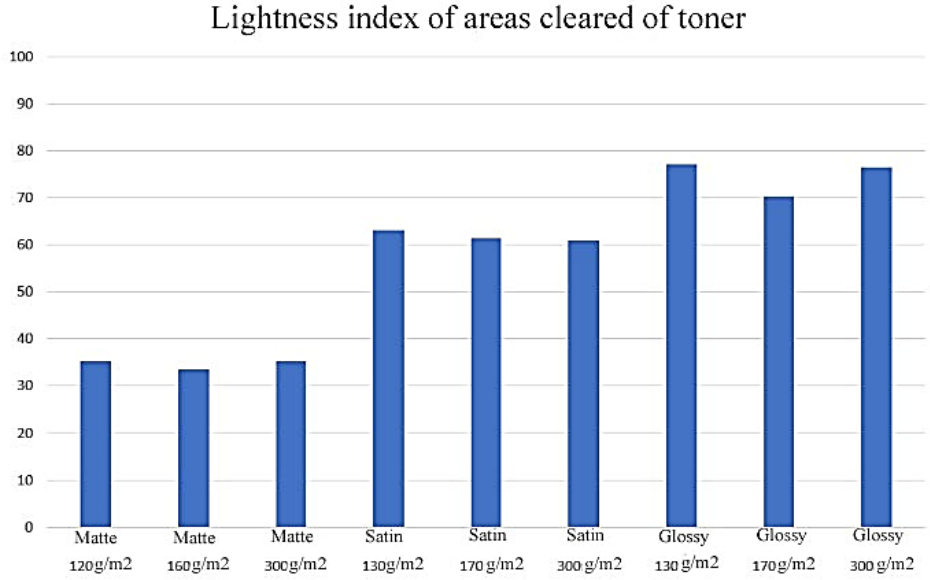


Figure 18. Lightness index of toner-cleaned areas of samples, distance to lamp 3 mm

The measurement results did not show a clear effect of the mass of a square meter of paper on the change in the lightness value of the cleaned areas. The main contribution to the spread of values between the indicators of one type of paper is made by manual measurement of lightness, as well as an insufficient number of measurement points.

Based on the results of the experiments, it can be concluded that the degree of paper cleaning from toner is more influenced by its optical properties, such as opacity and gloss. This explains the results of the experiment with matte and satin paper. The latter has a texture similar to matte paper, so there is no glare typical of glossy paper on it. In addition, the study revealed that the effect of pulsed light on a section of clean paper does not lead to a change in the color of the surface. This means that when using this technology to clean paper from black and white text applied to it, there is no need to pre-fill the sheet with black toner.

Based on the data obtained as a result of the experiments, an approximate pulse energy of the built-in flash lamp of the Nikon D3000 digital SLR camera was calculated. For this purpose, the area of the light spot equal to the cleaning area was calculated on a sample of satin paper with a density of 300 g/m², obtained from a distance of 1 mm, which was 0.8 cm². Satin paper is as close as possible to semi-gloss paper in optical properties, therefore, after comparing the cleaning results, a pulse energy density value of 10 J/cm² was selected. The approximate pulse energy of the flash lamp, equal to 8 J, was determined by the product of these values [4].

*Efficiency assessment*

To assess the efficiency of the optical toner removal method, energy costs in GJ (Table 1) were calculated for cleaning 1 ton of semi-gloss coated paper using the formula:

$$\frac{10*E}{p},$$

where E is the total energy density of the pulses (J/cm²),
p is the mass of 1 m² of paper (g/m²).

Table 1 – Energy costs for cleaning 1 ton of semi-gloss coated paper using the optical method (GJ).

| Imprint | Weight | |
|---|---|---|
| | 120 g/m² | 300 g/m² |
| Black | 3,92 | 1,57 |
| Red | 3,75 | 1,50 |
| Green | 3,83 | 1,53 |
| Blue | 6,67 | 2,67 |

Energy consumption for traditional processing and production of coated paper is about 25 GJ/t. According to the data obtained, energy consumption for cleaning coated paper using the optical method is several times less than for traditional processing. There is a dependence of the quantitative energy consumption for cleaning on the mass of a square meter of paper, which is associated with a decrease in the total surface area with an increase in the mass of a square meter and a fixed total mass. The most economical is cleaning paper weighing 300 g / m² from prints of red, green and black colors, and the most expensive one is cleaning paper weighing 120 g / m² from a blue print [5]. The cycle of toner removal and reprinting is possible up to 5 times without significant damage to the paper surface. Although the optical toner removal method is not applicable to uncoated papers and has limited applicability to matte coated papers, its use can provide approximately 5-fold reduction in energy consumption, pollutant emissions and climate change-related emissions compared to traditional recycling.

