ДИАЛОГ КУЛЬТУР

МАТЕРИАЛЫ XVII ВСЕРОССИЙСКОЙ НАУЧНО-ПРАКТИЧЕСКОЙ КОНФЕРЕНЦИИ С МЕЖДУНАРОДНЫМ УЧАСТИЕМ НА АНГЛИЙСКОМ ЯЗЫКЕ

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ON USING KEYSTROKE DYNAMICS TO PROTECT AGAINST BADUSB ATTACK

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Abstract. The paper discusses ways to protect against BadUSB attacks by analyzing the user's keyboard handwriting. The definition of the described class of attacks, the concept of keystroke dynamics and the principle of operation of systems based on its analysis are given. The scheme of the software tool used to protect against BadUSB attacks is presented.

Keywords: keystroke dynamics, BadUSB, typing speed, keyboard emulation, virtual keyboard, arduino micro.

ОБ ИСПОЛЬЗОВАНИИ КЛАВИАТУРНОГО ПОЧЕРКА ДЛЯ ЗАЩИТЫ ОТ АТАКИ BADUSB

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Аннотация. В работе рассматриваются способы защиты от атаки BadUSB с помощью анализа клавиатурного почерка пользователя. Приводится определение описываемого класса атак, понятия «клавиатурный почерк» и принцип действия систем, основанный на его анализе. Представляется схема программного средства, применяемого для защиты от атак класса BadUSB.

Ключевые слова: клавиатурный почерк, BadUSB, скорость печати, эмуляция клавиатуры, виртуальная клавиатура, Arduino Micro.

BadUSB is a class of attacks that exploits a vulnerability in the way USB-HID devices are processed in modern operating systems. The term BadUSB was first used by Security Research Labs researchers Carsten Nohl and Jacob Lell in their presentation “BadUSB – On Accessories that Turn Evil” at the BlackHat USA 2014 conference in August 2014. For the first demonstration of the attack, they enhanced a Phison 2251-03 (2303) USB controller [1].

Thus, a BadUSB device is a reprogrammable USB stick on a specific type of controller or a specially designed device based on Arduino boards (usually Arduino Micro or Arduino Nano), in a USB stick form factor. Among the controllers suitable for BadUSB attack are the following:

1. ALCOR AU698X,
2. SMI SM325X/SM326X,

3. Skymedi SK62XX SK66XX,
4. Solid State System SSS6677, SSS6690 and SSS6691,
5. Innostor IS903-A2, IS903-A3 [2].

The danger of this type of attack comes from its ease of implementation and the lack of security features on most modern computers. When connected to a computer running any modern operating system (OS), a BadUSB device appears as a Human Interface Device (HID), such as a keyboard or mouse, and is detected in the system accordingly. Typically, the OS uses standard keyboard and mouse drivers and quickly initializes the device, allowing an attack to be launched within seconds.

The attack itself consists of emulating keystrokes on the keyboard and transmitting the key codes to the operating system. For example, a terminal can be invoked to execute commands or a browser can be opened with certain websites. In fact, any action that a live person could perform on a keyboard is available in a BadUSB attack. Sometimes such devices are used for legitimate purposes, for example, by system administrators for mass customisation of computers. But more often BadUSBs that emulate a keyboard are associated with malware.

Keystroke dynamics is a unique biometric characteristic of a person. Keystroke dynamics are individual for each person, which makes it impossible to fake. Unlike passwords, keystroke dynamics cannot be forgotten or lost [3].

The main idea underlying keystroke dynamics authentication is to analyze keystroke patterns. Each user has unique characteristics when typing characters on the keyboard, such as typing speed, delays between keystrokes, duration of each key press, and others [3].

From a technical point of view, keystroke dynamics is a set of dynamic characteristics of keyboard operation. User characteristics may include the following information:

- Key hold times;
- Pauses between keystrokes;
- Overlapping movements;
- Speed of typing;
- Degree of rhythmicity in typing;
- Number of typos;
- Pressure on the keys.

Key Hold Time is the period of time a key is held down. The software measures this parameter from the moment the key is pressed (*onkeydown* event) to the moment it is released (*onkeyup* event). This parameter is usually expressed in milliseconds.

Overlapping movements – simultaneous movements of multiple fingers in people who are confident with typing techniques. Overlapping keystrokes occur when one key is not yet released and another key is already being pressed. The vast majority of overlaps occur when keys of neighboring letters in a word are pressed with different fingers.

The pause between keystrokes is the time interval when one key is released and the next key is not yet pressed.

Since one of the BadUSB attack variants involves emulating text input, recognising the keystroke dynamics of the computer owner can help prevent such an

attack. This method can be used in addition to existing solutions. In particular, if the KP of an authorized user is known, it is possible to check keystrokes from the moment a new device is connected.

Let's consider an example of the code of the BadUSB device based on Arduino Micro. It is logical that to emulate the keyboard operation the device must be recognised by the computer as a keyboard. For this purpose, the *#include "Keyboard.h"* directive is specified at the beginning of the sketch.

Emulation of text string input is performed using the Keyboard.Print command with the string as an argument. Thus, the command that creates a shortcut to a website on the desktop looks like *Keyboard.print("powershell -Command \"echo [InternetShortcut] `r`nURL=https://example.com/ > cmd\link.url\")");*

Each character within a Keyboard.Print command is emulated in short time intervals, making it possible to quickly execute a malicious or potentially malicious command. This makes it possible to recognise the time intervals between keystrokes to distinguish emulated input from real user water. At its simplest, the software tool should run in the background and record the intervals between keystrokes.

A simple application in the Python programming language has been developed to study input parameters and respond to potential attacks. Once launched, it records all keystrokes and collects simple statistics – mean, geometric mean and median of all intervals between keystrokes. The interface of the programme is shown in Figure 1.

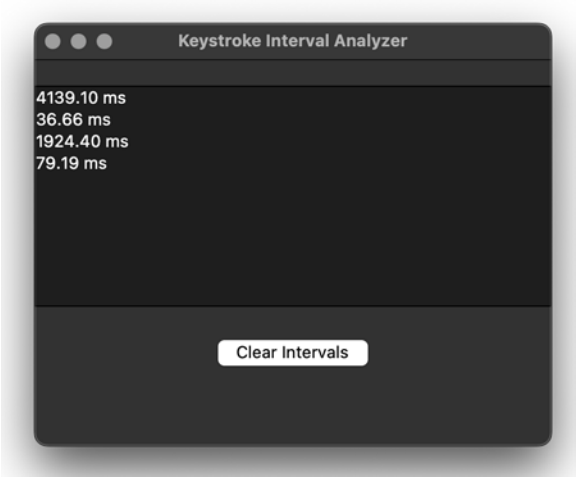

Figure 1. Interface of the analyser software

First of all, it is necessary to collect statistics on the typing speed of an ordinary user. Note that all experiments in this study were conducted on a Macbook Air M1 2020, OS MacOS Sonoma 14.1, with Python 3.12. For other devices, the intervals may differ, and will likely require adjustments to the thresholds.

As part of the experiment, 5 users entered random text over 300 characters in length 5 times. As a result, the average interval between keystrokes was 164.12 ms, the geometric mean was 97.79 ms, and the median interval value was 98.09 ms. The minimum interval obtained was 15.01 ms (during key overlap). Thus, it is concluded that intervals between keystrokes of less than 15 ms are not characteristic of humans.

A simple sketch for Arduino IDE is prepared to measure the intervals between presses emulated by BadUSB:

```
#include "Keyboard.h"
void setup() {
 Keyboard.begin();
 delay(5000);
 Keyboard.print("sample text");
 Keyboard.end(); }
```

5 seconds after the device with this firmware is connected, emulation of the *sample text* phrase is emulated. The Python software described above measures the intervals and calculates the totals.

As a result of 15 connections of the device to the computer with the running analyser software, the following values were obtained: the average value of the interval between emulated keystrokes is 0.95 ms, the maximum value is 3.76 ms, and the minimum value is 0.11 ms. Thus, taking into account the typing data of an ordinary user, it is possible to set the threshold value at the level of 5 ms.

Based on public data, we can conclude that the most frequent attack vector when using BadUSB is to invoke the powershell command line on Windows OS computers [4]. It is launched by emulating pressing the *Win* key and entering the corresponding command with pressing Enter. Accordingly, to successfully detect an attack, it is sufficient to analyze the intervals between 8-10 consecutive entered characters, which corresponds to the length of the powershell string.

Hence, based on the experiments, the condition under which the software detects an active attack via BadUSB based on Arduino Micro is the input of 8 consecutive characters with press intervals less than 5 ms. After such events sequence, software displays the attack warning, as shown in Figure 2.

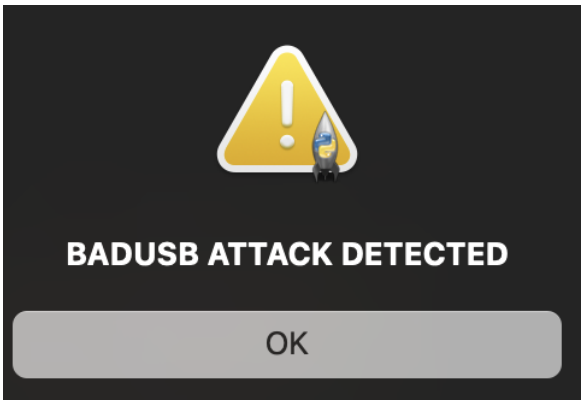

Figure 2. The message about detected attack

There are a number of other means of defense against the BadUSB attack. These include whitelisting connected devices and interrupting the user to enter random characters when a new keyboard is connected [5]. In contrast to these options, the method using keystroke dynamics analysis is non-invasive and does not interrupt the user's work even in case of user error.

As a result of the study, the characteristics of BadUSB based on Arduino Micro were studied and a prototype of a program capable of detecting BadUSB attack based on keystroke dynamics analysis was made.

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УДК 620.9

OVERVIEW OF THE APPLICATION OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN THE ELECTRIC POWER INDUSTRY

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Abstract. This article provides an overview of the application of artificial intelligence (AI) technologies in the electric power industry. Various areas of use of AI, forecasting electricity demand, optimizing the operation of power grids, as well as the use of AI for monitoring and managing power grids in real time are considered.

Keywords: artificial intelligence, data system, predictive analysis, monitoring, electric power industry.

ОБЗОР ПРИМЕНЕНИЯ ТЕХНОЛОГИЙ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В ЭЛЕКТРОЭНЕРГЕТИКЕ

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Аннотация. В данной статье представлен обзор применения технологий искусственного интеллекта (ИИ) в электроэнергетической отрасли. Рассматриваются различные области использования ИИ, прогнозирование спроса на электроэнергию, оптимизация работы электросетей, а также использование ИИ для мониторинга и управления электросетями в режиме реального времени.

Ключевые слова: искусственный интеллект, система данных, предиктивный анализ, мониторинг, электроэнергетика.

The generation of electric energy is carried out at power plants of various types. Thermal, nuclear and hydraulic power plants, as well as renewable energy power plants, operate in the Russian Federation. In the production of electric energy at power plants of various types, AI technology is used as part of the transition to a maintenance approach instead of traditional scheduled maintenance. Within the framework of this

approach, AI is based on real data on the condition of equipment and allows, through predictive analysis, to prevent failures and carry out repairs only when it is really necessary. To do this, solutions in the field of intelligent diagnostics and predictive analysis technologies using AI are being implemented at production facilities. An example of such a solution is the "Intelligent system for monitoring and forecasting the technical condition of industrial assets "F5 Predictive, Maintenance & Monitoring system" (F5 PMM) [1].

This system, by monitoring a large number of equipment parameters, makes it possible to predict the dynamics of their deviations and the timing of emergency events. At the same time, during the operation of this system, engineers and technologists improve it using machine learning. AI systems in thermal power plants make it possible to optimize the management of the fuel combustion process. Gorenje Thus, the AI system collects and analyzes a set of periodic and stochastic characteristics of a complex of industrial equipment. The collected data, in particular, information coming from an automated process control system, is processed using algorithms based on self-learning neural networks. This allows you to implement real-time forecasting of the characteristics of the technological process and implement intelligent control. Another example of the use of AI in the framework of optimizing the control of the combustion process at thermal power plants is the service for issuing recommendations on the optimal distribution of energy resources used at the facilities of the Novolipetsk Metallurgical Combine. Gorenje The basis of this system is a machine learning model, which is based on the analysis of long-term historical data. This model provides recommendations for optimizing fuel mixing proportions. The effect of using this technology is estimated at 3 million rubles per month.

The analysis is based on data, the main sources of which are automated process control systems, ERP, MES, any other systems that store information from sensors about repairs; external factors (humidity, temperatures, etc.). Data is transmitted to Clover Group specialists to prepare for analysis: structuring and enrichment.

It is important to understand that the accuracy of the forecast depends on the amount of data: if the customer has accumulated enough data, then the predictive analysis module will work immediately and you can get the effects right now. If there is not enough data, then after the implementation of Clover PMM, fees are just beginning, and setting up a predictive model will take several months [2].

Each hardware needs a different amount of data. For example, for the auxiliary equipment, the Atlas Copco compressor, one year's data was enough. After collection, the data is uploaded to the Clover expert analytical system, where mathematicians, together with industry experts, identify abnormal conditions and defects in equipment operation, identify violations of operating modes and build a predictive model of unit failures.

The system is further trained by industry experts and engineers, that is, digitizes the experience of experts and applies it to analysis. For example, if a structural element breaks down or an anomaly appears, you can classify the reason why this happened, for example, due to a violation of the operating mode. This requires the knowledge of experts, they explain what caused the anomaly, and mathematicians write this rule into the system, further training it based on expert opinion [3].

To output the results, Clover PMM integrates with the customer's IT infrastructure, for example, ERP, EAM class. The pre-failure conditions of the equipment, data on the actual and forecast technical condition of the structural element and equipment are transmitted to this system. If there is no repair management system, Clover is integrated into another one – it depends on the specifics of the customer's infrastructure.

It is important to understand that PMM is a big data analytics system that allows you to pull out a valuable grain in the form of physical dependencies and make decisions about equipment based on this information, rather than a classic automated process control system, whose main function is to control equipment according to parameter settings. These systems complement each other well: the automated process control system provides data, and Clover PMM analyzes it [4].

1. AI technologies are also used in power plants powered by renewable energy sources, which are characterized by weather-dependent generation of electric energy. AI, due to the processing of large amounts of meteorological information, makes it possible to accurately predict the generation of electric energy, which makes it possible to effectively integrate power plant data into electric power systems. In some cases, the effect of the introduction of AI is estimated to increase the accuracy of forecasts of "solar activity" by 30 %. Meanwhile, in wind farms, the use of AI makes it possible to predict the generation of electric energy by wind farms with an average error of no more than 1.05 %.

2. The use of AI in organizations engaged in activities in the field of transmission and distribution of electric energy. At the stage of transmission and distribution of electrical energy, AI is used to improve the reliability, observability and controllability of electrical networks. Thus, the ROSSETI Group of companies is currently actively using AI implementation approaches to ensure control over the correct functioning of digital protection systems and automation in electrical networks. These approaches make it possible to quickly respond to emerging emergency situations, prevent emergency events and reduce the number and duration of power outages. As in the segment of electric energy generation, in the segment of transmission and distribution of electric energy, AI is used for automated control of the technical condition of electric grid equipment. AI is also integrated into the design of digital substations in the field of networks and communication systems at substations, which contributes to the implementation of a fully automated approach to this process. In addition, the use of AI helps electric grid companies to identify metering devices that transmit unreliable readings, as well as to detect specific sections of the network where cases of improper connection of consumers occur.

3. The use of AI in organizations engaged in activities in the field of sales of electric energy. AI can be used by energy marketing organizations, as well as other enterprises engaged in the purchase of electric energy in the wholesale market of electric energy and capacity, to predict demand and price situation. At the same time, unlike other forecasting approaches, AI models take into account complex nonlinear relationships. The use of AI models in this field makes it possible to identify and quantify the relationships between the analyzed variables and various factors. It is worth noting that experts note the high results of AI in this area. AI is used in the

framework of servicing consumers of electric energy. For example, AI-based virtual digital assistants are designed with the ability to conduct dialogues in text or voice form, close to natural human communication. One of the key tasks of such virtual assistants is to provide information and advice to users on all issues related to interaction with energy marketing organizations. This often eliminates the need to visit the offices of energy sales organizations and contact contact centers. At the same time, AI-based virtual assistants are able to perform the functions of reminders about the transfer of meter readings or payment of receipts. This approach makes it possible to reduce the time and resource costs of consumers of electric energy, providing more efficient and convenient interaction with energy marketing organizations. For example, using the Naumen platform, Atomenergosbyt implements an integrated approach to remote service automation and quality management of customer experience, as well as service automation. As part of this project, the company's contact center is switching to a hybrid service model, where each client's request is transmitted to an intelligent system for further processing by an assistant bot or operator, depending on the topic and context of communication with the client. As part of customer service, AI-based consulting robots are also used in the Rushydro Group of Companies in the Unified Settlement and Information Center [5].

The new approach will automate the testing processes of electrical substation protection systems during design, configuration and operation. Neural networks are a very flexible and powerful forecasting mechanism that allows you to reproduce extremely complex dependencies. An important feature of a neural network, unlike, for example, regression statistical models, or autoregression models often used for forecasting, is the ability to associate a large set of factors with the analyzed parameter, which will allow taking into account a large number of different input parameters — historical data on electricity consumption and corresponding historical weather conditions, weather forecast, time of day, time year, type of day, etc. In this case, the function of the influence of the input parameter on the output result can be any complex (nonlinear, non-stationary, etc.) and of unknown shape. In addition, some of the input parameters of the model are numerical (historical values of electricity consumption, air temperature, time of day, etc.), and some are categorical (time of year, type of day, type of clouds, and others) [6].

Considering the above, various intelligent systems used in the electric power industry, as well as new methods of using artificial intelligence in production, were considered. Research shows that AI technologies play a key role in optimizing management and monitoring processes in the energy sector, increasing the efficiency and reliability of systems. The use of machine learning and data analysis algorithms can reduce equipment maintenance costs, predict failures and improve maintenance planning. New methods of applying artificial intelligence open up opportunities for the industry to create more flexible and adaptive systems that can quickly respond to changing market conditions and requirements. Looking to the future, we can emphasize the importance of further research and development in the field of artificial intelligence technologies in the electric power industry in order to ensure the sustainable development of the industry and increase its competitiveness in a rapidly changing energy market.

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THE CONSTRUCTION OF KISLOVODSK AS A SOVIET RESORT CITY IN THE 1920s AND 1930s

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Abstract. The resort infrastructure was already developed in Kislovodsk before the Revolution in 1917. After Bolsheviks came to power, there was a shift in focus towards ensuring access to resorts for the working class. While the city's primary functions were still mostly the same, living conditions had been impacted by changes in the political landscape and material structure of the city.

Keywords: Soviet Health Resort, Kislovodsk, urbanism, socialist city, recreation policy.

КОНСТРУИРОВАНИЕ КИСЛОВОДСКА КАК СОВЕТСКОГО ГОРОДА-КУРОРТА В 1920-1930-е ГОДЫ

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Аннотация. Курортная инфраструктура в Кисловодске была развита еще до революции 1917 года. После прихода к власти большевиков произошел сдвиг в сторону обеспечения доступа рабочего класса к курортам. Хотя основные функции города остались практически прежними, но на условия жизни повлияли изменения в политическом ландшафте и материальной основе города.

Ключевые слова: Советский курорт, Кисловодск, урбанизм, социалистический город.

The Caucasian Mineral Waters region included Kislovodsk, Zheleznovodsk, Yessentuki, and Pyatigorsk and each of this city is a unique place. However, there are other resorts in country as well; a guidebook written in 1935 by Mark Iosifovich Ganshtak, one of the directors of the Caucasian Mineral Waters during Soviet period, listed 25 more resorts of national importance [1]. Nevertheless, according to author, for tourists, only resorts of the Caucasus offer a unique world [1].

Kislovodsk is a city that draws tourists from all over the world and garners attention due to different factors. All year long, Kislovodsk is open as a balneological resort. Emperor Alexander I ordered the construction of Kislovodsk in 1803 as the fort

“Sour Waters”, despite the fact that the city's future was not quite colorful. Nevertheless, for just under a century, Kislovodsk received a status of city and developed into a popular destination for people who looking for varied treatment. During the 19th and beginning 20th century, along with the construction of a park, a Kursaal, a Narzan Gallery building, and a colonnade, the city also saw the appearance of a railway that linked it to the rest of the empire. Moreover, Kislovodsk is a home for different ethnic groups. According to the 1897 census, there were 4,644 people living in the Kislovodsk settlement [sloboda] [2]. Meanwhile, there was a nearby Kislovodsk village [stanica] with a population of 2,961 people [2], where mainly Cossacks lived. This territory has always been characterized by a complex and heterogeneous composition. Historically, the Caucasian region as a whole has been home to different nationalities such as Russians, Ukrainians, Armenians, Georgians, and many others. In addition, the nature of the city as a resort city influence on the quantity of population, Kislovodsk has been a popular destination for different tourists and visitors from all over Russia. Furthermore, by the beginning of the 1920s Kislovodsk's population grew to 16,676 [3]. Finally, in Kislovodsk lived a record 30,000 locals by 1929 and 18,000 people visited the city at that year [4]. In order to achieve such results, a lot of work had to be done to the reconstruction of the city.

In April 1920, the Bolsheviks ultimately seize control of Kislovodsk, bringing significant changes. By the summer of 1920, the process of development of the region began. At an emergency meeting convened on July 24, 1920, the director and commissioner of the Caucasian Mineral Waters department, noted, "The main and profound disadvantage of the Caucasian resorts is the fact that the resorts, especially Pyatigorsk and Kislovodsk, have turned into ordinary Soviet cities, where the life of the resort has receded into the background."[5] The Bolsheviks had ruled Kislovodsk for four months by July 1920.

Before the 1917 revolution, Kislovodsk was the third summer capital of the Russian Empire. However, after the Bolsheviks came to power, the city received a new understanding as a socialist resort town. Urban development in Russia began in a new direction: socialist cities were expected to represent the values of new ideology and society both in their planning and social structure. However, towns such as Kislovodsk and many others did automatically not fit in into the conception of a model “socialist” town, as in their imperial period they were places of leisure for bourgeoisie and nobles.

The problem that I am interested in, on the one hand, is embedded in the concept of Soviet urbanism and the Soviet city, on the other hand, this idea is correlated with the concept of recreation and recreation policy in the USSR. Moreover, another part that connects these two approaches is the concept of a specific type of cities (resort cities). The way a city looks is influenced by many factors: ideology, architectural style, city functions, and natural landscape. Soviet towns were characterized by their focus on industrial production and the promotion of socialist values, on the development of industry and infrastructure in urban areas to support the country's economic growth and advance towards socialism. Additionally, Soviet towns were designed to reflect the principles of equality and classlessness, in contrast to the social hierarchies present in the Russian Empire. Nevertheless, there were also towns on the territory of the Soviet Union that did not fit into this new idea of what a Soviet city

should be. And Kislovodsk stood out against the background of other Soviet towns. However, with the arrival of the Bolsheviks, town begins to acquire a new meaning as a soviet resort town. Therefore, it is important to trace what is actually hidden under the definition of a "resort town" and specifically Kislovodsk in this case.

The resort infrastructure for vacationers was already developed in Kislovodsk before the Revolution in 1917. The design and construction of Kislovodsk began back in 1812 and for a more than 100 years [6], houses for residents, hotels for vacationers, a Narzan gallery, kursaal, Narzan baths, temples were built in the city. These constructions had created a solid foundation for the growth of infrastructure designed to serve vacationers in the late 19th century. After Bolsheviks came to power, there was a shift in focus towards ensuring access to resorts and recreational facilities for the working class [7]. Moreover, while the city's primary functions were still mostly the same, living conditions had been impacted by changes in the political landscape and material structure of the city under the conditions of the new political regime. Such transformations required fundamental changes in the organization of the functioning of the city. However, due to external circumstances, most of the transformations were carried out without a single plan. In this case, how far does Kislovodsk fit the definition of a socialist city in 1920-1930s? Furthermore, how did it demonstrated?

One of the reasons why at the beginning there was no direct plan for the reconstruction of the cities in accordance with the new ideological patterns was the fact that Marxist theorists did not broadly discuss the concept of a socialist city before the revolution in 1917. The Bolsheviks, upon coming to power, were faced with the challenge of reconciling socialist ideology with the existing urban landscape and the need to build new cities, which would implement new ideas of social organization. However, how can socialist values be applied to "remake" a city that already has a historical background and developed material infrastructure? This issue could not be resolved immediately. The lack of resources made the task of reconstructing cities within a communist framework more difficult. Overcoming pre-war living conditions and achieving rapid urban development was severely limited by a shortage of material, human, and financial resources. By the mid-1920s, the question of what a socialist city should be arose again [8]. It was necessary to determine what a socialist city look should like, what infrastructure it should have, who would live in the city.

The concept of a socialist city is a rather complicated issue, and different Soviet theoreticians and contemporary researchers interpreted it in various ways. For the identification of whether particular city fits into this concept or not different criteria can be used. For example, Stephen Kotkin analyzes the concept of an idealistic socialist city appeared in the 1920-1930s by comparing it with a model of capitalist city. The author draws attention to the fact that in the Soviet practice of urban planning and construction, the emphasis was on collective spaces and public facilities instead of privet spheres. A socialist city itself was expected to be divided into two zones: production and residential areas, with a green space between them [9]. And this comparison with capitalist city especially important in case of Kislovodsk, because before to the revolution, the majority of hotels, shops etc. were privately held. Additionally, the resort industry generally followed the rules of the market.

However, Stephen Kotkin is mostly interested in the reconstruction of idealistic

image of a socialist city rather than in the analysis of its implementation. The study of the actual realization of a model socialist city can be found in the research of Stephen Bittner dedicated to the case of Moscow in the 1930s – in particular, to the attempts to rebuilt the Soviet capital with sophisticated heritage into an exemplary socialist city. He emphasizes the role of green areas and the organization of public spaces within the framework of the construction of a socialist city. This tendency is also traceable in the case of Kislovodsk – Kislovodsk's "heart" was essentially a park that covered an extensive area, therefore it was a crucial element of the city. In addition, he mentions that a socialist city should have been focused on ensuring equality and social justice, as well as on meeting the needs of all segments of the population, including the poor and minorities. In other words, for Bittner, the accessibility of housing, public transport, and infrastructure are the crucial elements of a socialist city [10].

Katerina Gerasimova and Sofia Chuikina point out another important element of the conception of a socialist city, which is the ideological paradigm in Russia after the October Revolution in case of city landscape. They consider the process of renaming the city Leningrad and its symbolic significance in the context of building a socialist society. Moreover, research present how the urban layout changed after the revolution [11]. Examples of Leningrad and Kislovodsk in this case have common roots, because both had developed imperial infrastructure, which, however, was "recycled" in different ways. To conclude, these works highlight the existence of various criteria and layers for analyzing cities, particularly when applying the term "socialist city" to them.

Returning to the case of Kislovodsk in the 1920s and 1930s, at first glance it is almost impossible to determine whether this city can be called socialist (according to the mentioned above criteria) or not by the end of the 1930s. Before the revolution, Kislovodsk already had the fame as a resort city, where people of the upper strata could came in the first place. However, what has changed after the revolution? To what extent had the government been able to change the image of a city, its space and turn it into a "people's health resort" [narodnaya zdravnitsa]?

It is essential to use works that I mentioned earlier in order to provide answers to these questions. Further, it helps to determine the degree to which Kislovodsk was "sovietized" at the end of the 1930s within the framework of these standards. Therefore, it is important to pay attention to the process of changes in the city. The first crucial factor to consider is the city's appearance and how it changed over the 20 years after the Revolution? Urban planning becomes an important element of these transformations, as it was supposed to reflect the new socialist ideals. Secondly, various political and social symbols played a crucial role in the design of urban spaces in socialist cities. Symbols such as statues, monuments, murals, and other forms of public art could be employed to celebrate socialist achievements, honor revolutionary figures. Thirdly, another significant aspect of urban area is the organization of different social services. Ensuring the availability of these services and providing equal circumstances for everyone to access them were necessary. In socialist systems, there is an emphasis on providing equal access to essential services such as housing, healthcare, education, and cultural amenities. The allocation of resources is often guided by principles of social justice and collective well-being, rather than individual wealth or privilege. Moreover, it can help to evaluate the effects of socialist ideology

on the standard of living and general well-being of urban dwellers by examining policies pertaining to housing, healthcare, education, and cultural initiatives. These criteria will help in developing a better understanding of the nature and degree of effectiveness of Kislovodsk's "sovietization" in the 1920s and 1930s.

Kislovodsk is known for its historical architecture, with many buildings that were constructed in 19th and early 20th centuries. These buildings represent a mix of architectural styles, including neoclassical, Art Nouveau, and Neo-Russian style. The rapid development of the resort in the end of 19th century led to the construction of many grand buildings and landmarks in Kislovodsk. These included spa resorts, hotels, and sanatoriums. Nonetheless, from 1914 numerous buildings were transformed into hospitals for the ill and injured soldiers during World War I. For example, a two-story structure housing the infirmary's officer corps was constructed on the fortress's grounds during World War I. The infirmary functioned as a hospital during the conflict. However, in 1926, one of the oldest sanatoriums in the city was founded instead of a hospital [12].

The Kursaal was another unusual example of modifications that gave building a new status. It served as a venue for opera, theater, and concerts featuring well-known Russian and European performers before to the Revolution, it served as a location for a number of political meetings during the Civil War. Furthermore, a sanatorium named in honor of A. Andreev was created in the building of the Kursaal [13]. These changes not only reflect the impact of external events on the city but also highlight its resilience and ability to evolve as circumstances demand.

Apart from the reallocation of buildings already in use among different entities, the construction of completely new buildings also took place. For instance, before the Revolution, vacationers could hire furnished rooms in the Ponyatovskaya apartment complex, which was situated on the corner of Kurortny Boulevard. The building was nationalized around 1920 and then converted into communal flats before being dismantled in the fall of 1926. Actually, by 1928, the house was destroyed and on this site of the former Ponyatovskaya apartment complex a new construction defined as the October therapeutic baths that created a constructivist design for the building[14]. It was one of the first civil engineering of the Soviet government in Kislovodsk and it represented the new fashions of the time.

By 1936, the same architect (P. P. Eskov) had built one of the first sanatoriums of the Soviet era – the sanatorium of the State Bank. While the predominant architectural style in the mid-1930s was historicism, characterized by a return to traditional and classical design elements, this particular sanatorium reflects elements of constructivism. By integrating elements of constructivism into the design of the sanatorium, P. Eskov have sought to create a structure that not only provided necessary facilities for health and recreation but also symbolized progress and innovation in the Soviet era. In result, during the 1920s and 1930s, an extensive network of sanatoriums was created for workers who came on vacation and needed time to recuperate in accordance with the new Soviet principles. This work on the creation of the Soviet resort base was carried out in different ways, since the authorities lacked both the time and resources to solve various tasks, and, theoretically, the experience of resort construction.

External political events also influenced the appearance of the city. By the late 1920s and early 1930s, anti-religious propaganda in the USSR was being promoted repeatedly. A vital aspect of the Soviet Union's efforts to repress religious rituals and advance atheism was the demolition of places of church. Kislovodsk was also impacted by this. If the city had five distinct church buildings before to the revolution, then none of them has survived to nowadays. Consequently, St. Nicholas Church, Rebrov Chapel, Holy Cross Cossack Church, Constantino-Eleninsky Church, and St. Nicholas Cathedral were all entirely destroyed between 1936 and 1938 [15]. There is little doubt that the community and the city's architectural legacy have been permanently impacted by the destruction of these historically and culturally significant structures. The absence of church buildings has turned the urban area of Kislovodsk into a non-religious (secular) city.

Mentioned above examples demonstrate that Kislovodsk experienced a common feature of many Soviet cities during that period: the adoption of a unified architectural style following the acceptance of the restoration plan in 1935. An urban environment that embodied the principles of modernism and socialism was to be created by building in a unified neo-classical style. At the same time, the constructivist buildings, which were constructed before the rest of the ensemble, may have been the only example of an earlier period of avant-garde and modernist architecture. While Kislovodsk may be considered a socialist resort due to its planned reconstruction and architectural style, the absence of overt symbols of Soviet power such as statues, monuments etc. in the city suggests a more subtle approach to ideological representation. This could be seen as a reflection of the city's focus on being a health resort and tourist destination rather than a center of political influence.

What is more, the construction of a sewage system in Kislovodsk was one of the Soviet Union's most important urban space transformation projects in the city. This project was part of bigger modernization and transformation of environment. In addition, the construction of a sewage system contributed to satisfy medical needs that mandated a suitable hygienic level in addition to influencing to the city's transformation. Chemical and bacteriological investigations conducted in 1925–1926 on the Berezovka and Podkumok rivers further support the critical necessity of sewerage [16].

Initially, the project of sewage system created in 1914, but it was not developed before the Revolution. Sewers began to appear in a number of cities across the Russian Empire, mostly due to the efforts of well known hydraulic engineer – Nikolai Klavdievich Chizhov. His project of sewage system in Caucasian Mineral water region required the construction of a network for the discharge of wastewater from bathroom buildings that included disinfection stations in addition to a public sewage network with biological treatment facilities. And such system was first attempted to be built in 1918, however the project failed without much success [17]. As a result, the issue of creating a full-fledged sewage network is raised again already during the Soviet period.

Building wastewater treatment facilities and a water supply system simultaneously was vital because the success of such a project undoubtedly influences other aspects of urban development. The resort was able to function at its optimal level if everything worked together. Such a system's construction requires substantial

financial investments in addition to the collaboration of multiple government departments. It became possible in 1928 with the Five-Year Plan [18] that included building of such infrastructure. Since it was not to achievable carry out the plan totally and 8,000,000 rubles were needed only for first stage, the work was divided into two stages according to the plan. The plan suggested splitting the work into two stages where the second stage's sewerage covers settlement areas that are not currently able to be sewageized [kanalizirovany], because "… this reconstruction is a matter of the very distant future." Building the main collectors and biological treatment facilities for the volume of liquid discharged into the rivers at that time was the main effort, performed in 1929 – early 1931 as a first stage of work. Afterwards, in 1931, it was proposed to expand the construction of sewer systems [19].

In fact, still it was not possible to complete all work as outlined in the five-year plan. The city government was dealing with problems. Lack of money was among the most significant and evident questions. The reason for uncertainty in the issue was that, even if the very necessary work were completed and had a favorable impact in a particular area, the other resorts in the Caucasian mineral waters would suffer substantial economic losses. As a result, regardless of their importance or cost, it was strictly prohibited to spend any expenses that were not included in the plan and estimates [20]. Even though each of the four resorts existed independently, the resorts of the Caucasian mineral waters were most frequently perceived as a single system where everything connected to each other.

By 1931, Kislovodsk had 200 estates connected to its sewage network, according to the report on the resort's services and medical and sanitary conditions. The low diameter of sewer pipes (from 150 mm to 425 mm) prevents rainwater and domestic water from entering the sewage system at the same time. The report's authors stress that the insufficient water supply is the primary cause of the sewage network's weak development. There cannot be sewerage without proper cleaning [21]. In consequence, there was a direct correlation between the water supply and the overall shortage of water in Kislovodsk. Initially, five springs supplied water to the city: the 1-yj Lermontovskij, 2-yj Lermontovskij, Inkgejzerskij, Semigradusnyj and Glaznoj water source. Nevertheless, during the summer months, from July to October, the volume of water declined due to the arid climate and Kislovodsk experienced a water crisis. The resort and the city as a whole could not be completely provided by such volume of water. Because of this, the crisis forced the reduction of summertime street watering from the water supply (instead using barrels filled with river water). However, this did not provide a solution to the problem. What is more, in the summer, the fountains were closed as well [22]. One of the directors of Caucasian Mineral Waters highlights this issue in the handbook as well: "The amount of water received from these sources does not meet the needs of the population and the resort." Nevertheless, Kislovodsk features the greatest percentage of sewage households in both the city and the resort (34 %) when compared to other cities in the Caucasian region. The complex connection between water supply and sewerage illustrates the challenges Soviet engineers and officials suffered in bringing the plan into action.

In 1932, it was proposed that work be done on the sewage network's expansion and the construction of a biological treatment facility in order to solve this problem.