In summary, the study demonstrated the effectiveness and prospects of using the optical method for removing toner from coated paper. Experiments showed that the best results are achieved on glossy and satin papers, which allow almost complete removal of toner due to their high reflectivity. Optical properties of paper, such as gloss and opacity, have a significant impact on cleaning efficiency, while material density has a lesser effect. The use of optical toner removal can significantly reduce energy costs and emissions, providing up to a 5-fold reduction in the negative impact on the environment compared to traditional recycling. However, the method has limitations: it is less effective for matte paper and is not suitable for uncoated paper. Despite this, the technology has potential for practical use in a number of areas where repeated use of coated paper is required, making it a significant contribution to the

development of environmentally friendly and cost-effective approaches to the disposal of printed products.

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# SOUND IMITATION IN ENGLISH: ONOMATOPES’ CLASSIFICATION AND STUDY METHODS

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**Abstract.** This article is devoted to the study of onomatopoeic vocabulary in terms of its importance in the process of learning a foreign language. The paper presents classifications of onomatopoeic words, describes their features, lists typical areas of use of onomatopoeic words and expressions, indicating their functions. The article focuses on non-traditional ways of studying such vocabulary.
**Keywords:** onomatopoeia, onomatope, classification, sound imitation, English.

# ЗВУКОПОДРАЖАНИЕ В АНГЛИЙСКОМ ЯЗЫКЕ: КЛАССИФИКАЦИЯ И ПРИЕМЫ ИЗУЧЕНИЯ ОНОМАТОПОВ

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**Аннотация.** Данная статья посвящена изучению звукоподражательной лексики в аспекте ее значимости в процессе освоения иностранного языка. В работе приведены классификации звукоподражательных слов, описаны их особенности, перечислены типичные сферы использования звукоподражательных слов и выражений с указанием их функций. В статье представлены нетрадиционные способы изучения подобной лексики.
**Ключевые слова:** ономатопея, ономатоп, классификация, звукоподражание, английский язык.

Onomatopoeia occupies a prominent place among the borderline phenomena of language, and therefore it is by no means accidental that linguists are interested in onomatopoeia and onomatopoeic words (onomatopes).

Despite the fact that onomatopoeia is a well-known linguistic phenomenon and allows you to replenish the vocabulary of a language with new, unique words, linguists still find it difficult to determine the features of these units. Some believe that onomatopes do not carry any semantic load and are not a means of

communication. Others find onomatopoeia an integral part of human speech, considering these units from the phonetic, morphological and syntactic aspects.

The dictionary of linguistic terms gives the following definition: “onomatopoieia (Greek onomatopoieia – production of names, from *onoma* – name + *poieo* – I do, I create) – sound imitation, the formation of words reproducing natural sounds, animal cries, etc. (woof-woof, moo, meow), as well as the creation of words by onomatopoeia (barking, clucking, cooing, meowing)” [1].

Onomatopoeic words perform expressive, simplifying and educational functions. For example, the use of onomatopoeia in a literary text is due to their expressive function, which allows the author to create out a more colorful narrative and express their inner state, feelings and emotions. In children's poetry, onomatopoeia most often performs a simplifying function, which helps to create a particularly uttered connection between the image of a sounding word and the image of an object, which contributes to the smooth perception of onomatopes by children. In addition, the use of onomatopoeia is noted in comics, where this phenomenon allows you to avoid a large amount of text describing any sound, which is a function of saving language resources. It is important to take into account the functions and areas of application of onomatopoeia in the process of learning a foreign language: onomatopes are used at the initial stage of learning to master auditory and pronunciation skills and to set the articulation base of a foreign language; at the primary and senior stages, onomatopoeia helps to maintain and improve the phonetic skills of students.

According to S. V. Voronin's classification [2], there are five classes of onomatopes, depending on the type of sounds:

1. Instants. Instants, as a class and at the same time as a type of onomatopes, denote a blow, i.e. “super-short” (“instantaneous”) noise or tone that is equally perceived by the human ear as an acoustic shock. Examples: tap “knocking”; pit “imitation of the quiet sound of something small falling (e.g. raindrops)”; bubble “boiling (over)”.

2. Continuants. Continuants, as a class of onomatopes, denote non-stop, i.e. “continuous” (“non-instantaneous”) fused tone or noise sound. Examples: hoot “to scream (about an owl)”; bleep “the squeak of a transmitter on board a satellite”; whish “to produce a quiet whistling or rustling sound (an object moving sharply through the air or water, about the wind in the foliage)”.