The total amount needed was 2,000,000 rubles, of which 1,300,000 were intended to be used for building a water pipeline and expanding the sewer network, and 700,000 for setting up a wastewater treatment facility. The medical director of Kislovodsk resort claims that without the work mentioned above, no steps can be taken to bring Kislovodsk, as a resort, up to high standards. Only with these actions would it be possible to bring the resort and the city into a normal sanitary and hygienic position [23]. Even in 1936, nevertheless, this part remained unfinished. Indeed, until the start of the Great Patriotic War, the sewerage system was not fully constructed in Kislovodsk.

Nonetheless, there were several examples of "signs of power" being erected around the city. Hence, in 1924, one of the earliest monuments honoring V.I. Lenin was created in Kislovodsk [24]. The decision to create a monument to V. Lenin in Kislovodsk early on in the Soviet period highlights the significance of commemorating policy as a way of promotion of ideological beliefs. The initial high relief designed by sculptor V.I. Ingal have faced challenges due to atmospheric effects, which could have affected its durability and visibility. Two years later, a bronze bas-relief was installed in its place, most likely in an attempt to resolve these problems and preserve the monument's status as a powerful and influential symbol.

Another emblem of Soviet power appears in the city a little bit later. The "Schutzbund Star," also known as the "Star on Gray Stones," was created in 1934 [25]. It initially came as a consequence of the Republican Resistance, or Schutzbund (Republikanische Schutzbund), an organization of social democratic and communist workers in Austria which started a rebellion in the beginning of 1934 that the government suppressed. As result, many participants escaped to the Soviet Union via Czechoslovakia. After serving as laborers and builders in the mountains, some Schutzbund members were relocated to the Caucasus. In Kislovodsk, they made this star over their vacation, and it ended up being popular. What is more, a further component of the ideology's expression were the two statues dedicated to I.V. Stalin. One was located in the Resort Park, close to the Colonnade [26], and another one was on the area of the "Vsekopromsovetkass" sanatorium [27]. Both statues appeared by the end of the 1930s, when the traditional image of the "leader of the peoples" (I. V. Stalin) was essentially formed. However, this practice of installing the figures of the leader has not been widely spread in the city.

However, Kislovodsk's street renaming initiative was an important part of the ideological program around symbols, as it was in many other USSR cities. With this effort, the old street names were to be replaced with new ones that represented the principles and goals of the Soviet government. Streets in Kislovodsk were renamed in honor of prominent figures who made important contributions to the nation's development as well as significant events in Soviet history. Street renaming project was a component of an overall attempt that changed the city's topography to better serve the political objectives of the Soviet Union. This approach not only affected the city's appearance but also acted as an ongoing reminder of the ideals and values that the government aimed to promote. For example, one of the main pedestrian streets initially appeared in 1893–1894, when the Kurzal first started being built. Golitsyn Avenue was given its current name in 1901 as an honor to General Prince Grigory

Sergeevich Golitsyn. A grape alley was constructed as decoration for the avenue; it was demolished during the early years of the Soviet administration. The avenue was formerly known as Vinogradnaya Alley until 1927, at which point it was renamed K. Marx Street, which is the name it still goes by today.

Access to various resources is another equally important aspect for a socialist city and socialism in general. Ensuring that every city dweller had equal access to basic services including housing, healthcare, education, and recreational facilities was a priority in the Soviet Union. Guaranteeing social equality and promoting the general well-being of the people served as the guiding principles for the allocation of resources among the residents. However, did this system "work" within the framework of Kislovodsk?

The allocation of resources in Kislovodsk have been impacted in part by the city's status as a people's resort. Sanatoriums and other medical facilities were built in city with the intention of serving visitors looking for healing therapies and experiences by offering recreational activities and medical services. Government focused on the resources that helped Kislovodsk grow as a resort. Water, power, building supplies, and workers working in the construction, medical, and cultural industries were all included in this category. It is essential sanatorium-resort area experience changes, but the entire city was also impacted. Not just tourists and medical professionals visit Kislovodsk; local adults and kids also living at this place. It is not correct to exclude from the brackets housing development, hospitals, schools, or other important urban infrastructure. They have significance for the city as well.

The difficulties that locals of Kislovodsk faced when attempting to get housing resources provide an example of some of the complications and inequalities that may occur when communist ideals are applied in reality. Housing for common city dwellers became less accessible as a result of the redistribution of housing square meters for other uses, such as sanatorium space allocation [28]. Kislovodsk's focus on building sanatoriums and other medical facilities to serve tourists may have limited the amount of places available for locals, especially in popular areas like the city center. Due to the nature of the city, the population was not static, and as a result, during the summer months, it grew as a consequence of a shortage of medical professionals who were mostly there to manage the resort's services [29]. It was difficult for such seasonal workers to find inexpensive and suitable accommodation due to conflict for housing resources between visitors and locals, as well as possible differences in income and housing costs.

The establishment of the right to education for all under Soviet power was indeed a significant advancement. While the process of liquidation and implementation may have been complex, the initiative marked a positive step forward. Before the revolution, Kislovodsk had a number of schools and gymnasiums that made primary education accessible to both boys and girls. Not everyone nevertheless was afforded this chance, and the majority of those who lived there stayed to be illiterate [30]. After 1920, the locals now had the opportunity to receive such a valuable resource as education: the organization of primary and secondary education in Stavropol region has begun. However, the absence of higher educational institutions in Kislovodsk meant that dwellers had to travel to nearby cities like Pyatigorsk, Mineralnye Vody, and Stavropol

to access higher education opportunities. Moreover, even in this case, most educational institutions were associated with medicine, since this particular area was paramount in the region.

To conclude, despite the establishment of sanatoriums and other infrastructure in Kislovodsk during 1920s and 1930s, it can be challenging to categorize the city as a "socialist city" in terms of symbolic elements in the space. While the presence of socialist institutions and buildings may have been significant, the overall aesthetic and cultural landscape of the city may not have fully reflected the ideological principles of socialism. The city's spa culture, architectural landmarks, and natural surroundings may have contributed to a more diverse and nuanced urban environment that blends elements of different historical periods and influences. In this sense, Kislovodsk may not fit neatly into the category of a "socialist city" in terms of symbolic elements in space. Moreover, the authorities tried to implement measures to ensure cleanliness and hygiene at the resorts in order to ensure safety and comfort for vacationers according to new socialist standards. However, sometimes it was difficult following to these rules, particularly when it related to sewerage. This meant that these works needed to be done quickly in order to address the resort's widely acknowledged need for renovation. After it was completely inappropriate when sewage was built without first building sewage treatment plants, and rubbish quickly seeped into the resort's sole reservoir, the Podkumok River that leads to situation when the Podkumok seems more as a sewer collection than a river in some areas. Undoubtedly, this situation made it more difficult for the city to function. Nonetheless, during the 1920s and 1930s, even the minor actions mentioned earlier and attempts to change the urban environment aided in the growth and avoided a total hygienic breakdown that would have led to the resort's closing.

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УДК 620.9

APPLICATION OF THE PRINCIPLES OF ENERGY SAVING AND ENERGY EFFICIENCY IMPROVEMENT TO CREATE A “COMFORTABLE HOME”

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Abstract. The article presents the results of research conducted to determine the most effective methods and solutions for creating comfortable housing with low energy consumption. The analysis of modern technologies and materials that reduce energy consumption in residential buildings, as well as increase their comfort and safety, has been carried out. The paper presents recommendations on the implementation of the principles of energy saving and energy efficiency in the construction of comfortable housing, which can contribute to improving the environmental situation and reducing utility costs.

Keywords: energy, energy saving, heat losses, energy efficiency, comfortable housing, energy resources.

ПРИМЕНЕНИЕ ПРИНЦИПОВ ЭНЕРГОСБЕРЕЖЕНИЯ И ПОВЫШЕНИЯ ЭНЕРГОЭФФЕКТИВНОСТИ ДЛЯ СОЗДАНИЯ «КОМФОРТНОГО ЖИЛЬЯ»

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Аннотация. В статье представлены результаты исследований, проведенных с целью определения наиболее эффективных методов и решений для создания комфортного жилья с низким энергопотреблением. Проведен анализ современных технологий и материалов, которые позволяют снизить потребление энергии в жилых зданиях, а также повысить их комфорт и безопасность. В работе представлены рекомендации по внедрению принципов энергосбережения и повышению энергоэффективности в строительстве комфортного жилья, что может способствовать улучшению экологической ситуации и снижению затрат на коммунальные услуги.

Ключевые слова: энергетика, энергосбережение, тепловые потери, энергоэффективность, комфортное жилье, энергоресурсы.

In the modern world, where environmental issues are becoming increasingly acute, energy conservation plays a key role in creating comfortable housing. The concept of housing comfort is not limited to just coziness and functionality of spaces, but also includes efficient resource utilization and reducing negative impact on the environment. In this context, energy-saving technologies and solutions become an integral part of the concept of comfortable housing, providing not only cost savings but also creating a healthy and sustainable living environment. This article examines the key aspects of comfortable housing with a focus on energy conservation, identifying its benefits for residents and the environment, as well as presenting modern technologies and innovative approaches that contribute to the creation of such housing.

According to the Federal Law of the Russian Federation dated November 23, 2009, No. 261-FZ "On Energy Conservation and Increasing Energy Efficiency and on Amendments to Certain Legislative Acts of the Russian Federation", whose main concept is to increase the energy efficiency of the economy, and the Energy Strategy of Russia for the period up to 2030, one of the main directions in energy development is energy conservation and improving energy efficiency [1; 2].

Energy efficiency involves the rational use of energy resources, applying the minimum amount of energy to achieve the same level of energy supply for technological processes or buildings.

It is necessary to reconsider the concept of "comfortable housing", especially considering the climatic characteristics of our country. It is important to understand that comfort is not just about amenities; it is about ensuring continuous access to essential resources necessary for life – thermal and electrical energy. These resources are not merely "services"; they are vital components without which guaranteeing the basic right to life is impossible. Everyone should have access to these resources at fair prices, determined based on individual consumption measured by individual meters. Consumers should have the ability to regulate their usage, whether it's water, gas, electricity, or heat energy. Therefore, payment for consumption should be proportional, rewarding those who conserve energy and resources. This also incentivizes consumers to use resources more efficiently, which is crucial for ensuring sustainable development. Additionally, the heating of buildings with regulated microclimates should be adapted to reasonable energy consumption. It's important to focus on the energy efficiency of such constructions, considering their resilience and environmental durability.

It should not be forgotten that the absence of thermal energy throughout the heating period and for a short period during severe cold spells can lead to human casualties. Causes may include fires resulting from overload of internal networks when electric heating devices are switched on, fuel shortages or delivery problems leading to heating interruptions, mechanical breakdowns, or software failures in control systems that may temporarily disable heating in some homes or even entire areas.

The energy efficiency of a heated building primarily depends on the quality of thermal insulation. This is a crucial operational characteristic determined by the actual

values of the complex of basic heat engineering and thermal energy indicators, i.e., the quality of thermal insulation of building envelope structures. The main thermal losses occur through the building envelope in residential buildings. In percentage terms, they are as follows: 20 % – roof, 20 % – walls, 10 % – floor, 30 % – windows. Additionally, 20 % of thermal energy can be consumed in ventilation systems (Figure 1).

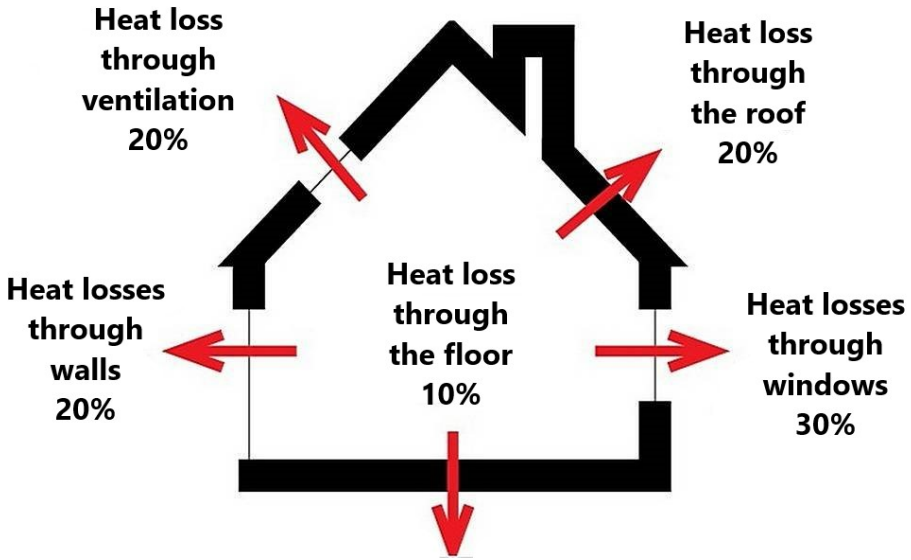

Figure 1. Heat losses in buildings.

When constructing modern multi-storey buildings, developers aiming to increase profits allow for a reduction in the level of thermal protection, leading to increased thermal energy losses through the building envelope structures. When insulating external walls, it is necessary to avoid thermal bridges. These occur with inaccurate insulation placement or changes in its dimensions over time. The most important parameter for a product insulating an external wall is the thermal conductivity coefficient. The most popular materials are expanded polystyrene, mineral wool from glass or stone, with λ values ranging from 0.030 to 0.045 W/(m·K). The lower the λ coefficient, the better the thermal insulation of the wall. Long-term studies show that the quality of thermal insulation in newly constructed buildings does not improve; total heat losses increase with the height of the buildings under construction. Research has also shown the presence of issues related to deteriorating building thermal insulation quality [6].

The first issue is the reduced apparent thermal resistance of the building envelope structures.

The second issue is the presence of hidden defects in the thermal insulation of the building envelope structures. Such defects can be easily detected using thermal imaging methods and, if possible, corrected before the building is put into operation. It often happens that real estate purchased as fully functional turns out to be unsuitable for normal use.

The third problem is increased energy consumption. Poor thermal insulation leads to heat leakage from the building during cold periods and heat penetration during hot periods. This requires more intensive use of heating and air conditioning systems, resulting in increased energy expenditures.

The fourth problem is uneven temperature distribution. Poor thermal insulation can cause uneven temperature distribution inside a building, which can lead to discomfort for residents or workers.

In addition to the effective operation of the heating system, a building must meet the requirements of regulatory thermal insulation and energy efficiency. Therefore, non-compliance with the relevant regulatory document requirements will either increase heating costs or make it impossible to maintain comfortable conditions. It is known that one-third of the energy resources in our country used for heating are wasted heating the atmosphere due to poor thermal insulation of heated buildings [7]. Consequently, specific energy expenditures in the housing and communal sector in our country exceed similar indicators in countries with similar climatic conditions by 3-4 times. There are numerous ways to improve heat conservation in homes, such as good insulation of walls, floors, ceilings, and windows significantly reducing heat loss and allowing for more stable indoor temperatures. This can be achieved by insulating walls with mineral wool, installing energy-efficient windows and doors, and adding insulation to attics and basements. Smart thermostats with programming functions enable optimization of heat energy usage based on schedules and residents' habits, which can save a significant amount of energy. To save electricity, it is advisable to replace regular bulbs and household appliances with energy-efficient LED bulbs and Energy Star-rated devices [8].

The international energy efficiency standard for consumer products, Energy Star, was developed in 1992 by the U.S. Environmental Protection Agency with support from the U.S. Department of Energy. Energy Star-certified devices have average energy consumption 20-30 % lower than their counterparts of equivalent functionality.

Starting from September 1, 2025, the Technical Regulation of the Eurasian Economic Union EAEU TR 048/2019 "On Requirements for the Energy Efficiency of Energy-Consuming Devices" will come into force. From this date onwards, the circulation of energy-consuming devices without documents confirming compliance with the energy efficiency class will be prohibited. According to the requirements of the Regulation, household energy-consuming devices must be assigned an energy efficiency class. There are a total of 7 main energy efficiency classes for energy-consuming devices: A, B, C, D, E, F, G, where A represents the most energy-efficient devices and G represents the least efficient. Technological progress, production optimization, and adjustments to electricity costs have led to an increase in the number of household appliances in class A. Consequently, it was necessary to update the list of established classes, and it was decided to introduce additional classes: A+, A++, and A+++, which are used for labeling particularly energy-efficient products (Figure 2).

Figure 2. Energy Efficiency Classes of Energy-Consuming Devices

Household appliances such as refrigerators, televisions, washing machines, dishwashers, electric lamps, dryers, vacuum cleaners, air conditioners, and more are classified based on energy efficiency classes. When choosing equipment, it is important to pay attention to the energy efficiency class and aim for devices in class A.

Therefore, creating comfortable housing from an energy-saving perspective requires a comprehensive approach and the integration of various technologies and solutions. Insulation and weatherization, smart management systems, the use of energy-efficient equipment, and consideration of occupants' needs – all these aspects play an important role in providing comfortable housing. Implementing these principles will help create housing that not only ensures the comfort of its residents but also contributes to energy consumption reduction and environmental preservation.

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УДК 004.8

HISTORY OF NEURAL NETWORKS AND MAIN ELEMENTS OF THEIR ARCHITECTURE

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Abstract. Theoretical and mathematical methods for constructing neural networks have been studied. The origins of the formation of neural networks, their brief history and current position are considered.

Keywords: information systems, neural networks, machine learning, gradient descend, least squares.

ИСТОРИЯ НЕЙРОННЫХ СЕТЕЙ И ОСНОВНЫЕ ЭЛЕМЕНТЫ ИХ АРХИТЕКТУРЫ

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Аннотация. В работе исследованы теоретические и математические методы архитектуры нейронных сетей. Рассмотрены истоки формирования нейронных сетей, их краткая история и положение в настоящее время.

Ключевые слова: информационные системы, нейронные сети, машинное обучение, градиентный спуск, метод наименьших квадратов.

Neural networks and artificial intelligence (AI) arose only 70 years ago but humanity has been developing these technologies for centuries. We can distinguish three main directions that led to the creation of modern computer technologies: the desire of a man to create an artificial life, the formalization of thinking and the development of information technologies.

The relevance of this scientific article is determined by rapid development and widespread use of neural networks and artificial intelligence in various spheres of life. Neural networks have become a key tool in solving complex problems such as pattern recognition, natural language processing, forecasting and much more. Moreover, references to "neural networks" have increased more than tenfold between 2010 and 2023 demonstrating their burgeoning significance. Similarly, the usage of "machine learning" and "AI" has witnessed a dramatic rise reflecting their growing importance in both research and practical applications. Corpus analysis vividly illustrates this

trend. The frequency of terms like "neural networks," "machine learning" and "AI" has skyrocketed in recent years as evidenced by the provided data. Therefore, it is important to understand how neural networks operate and how they are trained.

Objectives of this scientific article are:

– Introduction to the history of the development of neural networks and artificial intelligence. The article traces the path from early ideas and philosophical concepts to modern technological solutions.

– Explanation of the basic principles of neural networks. The structure of neural networks is explained, including the concepts of neurons, layers, weights, bias neurons, and activations.

– Description of the simplest methods for training neural networks. The authors focus on least squares and gradient descent explaining their role in parameter optimization and training of neural networks.

The following *research methods* are used: analytical method, diachronic analysis, corpus analysis, comparative analysis, induction method.

The first direction includes not only modern robots and bots but also more ancient attempts to transfer human abilities to inanimate objects, for example, automatons, golems, the myths of Talos (a bronze automaton from ancient Greek mythology) [1], and Frankenstein’s monster.

The second direction arose with the advent of Aristotle's laws of logic, the foundations of Heraclides' geometry and the beginnings of Al-Khwarizmi's algebra. The next step in the formalization of thinking was the ideas of Friedrich Leibniz. He proposed to create a universal language of thinking where any statement based on simpler ones and determine truth and falsity can be represented. Such a language could form the basis of a computer programming language. However, thanks to the research of Kurt Gödel it became clear that the capabilities of the mathematical apparatus are limited, and it will not be possible to create a universal language. However, despite these findings research has been continued [2]. The transition point between mathematics and computers was the Turing machine – an abstract computing machine capable of implementing any computational algorithm of any complexity [3].

The third direction began with the creation of the first computers, for example, Pascal's calculator or Charles Babbage's analytical engine. In the 20th century the first electronic computers finally began to appear. Their size could cover an entire building. This is how humanity received the means to create the first neural networks as well as the mathematical basis for their work.

The first neural network in history was described in 1946 by Walter Pitts and Warren McCulloch under the guidance of theoretical physicist Nicholas Rashevsky. In 1958 scientist Frank Rosenblatt built the first neurocomputer “Mark-1” based on the perceptron model [1].

In a general sense, a neural network can be described as a simplified model of a biological neural network which is a collection of artificial neurons interacting with each other.

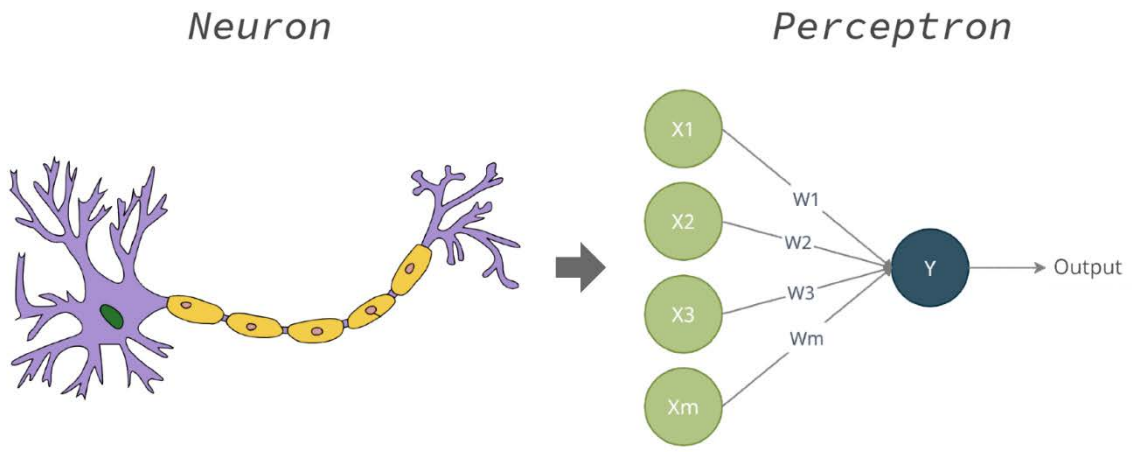

Figure 1. Neuron and first neural network model

Neurons and layers

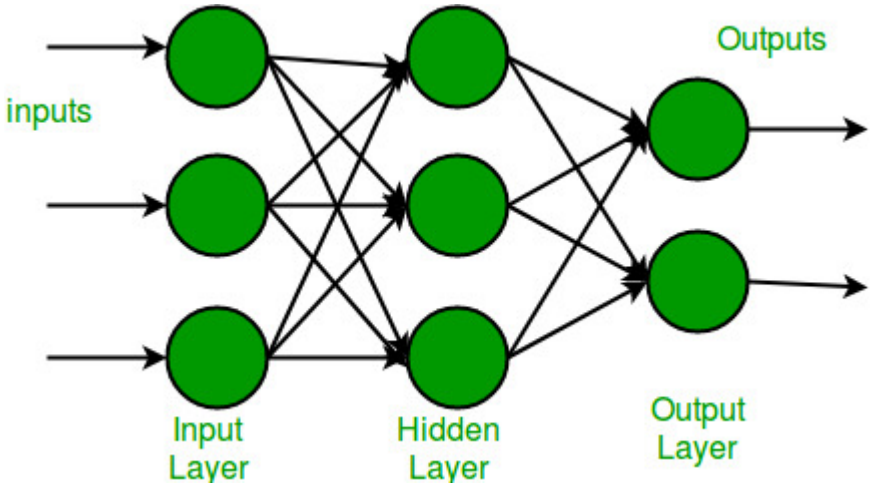

Figure 2. Perceptron layers

The Perceptron model is one of the first neural network models, the simplest option for creating a structure. An image of a number that the neural network will recognize is taken as an object of study. The image consists of pixels. Each pixel corresponds to a certain light power, which is indicated by a number from 1 to 255, to simplify calculations. All these values are divided by 255 so that the work is conducted with fractions from 0 to 1. These numbers are called activations (*a*). Next, all these numbers are conditionally arranged in a column and placed in the first input layer of the neural network. All layers of the neural network consist of neurons – the building components of the neural network which contain numbers. A layer of neurons is called a layer; depending on the complexity of the neural network it may only have input and output layers or additional hidden layers. The first (input) layer is used to receive data, and the last one serves to indicate the result. In the simplest neural networks it can consist of only a few neurons. The number of neurons in the layers and the number of layers is determined initially by the person who opens great opportunities for

experimentation. These principles are applied to any neural network that recognizes objects in our world using a set of numbers [4].

Weights and biases

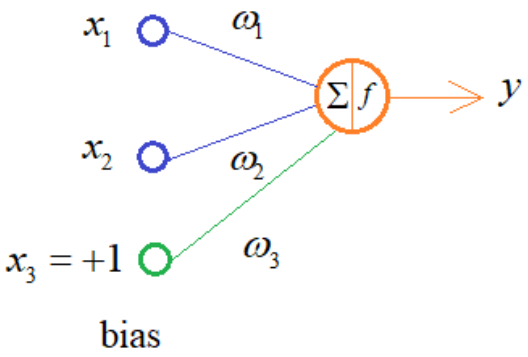

Figure 3. Weights and biases

The second key component of the neural network is weights (*w*) and biases (*b*). These two components are like “knobs” and “dials” that allow the neural network to adapt to different data sets. These numbers are a kind of connection that stretches from each neuron of the *n* level to each neuron of the *n+1* level. Weights are also numbers, however, unlike the data obtained initially which can be called parameters weights and biases are unknowns that the neural network determines during the learning process. Initially, weights and biases in the neural network are set randomly. Thus, mathematically the data appears as follows:

$\sum w_{ij} * a_i + b_j$, where i – number of neurons in n column and j – number of neurons in n+1 column [1].

The method of least squares

The method of least squares (LS) is an essential tool in the machine learning arsenal, especially for solving regression problems. Its main task is to find the line (or hyperplane in multidimensional space) that fits the data set as closely as possible minimizing the sum of squared errors between the predicted and actual values. The method became a simple predecessor of nonlinear methods that are used to train neural networks [4]. On the language of neural networks such methods are called the loss functions.

To understand the principles of its work one should imagine that they have a scattering of points on a graph and want to draw a line that goes as close to each of them as possible. LS minimizes the sum of the squared residuals between each point and the line, in other words, it minimizes the total error between the predicted values (on the line) and the actual values (data points).

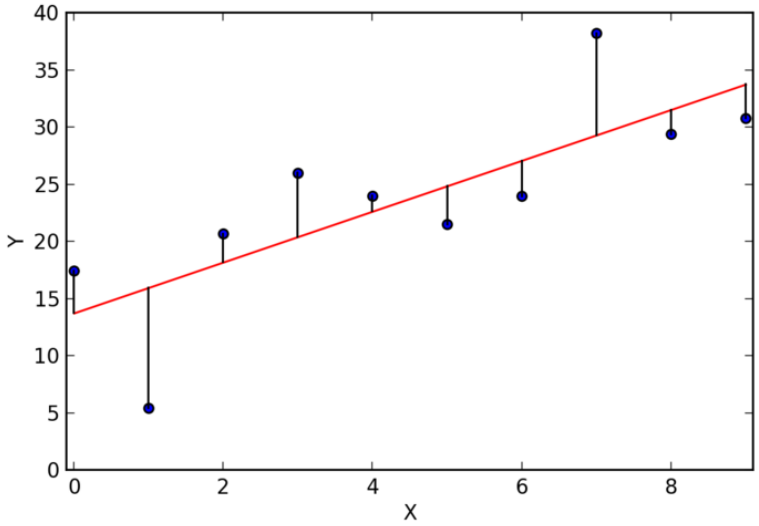

Figure 4. Residuals between predictions and data

Why should error squares be used? First, they make the loss function (a measure of error) smooth and differentiable which is important for optimization. Second, they give more weight to large errors than small ones helping the model focus on correcting the most significant errors.

In addition to training neural networks, LS is widely used in various areas of machine learning such as time series forecasting, data analysis, and image recognition.

Although LS has laid the foundation for the development of more complex methods, it is not directly used for optimizing neural networks. This is because neural networks are nonlinear in nature, and their loss function has a more complex shape than the “bowl” that can be found using LS. Instead, techniques based on gradient descent are used to optimize neural networks which allow one to approach the minimum of the loss function step by step.

*Gradient descen***t**

Gradient descent is the most popular optimization algorithm in machine learning. It is used to tune model parameters (weights and biases) to minimize the loss function.

There are three main options for gradient descent:

1. Mini batch: calculations are performed not for each example individually but for groups (batches) of *n* examples. It is an ideal choice for large data sets.

2. Stochastic gradient descent: at each iteration only one random example from the training set is used. With stochastic gradient descent it is important to shuffle the training set before each iteration to avoid systematic errors. This method is also “noisier” and less optimal than using the full data set.

3. Gradient descent series: calculations are performed for each example in turn. This variant of gradient descent will be described below.

Trying to find the lowest point in a valley one starts at a certain point and takes steps in the direction that is leading down. Gradient descent works similarly: it starts with an initial set of parameters and updates them in the opposite direction of the loss function's gradient.

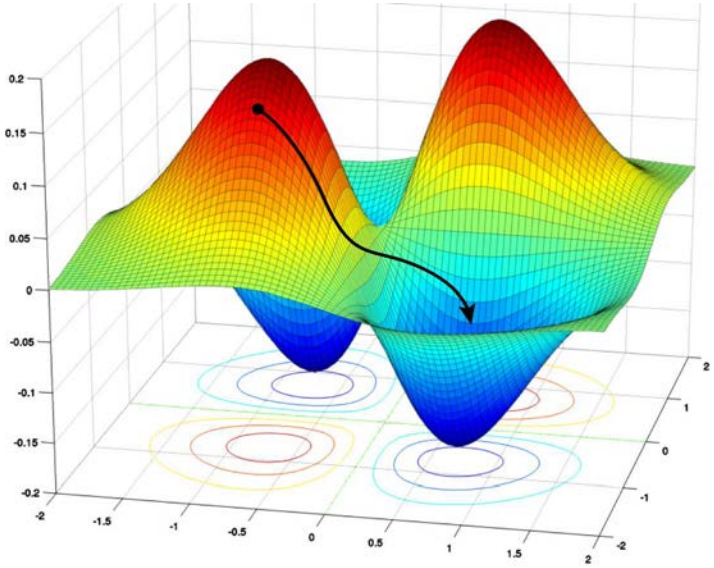

Figure 5. Gradient descent in function of two variables

Calculus is used to find the best model parameters minimizing the loss function. The slope of the graph of a function determined by its derivative indicates the direction towards the nearest minimum. In the case of a single-weight model calculating the slope of the loss function with respect to that weight gives the direction in which to move to reach the local minimum. The loss function tracks the error for each training example, and the derivative of this function with respect to the weight, in turn, indicates how to change the weight to minimize the error for that example [5].

In real models where there is more than one weight the described process is applied to all weights iteratively processing all training examples. Visualizing this process for many scales is difficult, but the concept remains the same.

Conclusions. The history of artificial intelligence occupies centuries of history. Humanity has repeatedly tried to create something like its own consciousness. However, only now, in the 21st century we are approaching the creation of full-fledged artificial intelligence capable of performing any tasks requested by a person.

It is worth mentioning that modern neural networks are complex structures that use enormous computing power. However, the methods described in this paper are the building blocks on which the massive architectures of modern neural networks are built.

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УДК 504.05

PROSPECTS FOR THE USE OF THE PU-10 UNIVERSAL FURNACE FOR WASTE DISPOSAL DURING THE FIELD DEPLOYMENT OF TROOPS

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Abstract. The article discusses problematic issues and possible solutions for the disposal of municipal solid waste during the field deployment of troops. The prospect of using the universal furnace PU-10 and the positive effect of its application are considered.

Keywords: solid municipal waste, recycling, field deployment of troops, universal furnace, incinerator.

ПЕРСПЕКТИВЫ ПРИМЕНЕНИЯ УНИВЕРСАЛЬНОЙ ПЕЧИ ПУ-10 ДЛЯ УТИЛИЗАЦИИ ОТХОДОВ ПРИ ПОЛЕВОМ РАЗМЕЩЕНИИ ВОЙСК

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Аннотация. В статье освещаются проблемные вопросы по утилизации твердых коммунальных отходов при полевом размещении войск и возможные пути их решения. Рассматривается перспектива применения универсальной печи ПУ-10 и положительный эффект от ее применения.

Ключевые слова: твердые коммунальные отходы, утилизация, полевое размещение войск, универсальная печь, мусоросжигательная установка.

Currently, the process of recycling municipal solid waste (MSW) in the Armed Forces of the Russian Federation is given extremely little attention. As a rule, municipal organizations of a separate region, with which relevant agreements have been concluded, are engaged in waste disposal from places of permanent deployment. Solid waste generated during the quartering of military units in the field is not disposed of at all [1, 2]. The task of field deployment of troops, including the disposal of MSW, lies with the commander of the unit.

A variety of waste disposal options are used, depending on the location of the unit relative to its rear units, as well as the evolving combat situation.

Incinerators have proven to be ineffective, in addition to the unmasking effect, their work causes serious harm to the environment. There is also an unresolved issue of separate garbage collection.

The positive experience of using incinerators is used as part of the APL-500, for the disposal of municipal solid waste, an installation based on a thermally insulated container is used, designed for the processing and destruction of solid waste and used in the absence of local incinerators (Figure 1). Its main function is the incineration of solid fractions of sewage and the disposal of household garbage and food waste. The unit runs on diesel fuel [3, 4].

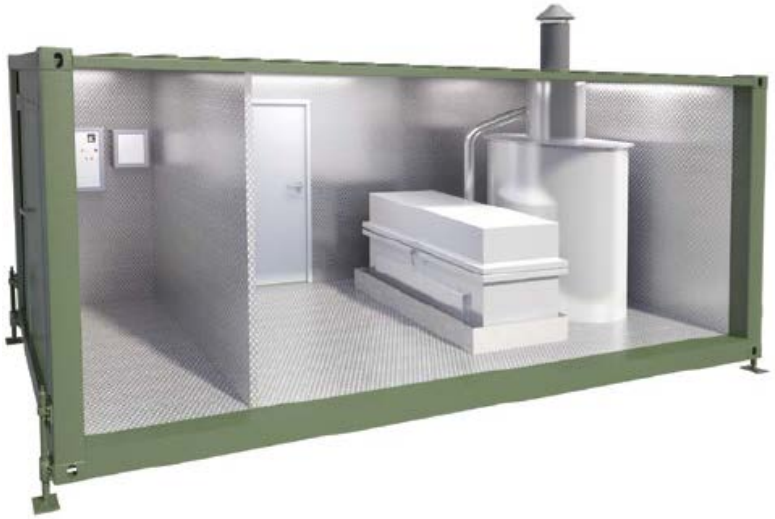

Figure 1. Diesel incinerator

Collecting, briquetting and removal from the placement area by passing transport for further processing at the landfill of the nearest municipality is a task with many unknowns and in some cases is not possible.

Placing a waste collection point in the form of cesspools in the area of the subdivision is the most effective way, but it is also the most negative for the environment.

None of the above options solves the problem of solid waste disposal in full, and requires an integrated approach.

One of the options for solving this problem is to reduce the volume of waste by using recyclable waste in the form of fuel. For these purposes, it is proposed to use PU-10 (a universal oven with a thermal capacity of 10 kW), which solves a number of related tasks, namely, heating a room with a volume of up to 48 m3, heating water for household needs, cooking and heating food, generating electricity, drying outerwear and shoes. The oven consists of a solid fuel burner, a hood with a cooking surface, a boiler, a refrigerator, a thermoelectric generator, a chimney and a dryer grill (Figure 2).