3. Frequentatives. As a class of onomatopes, frequentatives denote very fast sequences (series) of beats (pulses) in which each beat is almost not felt separately, but there is still no complete fusion of the sequence of beats into a single sound. Examples: crack “to produce a crack, a sharp jerky sound (when breaking something, during an explosion)”; ripple “to cover with ripples; to flow, murmur”; burble “to boil violently, to bubble”.

4. Continuant instants. Continuant instants, as a class of onomatopes, denote a blow with a subsequent and/or preceding failure. Examples: dump “hard to fall (with a dull or booming sound)”; clamp “heavy tread, booming steps”; clank “ringing, clanging of iron”.

5. Mixed frequentatives. They denote a quasi-beat or non-beat, i.e. a quasi-beat (dissonant beat) with a subsequent or preceding non-beat. Examples: ring “to ring (about weapons); to sound loudly (about a trumpet); to ring (about a bell)”; drum “to beat”; thrash, thresh “to beat; to hammer”.

Onomatopes are also subdivided into two groups depending on the type of imitation – acoustic and articulatory. Articulatory onomatopes are further subdivided into three main types – oral, nasal and throat – according to the place of their articulation.

The classification of onomatopes according to the thematic principle includes the following types of units:

1) onomatopes denoting the sounds of the animal world;
2) onomatopes denoting the sounds of nature;
3) onomatopes denoting the sounds of various mechanisms;
4) onomatopes expressing the sounds produced by various objects;
5) onomatopes produced by humans [3, p. 63].

The spelling classification includes onomatopes, which consist of double and triple hyphenated words (knock-knock – knock on the door, plod-plod – hoof stomp, hee-hee – high laughter), from rhyming combinations (blow-wow – dog barking, ding-dong – doorbell, flick-flock – shuffling of feet) and repetitive forms (pit-a-pat pit-a-pat – heartbeat, honk honk honk a honk – clown horn). This typology is important for the correct spelling of onomatopoeic words, which is of particular importance in the process of learning a foreign language [3, p. 63].

The above mentioned classifications of onomatopoeia, as well as the description of their characteristic features, allow us to stipulate that onomatopes, although they do not have a nominative function, have lexical meaning of their own and are words of full value, as they are used as a means of communication. In the system of parts of speech, onomatopoeia acts as a special, independent category of words [4, p. 76].

In the process of learning a foreign language it is important to understand that one word in Russian can correspond to many variants in English; for example, hiss – if we are talking about a snake; sizzle – if we fry something in oil; fizz – if we open a bottle of soda. To replenish the stock of onomatopes and to understand the specifics of their contextual use, it is useful to refer to an electronic lexicographic resource with many examples of onomatopoeia in English [5], where the meaning of the word, its features, as well as synonyms are given.

Given the specifics of onomatopoeic vocabulary, foreign language learners may notice that the traditional approach of memorization in this case may not be effective. In this regard it is important to know about the technology of the process of teaching English and onomatopoeia, in particular. The use of pictures, comics, videos and online dictionaries during the lesson has a positive effect on the assimilation of onomatopoeic vocabulary by students.

Among the effective tools for memorizing onomatopoeia, we will name such as mental maps, movies and TV series with subtitles, ASMR videos, as well as videos about foley sound effects.

When creating mental maps, all sounds are sorted by source (sounds of nature, animal sounds, sounds of various devices, etc.), which allows our brain to better assimilate information.

Watching movies and TV series with subtitles, viewers note that subtitles often include not only characters' speech, but also descriptions of background noises. For example, cracking; metal grinding; muffled thud; faint whirring, etc. By paying more attention to such details it will be easier to associate words with certain sounds.

As for ASMR videos, it should be noted that these are specific classes, as they imply really strange videos where people use hypersensitive microphones in every possible way to create sounds that give you goose bumps when listening to them. It is advisable to watch such videos with headphones in order to fully experience the effect. Very often the creators of ASMR comment on their actions, naming each sound played. After watching several videos, a number of words will definitely be remembered for a long time. However, such videos still need to be found, as some authors can record sounds without any explanation.

The foley sound effects video also refers to effective ways to study onomatopoeia. Foley is a special field in filmmaking that creates sound effects for films, TV series and computer games. As a rule, many sounds are imitated using various equipment. For example, the crackle of a fire is created when you squeeze a bag or newspaper with your hand; the sound of waves while stirring the water in the bathtub; the flapping of bird wings while opening and closing an umbrella, etc. It is important to watch such video recordings with subtitles in order to learn and repeat the units necessary to memorize.

The study of onomatopoietic vocabulary is essential when learning a foreign language, since onomatopoeia is a part of authentic texts (poems, sayings, songs) with contribution to vocabulary replenishment and broadened horizons.

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