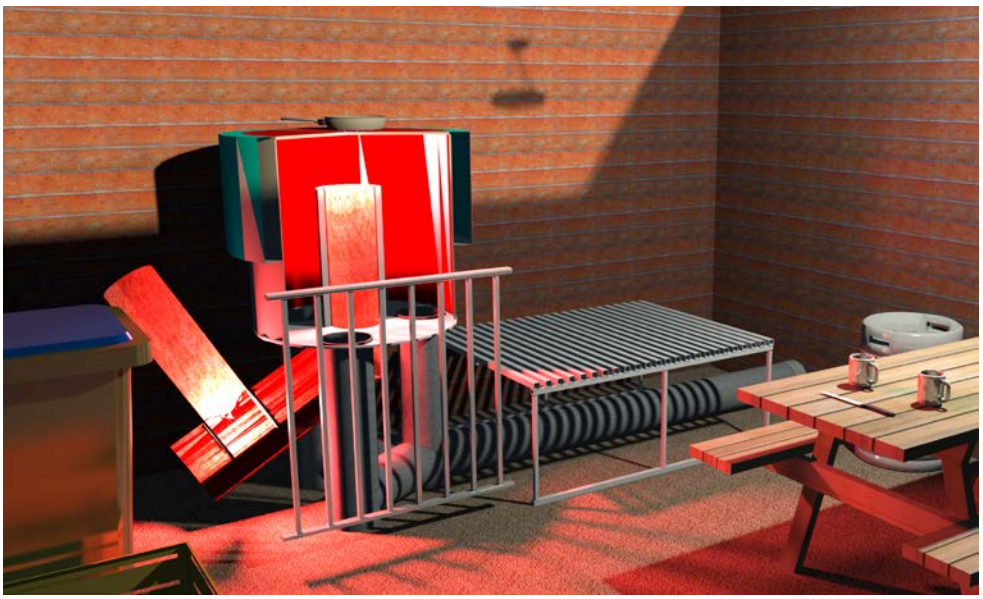

Figure 2. An example of the use of PU-10 in military deployment sites

For the operation of PU-10, wood fuel is used as the main fuel, solid waste (plastic, polyethylene, paper and cardboard packaging), liquid fuel (used engine oil, diesel fuel) can be used as auxiliary fuel as well as liquefied and natural gas. To use auxiliary fuel, the PU-10 can be equipped with a drip-type oil burner, diesel or gas burner.

The fuel is burned in a solid fuel burner. The flue gases are ignited in the hood by heating the hob, boiler, thermoelectric generator and the air under the dryer grate.

Based on previous studies, more than half of the volume of all daily waste of military units when placed in the field is household waste, 8-9 % for food and about 10 % for tin cans, glass and rags. The total weight of accumulated waste per shelf per day can be about 2.1–2.5 tons, or 12.7–14.2 m3 [5].

Let's consider the positive effect that can be obtained (Figure 3) from the recycling of waste from a motorized rifle regiment per day when placed in the field.

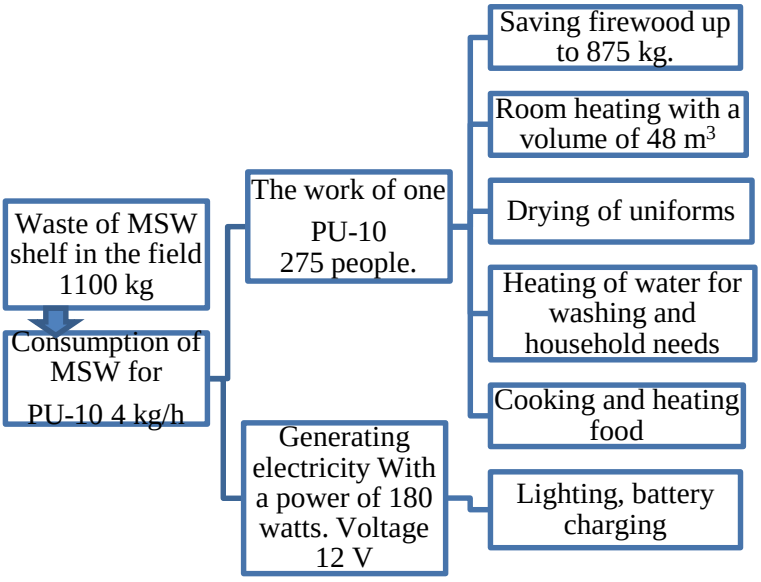

Figure 3. The scheme of application of PU-10 and the resulting effect

The main effect when using a furnace is to reduce the amount of waste, but at the same time we additionally get a number of additional functions, such as drying uniforms, which occurs by cooling the flue gases from the hood through the refrigerator into the chimney located under the grill of the dryer, heat the air under it and are discharged outside the room into a smoke masking device that allows use this oven in close proximity to the contact line.

As the experience of combat operations has shown, due to the use of modern detection equipment by the enemy, as well as high-precision weapons of destruction, solid fuel furnaces currently used in modern conditions have a serious drawback, such as a decrease in the camouflage properties of personnel shelters, due to their detection by thermal imagers mounted on unmanned aerial vehicles (UAVs) (Figure 4). This problem is partially solved in PU-10 by using a smoke masking device.

Figure 4. Thermal radiation from the exhaust pipe detected by a thermal imager mounted on a UAV

The heating temperature of the hob allows you to cook and warm up food, boil water in a boiler for household needs. The thermoelectric generator located on the furnace generates electricity under the influence of the heat of the flue gases, which can be used for lighting or charging office equipment batteries.

Based on the above, it can be concluded that the use of PU-10, when placing units in the field, allows you to reduce the amount of waste by half and solve some of the tasks by combining a number of functions of heating units, incinerators, lighting devices and water heaters.

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УДК 519.711

ANALYSIS OF EXISTING TOOLS FOR DETECTING UNAUTHORIZED ACTIONS AND ATTACKS IN COMPUTER NETWORKS

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Abstract. The article discusses the main types of malware threats. It is analyzed how these programs harm the computer network. The characteristic of signature and heuristic analyses for detecting malicious software is given.

Keywords: Internet, network security, file virus, signature analysis, heuristic analysis, computer network, unauthorized actions.

АНАЛИЗ СУЩЕСТВУЮЩИХ ИНСТРУМЕНТАЛЬНЫХ СРЕДСТВ ВЫЯВЛЕНИЯ НЕСАНКЦИОНИРОВАННЫХ ДЕЙСТВИЙ И АТАК В КОМПЬЮТЕРНЫХ СЕТЯХ

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Аннотация. В статье рассмотрены основные типы угроз вредоносных программ. Проанализировано, как данные программы наносят вред компьютерной сети. Дана характеристика сигнатурного и эвристического анализов для выявления вредоносного программного обеспечения.

Ключевые слова: интернет, сетевая безопасность, файловый вирус, сигнатурный анализ, эвристический анализ, компьютерная сеть, несанкционированные действия.

Thanks to the intensive use of the Internet, network security is becoming a key foundation for all web applications. Intrusion detection by analyzing records in network processes is an important way to solve network security problems. An intrusion can compromise not only the integrity of the data, but also the system itself. With the development of information technology and an increase in data transfer speeds, there are threats of improper use of the Internet. More reliable control systems are needed that solve the problem of protecting networks without human intervention.

Modern malicious software contains a wide range of viruses that damage not only the infected system, but sometimes the entire local or global network. Viruses are divided into classes with common characteristics [1]:

- habitat;
- algorithms of operation.

File viruses are mounted in files. Bootable files are hidden in boot sectors on the hard disk. Macro viruses infect documents and spreadsheets of text editors. Network viruses spread via email or the network.

Viruses can be combined to make their detection more difficult. Combining masks the presence of viruses in the system while attackers destroy it or steal user data. Examples of such combinations are file-boot and network macro viruses. They have a complex algorithm of operation and use stealth and polymorphic technologies to get into the system [3].

Virus algorithms are characterized by:

1) residency;

2) use of stealth algorithms;

3) self-encryption and polymorphism;

4) use of non-standard measures.

The resident virus encapsulates its part in RAM, which then intercepts the operating system's access to the infected objects and writes to them. Resident viruses are stored in memory and are active until the computer is turned off or the OS is restarted. Non-resident viruses do not infect computer memory and remain active for a limited time.

Stealth algorithms hide viruses in the system. The most common stealth algorithm is the interception of OC requests to read/write infected objects [4].

Stealth viruses at the same time "substitute" invulnerable areas of information instead of themselves. In the case of macro viruses, this is a ban on calls to the macro viewing menu.

Self-encryption and polymorphism are used by all types of viruses in order to make the virus detection procedure as difficult as possible. Polymorphic viruses do not have signatures and do not contain a single permanent piece of code. In most cases, two samples of the same polymorphic virus will not have a match. This is achieved by encrypting the main body of the virus and modifying the descriptor program.

According to destructive capabilities, unauthorized actions (UA) are divided into:

1) harmless viruses – do not affect the operation of the computer in any way, except for reducing the free memory on the disk as a result of their spread;

2) safe viruses – the impact of viruses is limited by a decrease in free disk memory and graphic, sound and other effects;

3) dangerous viruses – can lead to serious computer failures;

4) very dangerous viruses – can lead to program loss, data destruction, abrasion of information necessary for computer operation recorded in system memory areas, as well as contribute to accelerated wear of moving parts of mechanisms, such as hard drive heads.

The conducted UA analysis shows that it is necessary to develop methods and models for recognizing both old and new modifications of unauthorized actions, allowing to determine their type.

Signature analysis. Signatures allow you to identify already known viruses. A signature is a set of features that can be used to characterize an object. The signs allow you to briefly describe huge objects. Hash functions that characterize an object using short features also function on this principle. The signs of the file type, date, address and size are called “weak signatures" [5].

The signature is a unique sign of intrusion, which can be used to attribute the fragment contained in the UA. If the intrusion is not unique, then the signatures described will be of the same type and will represent a sequence of consecutive bytes and addresses in the file of this sequence. If the file size is known, this will be an additional trigger for the reliability of UA detection. The more information we have about the attack, the more accurately we can characterize it. Different signatures are used for different types of intrusions. The strongest signature includes an unchanged part of the virus (if it is polymorphic), which significantly increases the size of the signature.

Fragmentation is used to minimize the size and length of signatures. Fragmentation allows the use of discontinuous signatures having two parts:

1) general (characterizing the whole type of intrusion);

2) unique (manually modified).

There is also a method of “half-hearted” signatures, which allows you to use parts of different signatures when detecting polymorphic DNA. The method operates with bit fields and may not be used with all signatures (everything will depend on their type). The difficulty of recognizing polymorphic intrusions is that they are permanently stored in memory after decoding the body. The difficulty is to determine the decryption time, which is the timer for the start of the intrusion. Half–hearted signatures can detect even such intrusions by decrypting the executed and executed fragment [6].

The disadvantage of the method is the magnitude of the signatures; therefore control codes are used. They are formed from the virus code and are unique. There may be several intrusions with the same control codes (collisions), but this will not affect their detection.

Control codes can replace hash functions like SHA and MD5, despite the complexity of their application, they are very compact and fit into one word (32 or 64 bytes) and eliminate the possibility of collisions. When using hash functions, the following fields are available in the antivirus database: offset, length, and hash of the file. When working with a file, the antivirus checks the hash of the fragment in the database with the specified offset and compares it with the reference value. The value is equal – the fragment will be searched for. This method is not inferior in accuracy to signature methods and has high performance and minimal requirements for system resources [7].

The main advantage of signature methods is the accurate detection of the type of virus. This feature allows you to add both signatures and UA blocking methods to the database.

Disadvantages of the signature method:

– UA samples are needed;
– the need for an update;
– manual UA analysis in case of collisions;
– identifies only known UAS.

The main disadvantage of the method is its minimal autonomy and dependence on updates. This method is the best from the point of view of monetization – the user must always pay for the possibility of updating his system.

Heuristic analysis (EA). The main purpose of heuristic analysis is to track unknown and new modifications of unauthorized actions. EA accepts and examines program files, and based on the results of the work, a conclusion is made about the presence of intrusions. To obtain the correct result, the following steps must be performed [7]:

1. Semantic analysis. It allows you to recognize and turn executable commands into an operable form. After that, the data of the commands is analyzed to find sequences in the code of programs that implement dangerous actions;

2. Interpretation. This step helps to find polymorphic programs (when an action begins to perform an intrusion not immediately, but after a certain predetermined time or cycle). This step requires running the program. A command stream is used for detection, which can have negative consequences for user information, so executing this code on a computer is not desirable. To do this, the emulator simulates hardware and software functions that record the activity of the executable code;

3. Pragmatic analysis. It allows you to determine the purpose of the attack algorithm based on the content of the teams and their groups.

Semantic analysis. The program affects many factors (the value of registers, processor flags, memory areas). Most of these parameters will not be taken into account when detecting intrusions. When detecting, "discrete" virus models are used, and not every program action acquires the status of "events", which are program actions related to system calls that lead to changes in the system. Semantic analysis searches for and recognizes sequences of commands in the disassembler listing that implement "events" belonging to "discrete" models. Recognition occurs as follows: a set of any elements (bits, bytes, words, or their sequences) that can be represented as an “alphabet”, and these elements themselves are “letters of the alphabet”. By combining elements and making different sequences out of them, we get different "phrases". A lot of phrases are described and will be a “language”.

For reference types of intrusions, finite state machines are created to recognize a sequence of assembly commands that implement their behavior. The program is first disassembled, and then recognized by automata. Based on the number of recognized fragments and their functionality, the analyzer makes a verdict on the malware of the executable file.

Semantic analysis is divided into static and dynamic. Static consists in disassembling the executable file image from the drive and analyzing it by finite state machines. This method is ineffective due to the proliferation of packers and anti-hacking software protection systems. Such programs archive/encrypt the contents of executable files, after which the program code cannot be disassembled. The problem is solved by using libraries of decompression algorithms, through which the antivirus

can decompress packaged files. The effectiveness of the method depends on timely updating of the packer type and unpacking support [7].

The dynamic approach uses semantic analysis with a debugger/emulator. In this case, it is not the disassembler listing that is checked, but the code fragments during step-by-step execution or interpretation that have preprocessing. Commands are sent to the input of the machine sequentially, as they are interpreted by the emulator, which gives an advantage when analyzing packaged or self-modified objects, since it becomes possible to examine objects after the packers/encryptors restore the original bodies in memory and transfer control to them. This method works without using packer libraries but is resource-intensive.

Dynamic semantic analysis is widely used in almost most antiviruses. Its advantage is the low level of possible errors, and the disadvantage is low efficiency when working with non-standard codes, because the machine is most often configured to recognize a given sequence of certain characters. It is enough to find a sequence equivalent in functionality, which the machine is configured to recognize, and the method will lose its effectiveness [8]. For example, replacing some commands with equivalent blocks. You can use API functions instead of InternetOpenUrl, and libraries instead of InternetReadFile wsock32.dll, socket, send, recv, to perform similar functions. This will lead to the fact that the machine will not be able to switch to its final state and recognize everything. In order for the machine to continue to recognize the fragment, it is necessary to modify it, taking into account all possible variants of the equivalent code, and this is practically impossible.

Interpretation of malicious code by the emulator. The emulator creates an artificial environment to simulate the necessary functionality for research with a high level of protection of the user's system. Even if a malware or virus is running, it will not be able to damage the system or network from the emulator.

The need for emulation is that the program is not a static object, and it is not always possible to recognize it using static methods. Examples of such programs are polymorphic viruses and packers [6]. The static signature is programmed to appear after executing a certain number of commands.

Commands can be executed like debuggers – sequentially, making a stop after executing the command, setting the processor to step-by-step tracing mode. This is how code tracing is used in real-world conditions. The condition will be the need to monitor the work of the human operator debugger to control the process and stop it. The operator will also be able to determine any program accesses to the external environment.

Antiviruses, when monitoring the actions of running programs, also use debuggers that are fully controlled by their internal control system, the proactive protection module. This module can recognize and block standard types of unauthorized actions, working as a kind of filter. It should be noted that such an analysis will take place in real-time execution of programs, which will allow you to obtain up-to-date data on the availability of UA. The analyzer examines the interaction of the program with the system (checks the arguments of API function calls), giving the program access to real computer resources, which guarantees the correctness of the results. The disadvantage of this method is the possibility of UA penetration into the

system and malfunction.

For security reasons, programs are run in the emulator to proactively protect against UA. During emulation, the program is executed on an interpreter that reproduces the external environment: devices, memory, system calls. The logic of UA recognition remains like proactive methods. The disadvantages of emulation are:

1. The need to simulate computer hardware nodes and parts of the operating system. This is a complex process and requires a detailed study of the systems on which these methods and software products will work. There are many software tools on the market that emulate the main modules of the system when working with intrusions, but virus developers do not stand still and have learned to bypass even emulators. The simulation of work on the Internet is important for emulation. Here it is necessary to simulate the functions of downloading and receiving files and then storing them on disk.

2. Low performance. The emulator describes the processes of a running system, which requires the use of huge computing resources. The speed of the software model is much lower than that of its hardware counterpart, even taking into account its maximum possible optimization. Some developers create special emulation systems using physical processors, which allows them to conduct research with maximum power.

3. Limited depth of emulation. Most often, a limited set of commands is used during emulation. Only part of the program is emulated, and the emulator stops working either after executing each instruction, or by emulating the operation of blocks, and only after that it performs tests for the presence of UA. After the end of the program, its emulation becomes meaningless, since it switches to a cycle of waiting for new events. New input data or commands can serve as such actions. When switching to standby mode, the emulator should shut down and move on to the next program. There are two ways to determine the onset of such a cycle:

1. Setting the emulation steps. For example, after completing a set number of different steps or operations, complete the emulation. Complete the emulation by completing a certain number of steps or a certain number of different commands;

2. Setting the time for emulation. After the time allotted for execution, the program completes the emulation. This method will be able to bypass the limitation of the command counter. This method will not slow down the system, because empty cycles do not load the system even when repeated. The execution time of these operations is set experimentally.

Disadvantages of heuristic methods:

1. EA produces many erroneous detections during operation.

2. Complexity. Despite the difficulty of setting up correctly, the method can slow down the system.

Due to the specifics of heuristic methods, these disadvantages are difficult to compensate even with hardware. With further use, it is advisable to modify and refine them in order to fulfill the task assigned to them of detecting intrusions. To use EA methods effectively, it is necessary:

1. To increase the effectiveness of recognition of new modifications of UA.

2. Reduce the level of false positives.

3. Increase the speed of the method.

4. Minimize the degree of use of system resources.

5. The possibility of adaptability.

Modern EA based on behavioral analysis and emulators make it possible to effectively identify unauthorized actions of a known type and unknown to the system [5].

As a result of the analysis, shortcomings of existing methods, models and systems have been identified that do not allow effective implementation of intrusion detection and timely response procedures. The analysis of the problem of malware recognition has shown that there is a need to develop new approaches to detecting and analyzing intrusions, which should be based on an analysis of their behavior and act bypassing encryption. New approaches should effectively identify known and new aircraft modifications and minimally load the system. The system should also protect computer networks without the need to constantly update antivirus software.

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THE USE OF MULTI-FACTOR AUTHENTICATION TO ENHANCE THE SECURITY OF PROCESS CONTROL

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Abstract. The article discusses aspects of the application of multi-factor authentication in the field of transport process management to ensure a high level of train safety. The authors of the article draw attention to the importance of setting passwords on network devices, such as routers, in the railway infrastructure. Effective access control to these devices plays a key role in ensuring the security of information data transmission. Unauthorized access to routers can lead to serious attacks, including configuration changes, blocking of services and data leakage. The article explores the process of network configuration and configuring routing protocols to provide an additional level of security.

Keywords: railway transport, router, password configuration, network address, router interface, network device.

ПРИМЕНЕНИЕ МНОГОФАКТОРНОЙ АУТЕНТИФИКАЦИИ ДЛЯ ПОВЫШЕНИЯ БЕЗОПАСНОСТИ УПРАВЛЕНИЯ ТЕХНОЛОГИЧЕСКИМ ПРОЦЕССОМ

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Аннотация. В статье рассматриваются аспекты применения многофакторной аутентификации в сфере управления транспортным технологическим процессом для обеспечения высокого уровня безопасности движения поездов. Авторы статьи обращают внимание на важность настройки паролей на сетевых устройствах, таких как маршрутизаторы, в железнодорожной инфраструктуре. Эффективное управление доступом к этим устройствам играет ключевую роль в обеспечении безопасности передачи информационных данных. Несанкционированный доступ к маршрутизаторам может привести к серьезным атакам, включая изменение конфигурации, блокировку сервисов и утечку данных. В статье исследуется процесс конфигурации сети и настройка

протоколов маршрутизации для обеспечения дополнительного уровня безопасности.

Ключевые слова: железнодорожный транспорт, маршрутизатор, конфигурирование паролей, адрес сети, интерфейс маршрутизатора, сетевое устройство.

The development of production processes, research activities and technology leads to the evolution of complex structures in the economy and society. The growing volume of information requires effective solutions in the management of automated processes [1]. The level of informatization should correspond to the level of development of society, and the growth of this level is a key factor for achieving human progress. The importance of informatization increases with the increase in the amount of information needed for decision-making [2].

With the growth of infotelecommunication tools and digital data, railway systems are becoming more and more automated. Data transmission networks are becoming an integral part of the railway infrastructure, providing communication and data processing over long distances [3]. As the amount of data increases, it becomes necessary to ensure a reliable level of security, starting with setting passwords on the router.

A router is an important network device used to transport data packets in computer networks. Thanks to his work, it is possible to achieve connectivity of network segments and successful package delivery to the designated location [4]. The appearance of such a network device is shown in Figure 1.

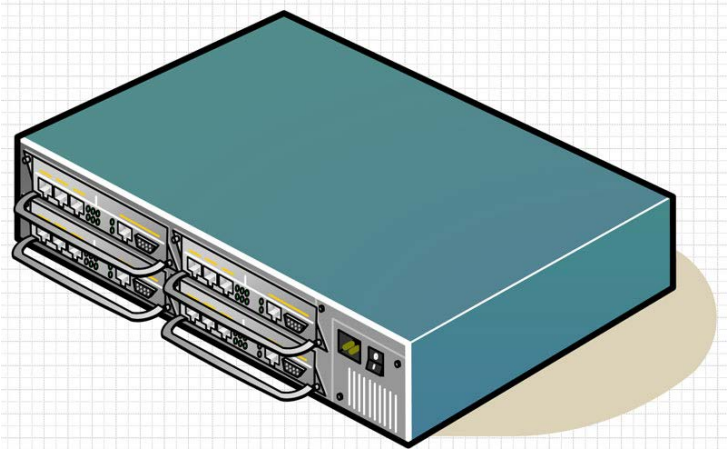

Figure 1. Image of the router design

The creation of passwords for routers in the information transmission network of a railway transport organization plays a key role in ensuring the security of transmitted data. Setting passwords on routers allows you to control access to the administrative interface of devices and to the data itself on the network [5,6]. Administrators must create passwords of varying complexity for different access levels to prevent unauthorized access to the network.

To illustrate the process of setting passwords on a virtual environment router, a network diagram was created that includes two routers, two switches and four

computers of a transport organization [7]. The configuration of the router's serial interfaces is an important step to ensure connectivity to remote devices.

The data used to configure the architecture of the packet information transmission network is shown in Table.

Table – Addresses of networks and router interfaces

IP address	Network 1	Network 2	Network 3	
Networks	192.168.20.24/29	172.16.20.96/27	200.5.5.0/30	
Gateway	192.168.20.25	172.16.20.97	200.5.5.1	
The first PC	192.168.20.26	172.16.20.98		
The last PC	192.168.20.30	172.16.20.126		
Broadcast	192.168.20.31	172.16.20.127		
Network Mask	255.255.255.248	255.255.255.224	255.255.255.252	
Interfaces	F0/0	F0/0	S1/1	S1/2

One of the important stages in the high-quality functioning of the data transmission network of a transport enterprise is the process of configuring the serial interfaces of the router [8]. Since it is this stage that allows you to connect to remote devices, which is considered especially useful for laying connections to remote transport points. The process of configuring the interfaces of the first router of the railway transport organization is shown in Figure 2, Figure 3.

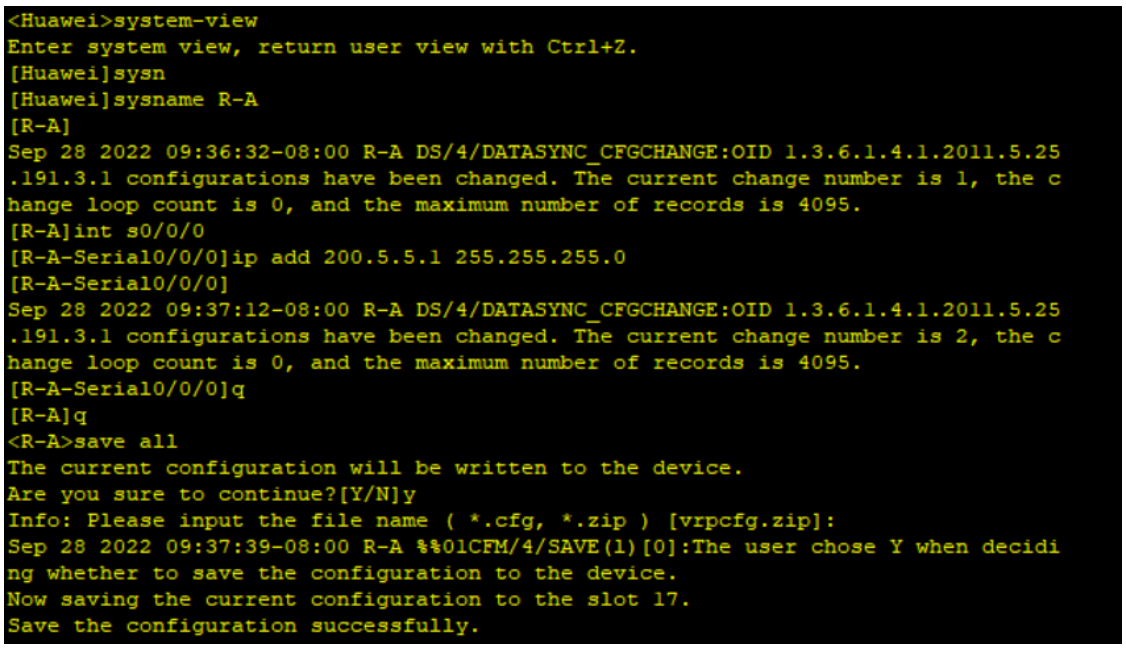

Figure 2. The process of configuring the serial interfaces of the first router of the transport organization

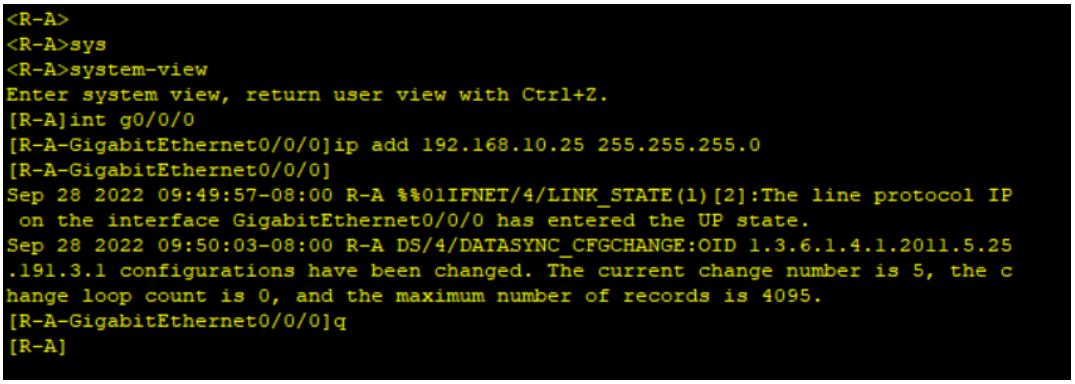

Figure 3. The next stage of configuration of serial interfaces of the first router of the transport organization

The use of the RIP protocol to optimize data routing in the computer network of a transport enterprise provides automatic detection of changes in the network topology and updating of the routing table. The main actions related to the organization of the RIP protocol on the first router of a small transport enterprise are shown in Figure 4.

```
<R-A>
<R-A>sys
<R-A>system-view
Enter system view, return user view with Ctrl+Z.
[R-A]rip
[R-A-rip-1]network 192.168.0.0
[R-A-rip-1]
Sep 28 2022 10:18:44-08:00 R-A DS/4/DATASYNC_CFGCHANGE:OID 1.3.6.1.4.1.2011.5.25
.191.3.1 configurations have been changed. The current change number is 6, the c
hange loop count is 0, and the maximum number of records is 4095.
[R-A-rip-1]network 200.5.0.0
[R-A-rip-1]
Sep 28 2022 10:19:04-08:00 R-A DS/4/DATASYNC_CFGCHANGE:OID 1.3.6.1.4.1.2011.5.25
.191.3.1 configurations have been changed. The current change number is 7, the c
hange loop count is 0, and the maximum number of records is 4095.
[R-A-rip-1]q
[R-A]q
<R-A>save all
The current configuration will be written to the device.
Are you sure to continue?[Y/N]y
Sep 28 2022 10:19:25-08:00 R-A %%01CFM/4/SAVE(l)[0]:The user chose Y when decidi
ng whether to save the configuration to the device.
Now saving the current configuration to the slot 17.
Save the configuration successfully.
<R-A>
```

Figure 4. Configuring the RIP Dynamic Routing Protocol

Analyzing the routing table helps you monitor traffic and network performance. The information reflected in the routing table is shown in Figure 5.

```
<R-A>
<R-A>
<R-A>d
<R-A>dis
<R-A>display ip r
<R-A>display ip rou
<R-A>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 7        Routes : 7

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
   192.168.10.0/24  Direct  0    0           D   192.168.10.25   GigabitEthernet
0/0/0
  192.168.10.25/32  Direct  0    0           D   127.0.0.1       GigabitEthernet
0/0/0
      200.5.5.0/24  Direct  0    0           D   200.5.5.1       Serial0/0/0
      200.5.5.1/32  Direct  0    0           D   127.0.0.1       Serial0/0/0
      200.5.5.2/32  Direct  0    0           D   200.5.5.2       Serial0/0/0

<R-A>
```

Figure 5. Routing table of the first router of the transport organization

An important procedure to ensure a high degree of reliability of the railway organization's data is to set a password for the console input of the router. Such an action helps to prevent unauthorized access to the packet information transmission network and eliminate the possibility of attacks on the system.

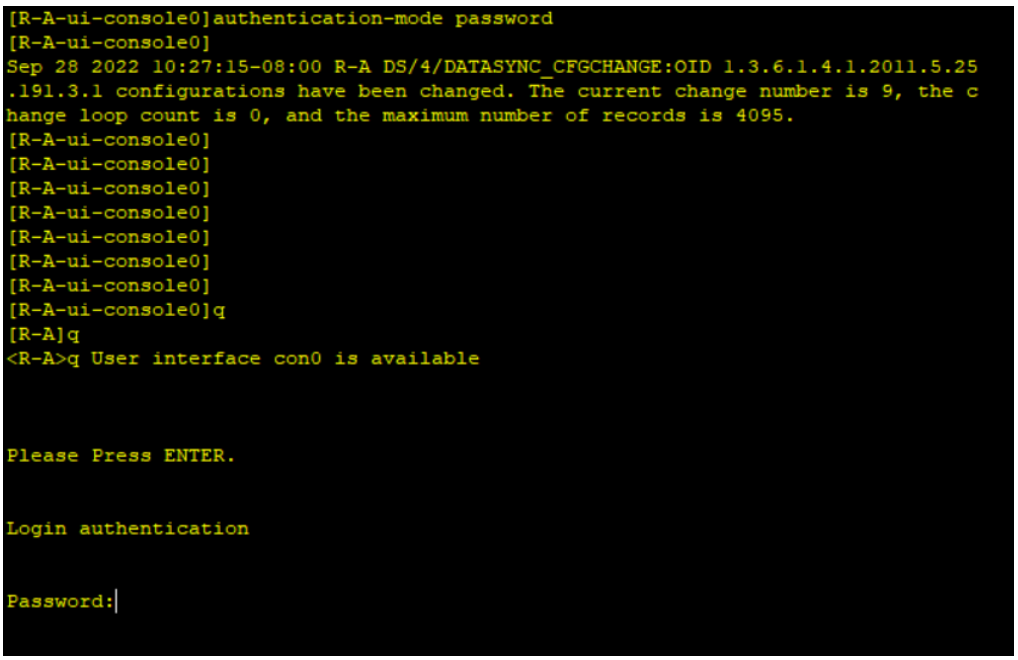

Figure 6. The process of providing an additional level of security to the console input of the router of the transport enterprise

Setting passwords on the router's console input and on virtual lines plays an important role in ensuring network security and preventing unauthorized access (Figure 7).

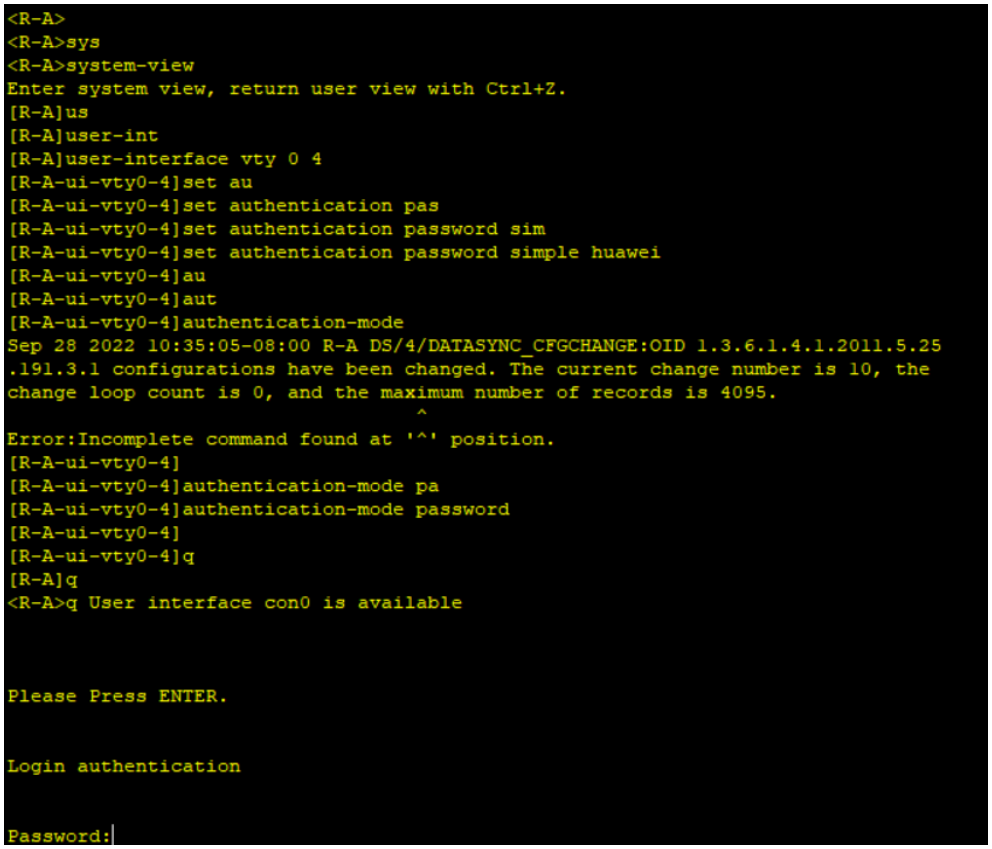

Figure 7. Protection against unauthorized access by setting a password on the virtual lines of the router of the transport company

The telnet command is used to provide remote access to the device (Figure 8).

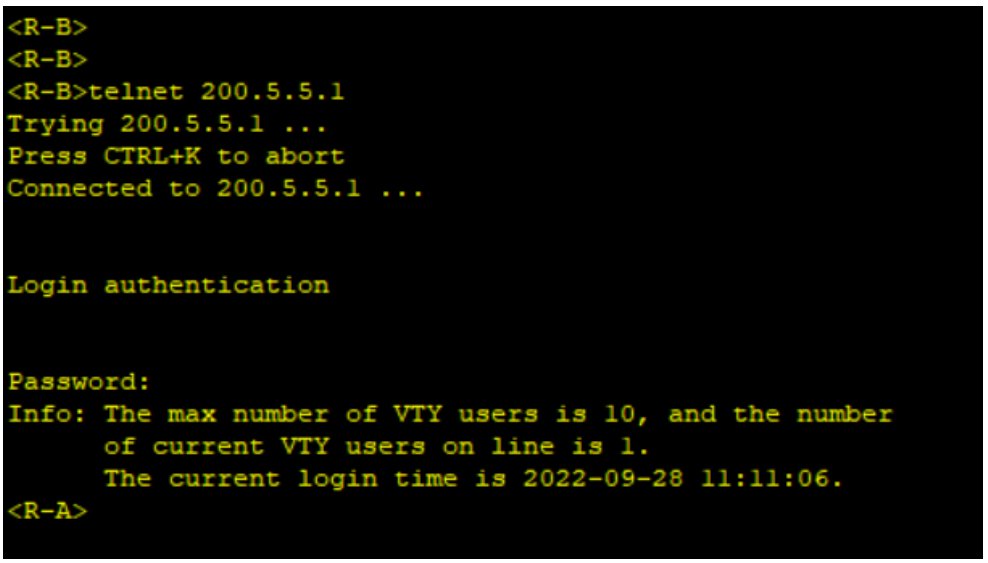

Figure 8. Providing remote access to the configured router of the transport organization

In the process of organizing the architecture of the packet switching network of the transport railway enterprise, additional security measures were implemented, such as setting a password for virtual lines, protecting the console input of the router and organizing remote access to the router settings to ensure the confidentiality of transmitted data.

This article highlights the importance of security and proper access management in the transport data network. With the increasing volume of data and automation in railway systems, safety is becoming increasingly critical. Proper password configuration and access control will help prevent potential threats and protect your data.

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УДК 662.769

NEURAL NETWORKS AS A WAY TO IMPROVE THE EFFICIENCY OF AN ORGANIZATION

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Abstract. The paper discusses ways to use various types of neural networks in the business activity in order to improve economic performance and optimize everyday routine non-labor-intensive tasks. The purpose of this study is to analyze the possibilities and prospects of a new technology for the world. The main part of the information for the work was obtained by observing and evaluating the experience of using artificial intelligence by foreign companies in various fields of activity. As a result of the analysis, the real prospect of using this technology in various business areas is determined, taking into account all the needs of the modern competitive world.

Keywords: neural networks, artificial intelligence, Internet, digitalization, advertising, marketing, logistics, technical customer support.

НЕЙРОСЕТИ КАК СПОСОБ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ ДЕЯТЕЛЬНОСТИ ОРГАНИЗАЦИИ

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Аннотация. В работе рассматриваются способы использования различных видов нейросетей в деятельности организации с целью повышения экономических показателей и оптимизации повседневных рутинных нетрудоемких задач. Целью данного исследования является анализ возможностей и перспектив новой для мира технологии. Основная часть информации для работы была получена путем наблюдения и оценки опыта использования искусственного интеллекта зарубежными компаниями в различных отраслях деятельности. В результате анализа определяется реальная перспектива использования данной технологии в разнообразных сферах бизнеса, учитывая все потребности современного конкурентного мира.

Ключевые слова: нейросети, искусственный интеллект, Интернет, цифровизация, реклама, маркетинг, логистика, техническая поддержка клиентов.

Artificial intelligence in the modern competitive world is capturing new and new heights. Over the past 2 years, the world's largest corporations have learned how much costs can be reduced thanks to the introduction of neural networks into the business processes, so the demand for them has increased hundreds of times. Today, artificial intelligence can perform a plenty number of tasks: from simple communication with a person to analyzing hundreds of terabytes of incoming data of different by content, functional application and importance. The impact of this technology on the modern world is difficult to overestimate, which is why it is important to assess the degree of integration of artificial intelligence into various business processes, its possible prospects and threats from excessive trust in widespread digitalization.

For example, Salesforce recently reported higher-than-expected revenue growth, driven by its new AI products. And AI image generator Midjourney is reportedly on track to book $200 million in revenue in 2023 – incredible for a startup that only launched its product last year [1].

Neural networks in advertising.

It is difficult to predict in which direction the development of this technology will go in the coming years, but despite this, it is now clear that improvement is in full swing. In addition, it is worth noting that not all, even the most progressive companies have started using neural networks. Of course, all IT giants, media holdings, e-shops and similar companies from the fastest growing sectors of the economy integrate artificial intelligence into their activities, but there are a number of industries where neural networks are not needed, or at least they have not yet found a place. An example is a number of luxury car manufacturers, mining and food industry companies, and similar industries. With regard to those organizations that use the new technology today, it is worth separating 2 formats for using artificial intelligence.

Firstly, neural networks can be used as "creators" of advertising content, it means that the material itself can be generated in whole or partially using artificial intelligence. At the moment, AI is already able to write texts, create graphic and video content for marketing purposes, generate a realistic human voice, and much more. Competent and advanced marketing specialist use all these opportunities to create ingenious, authentic and high-profile advertising campaigns. A high-quality example of using technology to create advertising is "The Economist" magazine, whose goal was to increase sales of paid subscriptions, for which a group of marketers did a great job with a new technology for them. Experts set up the neural network in such a way that it generated headlines, images and other elements in real time. If the conversion rate from a certain set of elements was low, then the elements changed. Thus, after a few weeks and a large number of attempts to modify the advertising banner, the ROI coefficient increased 10 times and the number of paid subscriptions increased by a significant number – more than 10 thousand people. [2]

Figure 1. The cover of The Economist magazine, which was created by neural networks

Secondly, in the field of marketing, neural networks can be used to analyze consumers and their behavior, identify market trends, segment the audience, predict demand and develop personalized marketing strategies. Neural networks can also be used to analyze data on products and advertising of other companies, evaluate the effectiveness of marketing campaigns, predict demand for goods and services, optimize pricing and many other tasks related to business and marketing. A memorable example of a deep and thoughtful strategy for using artificial intelligence for the purpose of advertising is the company "Ashmanov and Partners". This organization has developed a project that identifies people who wear glasses, so that in the future marketing departments competently allocate the budget and provide advertising of glasses only to those who need them. The work was carried out on a large scale. The neural network analyzed millions of photos of people on the "VKontakte" social network for the presence of glasses. After the initial sample, there were about a quarter of a million users who were passed through the neural network again to clarify the information. After several months of work, results were obtained on people with vision problems. Thanks to this analysis, everyone benefited: the marketing departments of companies began to spend their budgets more efficiently, and Internet users began to receive the most accurate and useful advertising that would meet their real needs and interests.

Neural networks in technical support.

Nowadays, many large companies use neural networks to improve customer service. The list of their capabilities is growing from year to year, but now the most popular reasons for implementing innovations in technical support are:

- instant response to customer questions and requests;
- the speed of finding correct and clear answers;

– the ability to predict the needs of the author of the application, thanks to the analysis of the call history;
– effective analysis of typical queries.

These and many other reasons make it possible to free technical support staff from routine and focus on more complex tasks that require human touch. [3]

Voice recognition is another breakthrough in the use of neural networks to improve customer service. By sending the recorded audio file to the model, the company receives a text transcription of the spoken speech. The accuracy of this process may not be ideal, but it is high enough to use the result obtained. Google uses neural networks to improve search results, offer personalized recommendations, and process queries through Google Assistant. Due to this, users receive structured information in different languages of the world, instead of a huge amount of diverse information [4].

Neural networks in logistics.

The use of neural networks in logistics is becoming more widespread, allowing companies to optimize processes, increase efficiency and reduce costs. Machine learning algorithms efficiently analyze data on traffic, distance, and delivery time to find the shortest routes and reduce shipping costs. This is especially important when the goods need to be delivered to the consumer as soon as possible.

An illustrative example of the use of neural networks in warehouse logistics is the automation of the processing and classification of goods in a warehouse. Computer vision systems based on neural networks can automatically scan and classify goods, find vacant places, and track their movement around the warehouse. This helps companies improve the efficiency and accuracy of warehouse operations [5].

A striking example of the use of neural networks in warehouse logistics is the practice of the French company L'Oréal, which has provided its warehouses with an unmanned inventory system that allows not only to significantly reduce costs, but also, in general, to provide simplified employee access to information about the condition of the warehouse and goods on it. A drone equipped with built-in camera flies past the shelves for each position and tier to take inventory. Thanks to video processing using artificial intelligence, the drone can read barcodes, recognize empty spaces, take into account the height of layers and determine where one cell ended and another began. With this, the company reduces the cost of additional human resources, increases the safety of employees, since there is no need to work at height, and also optimizes the inventory process, making it fast and error-free.

Figure 2. The process of operation of an unmanned inventory system in a warehouse

We can see the capabilities of neural networks literally everywhere, every advertisement and every product at some stage was created thanks to this technology. Nevertheless, it is worth mentioning the prospects, which, unfortunately, may not always be positive:

– the disappearance of a number of professions that can be automated;
– development of more complex and efficient learning algorithms that will allow neural networks to learn from even more complex and diverse data;
– errors – the risk of AI errors remains high;
– a biotechnical breakthrough. Neural networks are actively used in this area in order to treat incurable diseases;
– the potential risk of a "the rise of the machines";
– creation of more compact and energy-efficient neural network architectures that allow computing on mobile devices and embedded systems.

This technology is definitely the future. Absolutely everyone in the future will be connected to neural networks, as they will be integrated into every aspect of human life: from advertising, which we see hundreds of times a day, to food that has been perfectly grown using unique methods created by neural networks.

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УДК 676

THE USE OF INTELLIGENT TECHNOLOGIES TO ANALYZE PAPER WEB PERFORMANCE

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Abstract. The production of high quality paper products requires that the properties of the paper meet the standards required for its intended use. The most important factors influencing the finished product are the weight per m^2, the moisture content and the thickness of the paper web. In order to maintain all the required paper quality parameters within the set values, a sophisticated CD (Cross Direction) control system is used. The use of neural network technology makes it easier to build CD control systems.

Keywords: paper products, web performance, paper quality, automation, intelligent technologies, control system.

ИСПОЛЬЗОВАНИЕ ИНТЕЛЛЕКТУАЛЬНЫХ ТЕХНОЛОГИЙ ДЛЯ АНАЛИЗА ПОКАЗАТЕЛЕЙ БУМАЖНОГО ПОЛОТНА

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Аннотация. Производство высококачественной бумажной продукции требует, чтобы ее свойства соответствовали стандартам в зависимости от назначения. Наибольшее влияние на готовый продукт оказывают такие показатели, как масса 1 $м^2$, влажность и толщина бумажного полотна. Для поддержания всех необходимых параметров качества бумаги в установленных значениях существует сложная система CD control (Cross Direction Control – управление по ширине полотна). Применение нейросетевых технологий позволяет облегчить построение систем управления CD control.

Ключевые слова: бумажная продукция, показатели полотна, качество

бумаги, автоматизация, интеллектуальные технологии, система управления.

Controlling parameters across the width of a moving paper web (CD control) is a complex control task. It involves moving a large number of actuators to influence a profile containing a large number of dimensions. In a paper machine (PM), the number of adjustable elements in the actuators is typically between 50 and 200, and the number of measurements in the profile is typically between 300 and 1000 [1].

The CD control system also includes relationships between many measured properties that affect the quality of the paper web. Typically, the CD control system affects several properties such as basis weight, moisture content and caliper.

It is clear from the definition that CD control deals with the measurable parameters of the paper web in space rather than in time. The latter refers to the area of machine direction (MD) control. The definition also points to one of the limitations of CD control systems, namely an operator-defined setpoint. In many cases the aim of the control is to achieve the closest value to the mean, but in some cases (e.g. at the edges of the web) the most sophisticated type of control is required to achieve the desired quality of the finished product.

Web width control of thickness, weight, moisture or bale thickness profiles is usually achieved using the standard CD control system strategy. This strategy is suitable for controlling one of these profiles with a single actuator. An example of the network structure of a weight profile is shown in Figure 1 [2].

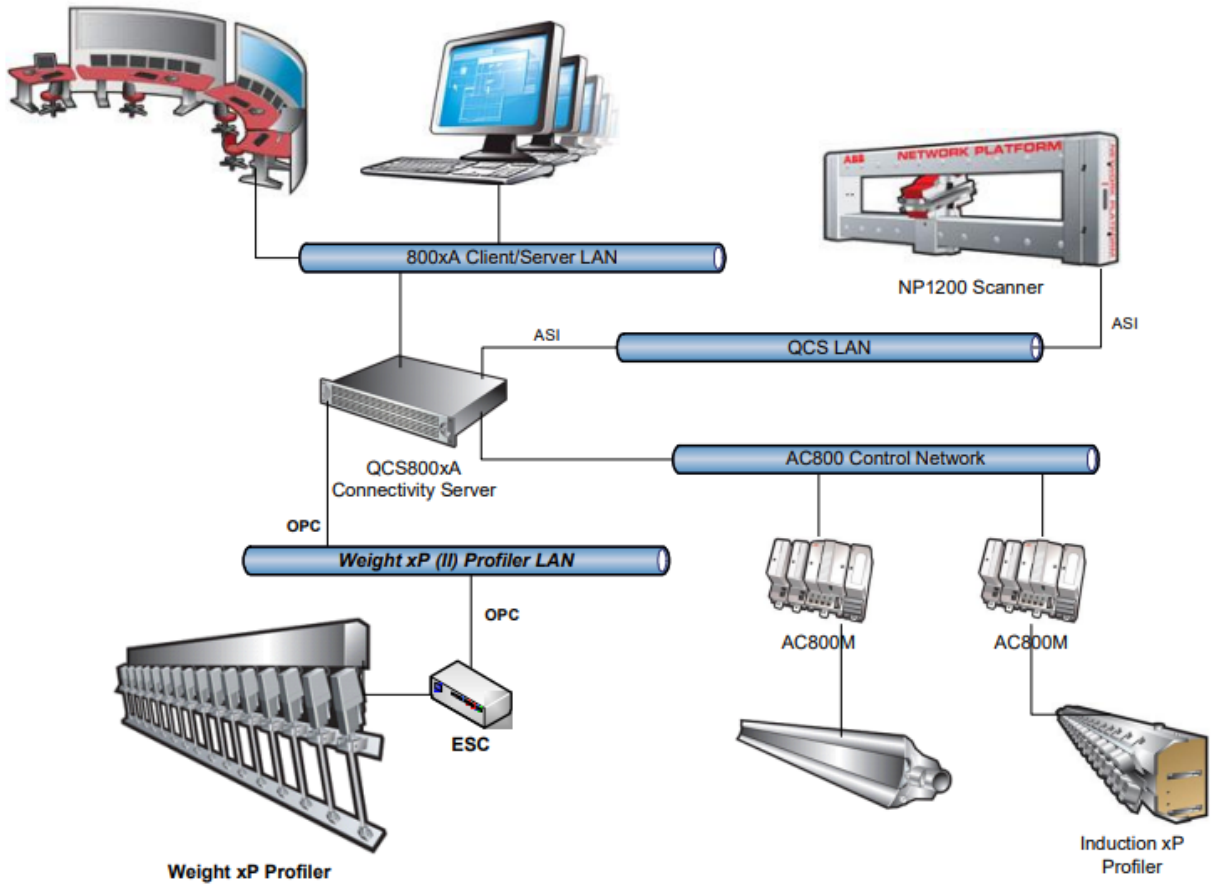

Figure 1. Network structure of the weight profile

The QCS (Quality Control System), based on a scanning device, is designed for operational monitoring and control of paper web parameters during the production process in longitudinal and transverse directions (weight per 1 m^2, moisture content, thickness).

The measured quality index profile can be adjusted by the web width control system. Systems such as CD control contain many actuators that locally influence the properties of the paper web during production.

The objective of a CD control application is to keep the measured profile as close as possible to the target value using the available actuators. It consists of a control algorithm and operator and engineer screens.

One of the main parts of the CD-control system is the scanner, which moves across the paper web. On the moving heads of the scanner there are sensors for measuring the main parameters: weight, moisture and thickness of the paper web. The measuring devices calculate the value of a particular parameter across the entire width of the paper. The controller boards process it and, through the network module, transmit it to the main controller [3].

The construction of control systems of objects with a large number of distributed parameters, in particular the control system of transverse profiles of paper web quality parameters, is reasonable using neural models and adaptive regulators, which will constantly correspond to the parameters of the control object.

The application of a neural controller in the control system of the main paper quality parameters implies the construction of an algorithm that provides the formation of sets of examples for training the neural model and the controller, the evaluation of the adequacy of the neural model to determine the retraining period of both the model and the controller, as well as a smooth transition from the outdated model and the controller to the newly trained ones. The dynamic process map eliminates the need to input corrections for web displacement and shrinkage, and allows the coordinates of the actuator positions to be accurately matched to the scanner measurement points on the roll. The transport delay of the process is calculated according to the speed of the machine, which makes it possible to precisely determine the correspondence between the movement time of the actuators and the measured responses of 1 m^2 mass, moisture content and thickness to generate training examples.

The control is performed by the trained neural controller module, taking into account the constraints on the control actions. The retraining time of the neural controller depends on how often the control error exceeds the limits. The neural model of the process is required to train the neural controller.

After each retraining of the neural model, the model should be checked for adequacy to the control object. The model is tested using a set of test examples that correspond in time to the examples from the training sample, but are not included in it. Figure 2 shows the functional diagram of the neural network control system [4].

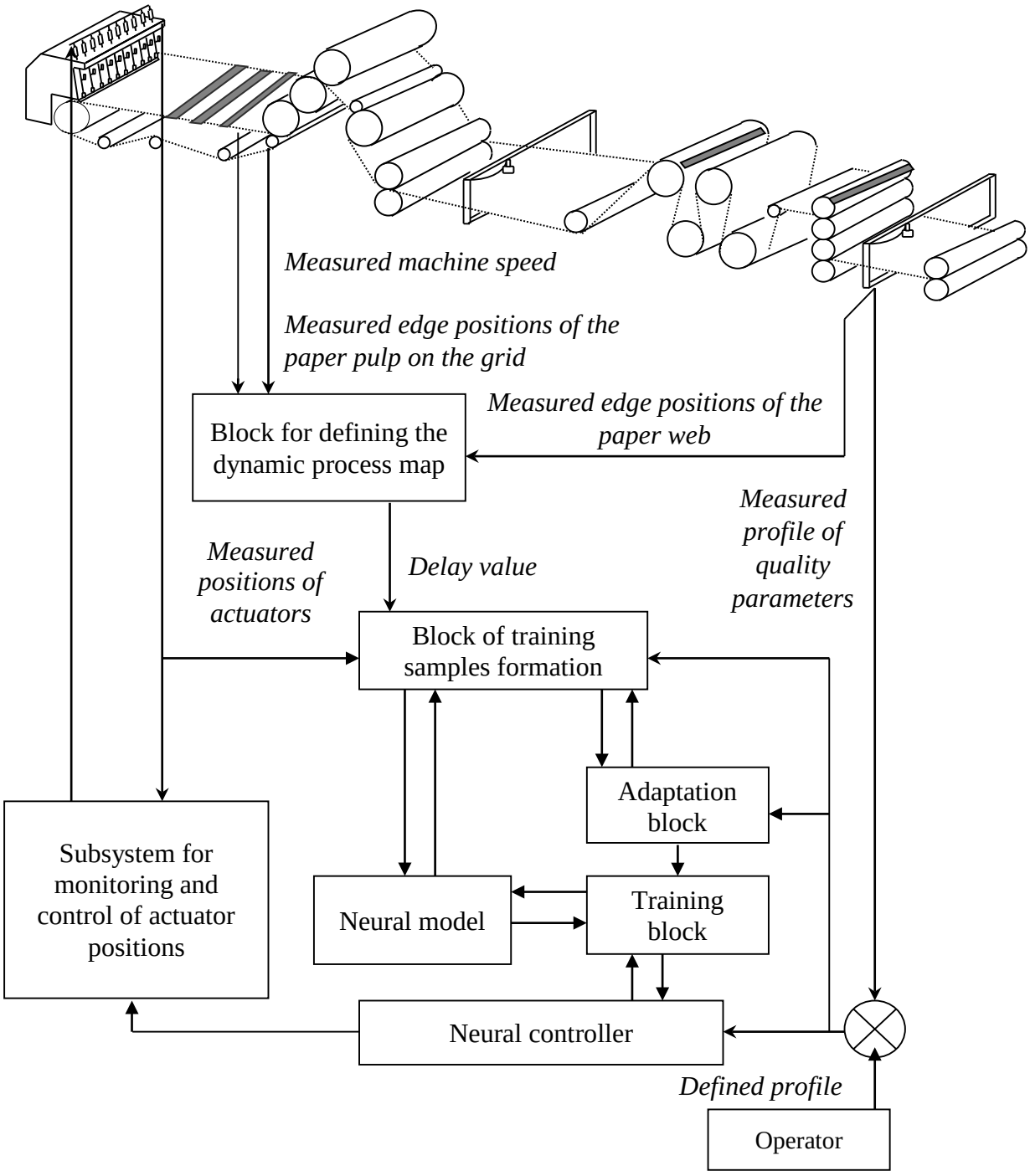

Figure 2. Scheme of neural network system for controlling paper quality parameters

Since neural networks have a limit to their trainability (there is a limit to the amount of information that the network can remember, generalise and reproduce), retraining an outdated neural controller module after some time will result in the neural network, saturated with information, no longer being able to adequately perceive newly arriving data about the process. This disadvantage can be overcome by training a new neural controller module each time. In this case, the training sample should be time-shifted, i.e. it should contain a certain amount of data from the previous sample.

This method is the simplest and most reliable, because if undesirable deviations in the operation of the neural regulator occur (related to random processes during training), they will disappear completely after replacing the regulator module. This

means that the new controller module does not inherit and therefore does not accumulate outdated information about the process, but is fully oriented to the information contained in the current training sample.

The adaptation algorithm starts to work when the average value of the control error exceeds a given value [5]. If the new neural controller module degrades the control quality, a return to the old module is performed. The next training of the neural controller is initialised after 20-50 % update of the training sample from the moment of unsuccessful training of the controller.

Thus, cross-profile control systems require a great deal of knowledge and many years of experience from the operator, which poses the task of creating an intelligent control system of interrelated indicators of paper web quality, which is part of the control system.

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MAINTAINING THE QUALITY OF AN ENERGY STORAGE NETWORK

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Abstract. This paper studies the question of possible methods of suppressing harmonic strain using energy storage systems. Consideration of existing methods of harmonic suppression. Consideration of relatively new solution of harmonic component compensation on the basis of active filters.

Keywords: energy storage systems, inverter, active filter.

ПОДДЕРЖАНИЕ КАЧЕСТВА СЕТИ С НАКОПИТЕЛЕМ ЭНЕРГИИ

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Аннотация. В данной статье изучается вопрос о возможных способах подавления гармонических стравляющих с использованием систем накопления энергии. Рассмотрены существующие методы подавления гармоник. Представлено относительно новое решение компенсации гармонической составляющей на базе активных фильтров.

Ключевые слова: системы накопления электроэнергии, инвертор, активный фильтр.

Modern industrial enterprises have high requirements for power quality, as power quality is one of the key parameters in industrial enterprises.

One of the frequently encountered aspects, in order to improve the quality of electricity, is the modernization and renewal of the electricity infrastructure. This includes replacement of obsolete equipment, improvement of the transmission and distribution system, and introduction of modern technologies and innovative solutions. Thereby increasing the load and distorting the network [1].

The appearance of harmonics in the electrical network is one of the problems faced by many electricity consumers.

The magnitude of each harmonic can be calculated using a formula and the sums decomposed in Fourier rad:

$$U = \sum_{n=1}^{\infty} U_n \cdot \sin(n\omega t + \varphi_n).$$

Figure 1 shows the effect of the 3rd harmonic on the fundamental harmonic [2].

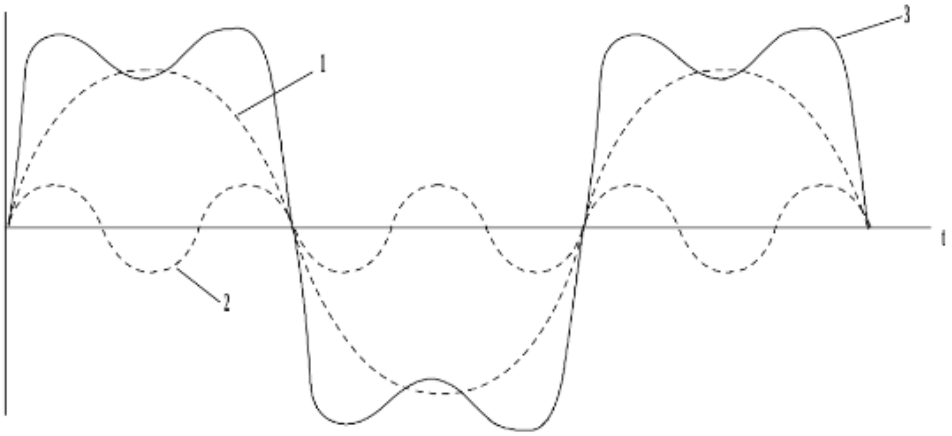

Figure 1. Effect of the 3rd harmonic on the fundamental harmonic

Under the number 1 is the main harmonic, 2 is the 3rd harmonic, and 3 is the component [3].

Harmonic compensation can be accomplished in various ways:

– linear chokes;
– passive filters;
– isolation transformers;
– magnetic synthesizers;
– active filters.

This paper considers harmonic suppression using energy storage systems with the algorithm of active filters.

The use of the system for suppression is possible in several variations (Fig. 2).

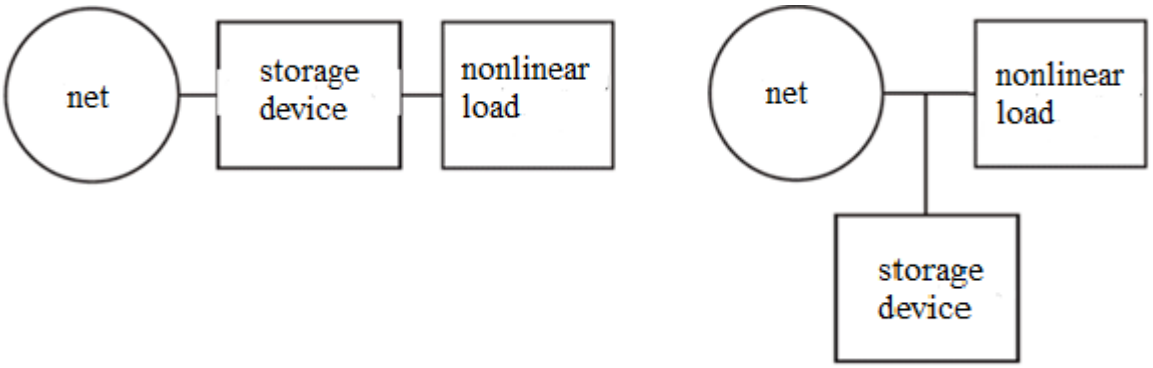

Figure 2. Series (left) and parallel (shunt) compensation (right)

Accumulation systems of series type can be applied for compensation of voltage losses, parallel active filter – for compensation of reactive power and higher harmonics, and hybrid filter – for compensation of asymmetry of three-phase voltage system [4].

The use of these accumulation systems, unlike passive filters, consists in working not with one frequency (harmonic), but "adjusts" to harmonics by their order (frequency), and has a completely different principle of operation – the accumulator "splashes" into the network currents of the same frequency and amplitude, but with an inverse curve of the sinusoid (in counter-phase).

As an example, a model with a parallel connected storage device is considered (Fig. 3).

The model under study consists of a DC source, a single-phase inverter on IGBT transistors, a choke to suppress noise at the inverter output, a nonlinear load and a network with a non-sinusoidal signal.

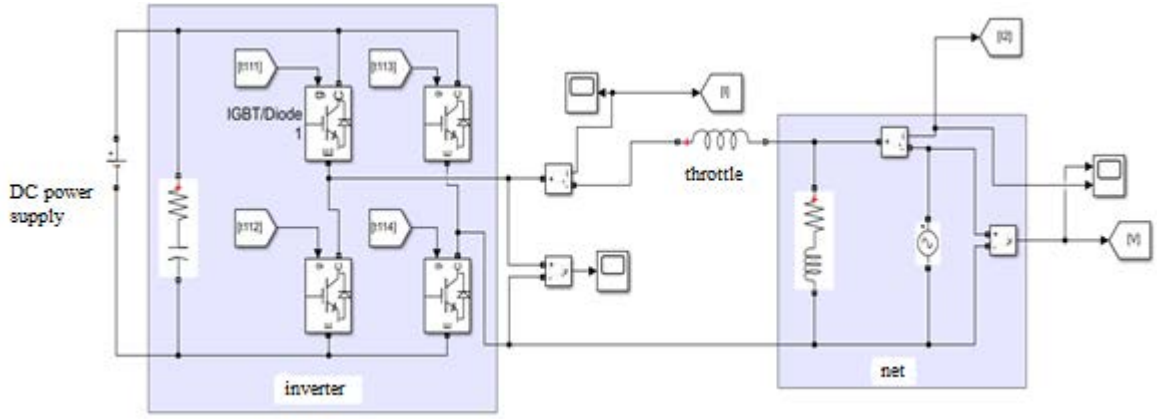

Figure 3. The scheme used

The principle of operation of the parallel type is to inject into the network the counter-phase current I_{inverter} with higher harmonics and the reactive component of the main harmonic of the nonlinear load current. The inverter keys are controlled by an automated control system (ACS), the operation of which is synchronized with the grid by means of a phase frequency autotuning (PLL) unit [5].

PLL works on the basis of phase difference between two signals. It detects this difference and provides a feedback mechanism to change the frequency of the voltage-controlled oscillator.

The PLL compares the voltage-controlled oscillator signal with the input / reference signal.

It generates an error signal that corresponds to the phase difference between the signals. This "feedback signal" is then fed back to the voltage-controlled oscillator to regulate its frequency (Fig. 4).

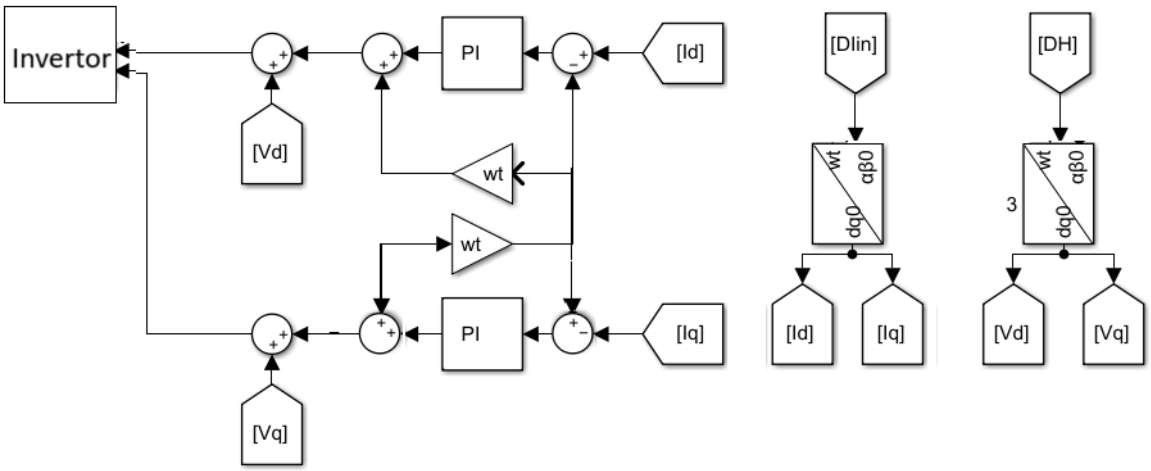

Figure 4. FHR algorithm

The results of FHR are presented in Fig. 6, Fig. 7.

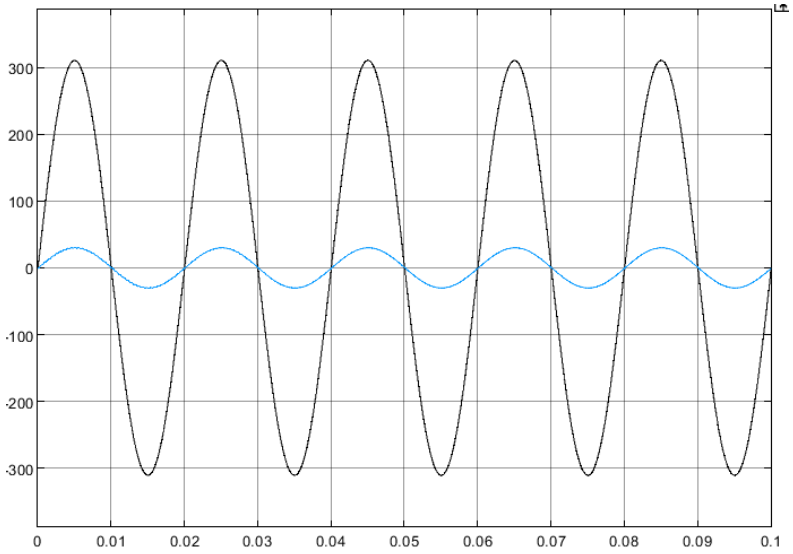

Figure 6. Current and conjugation at load

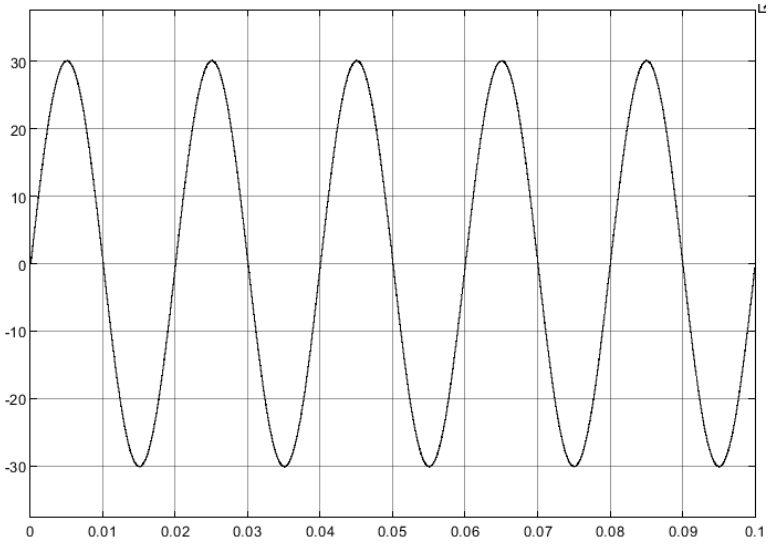

Figure 7. Inverter side currents

Next, the system must compensate for harmonic mains currents by setting an anti-phase amplitude.

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УДК 621.39

MODERN ORGANIZATION OF DIGITAL CHANNEL COMMUNICATION FOR RELAY PROTECTION AND EMERGENCY CONTROL

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Abstract. This paper considers important features of the use of digital type communication channels in the electric power sector. Actual aspects of digital channel communication application for exchange of relay protection and emergency control commands are investigated. The modern principle of organization of reliable and fast transmission of critical data between power industry facilities based on the protocols of the new international standard IEC 61850 is presented.

Keywords: electric power industry, substation, communication channels, RPA, digitalization, control and monitoring.

СОВРЕМЕННАЯ ОРГАНИЗАЦИЯ ЦИФРОВОЙ КАНАЛЬНОЙ СВЯЗИ ДЛЯ РЕЛЕЙНОЙ ЗАЩИТЫ И ПРОТИВОАВАРИЙНОЙ АВТОМАТИКИ

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Аннотация. В данной работе рассматриваются важные особенности использования каналов связи цифрового типа в электроэнергетическом секторе. Исследуются актуальные аспекты применения цифровой канальной связи для обмена команд релейной защиты и противоаварийной автоматики. Представлен современный принцип организации надежной и быстрой передачи критических данных между объектами электроэнергетики, который основан на протоколах нового международного стандарта МЭК 61850.

Ключевые слова: электроэнергетика, подстанция, каналы связи, РЗА, цифровизация, управление и контроль.

In modern industry, where information technologies play a key role in all spheres of activity of production enterprises, including power sector facilities, the development of digital communication channels is an urgent direction to improve the efficiency of the realization of the processes of generation, transmission, distribution and consumption of electric energy.

In the electric power industry, the proper functioning of power systems depends on many factors, including the competent organization of channel communications

designed for the transmission of critical information. Modern communication channels play a key role in ensuring the safety and reliability of power units located in the electric power sector, as well as electrical equipment in the field of relay protection (RP) and emergency automation (EA) [1].

The purpose of the work is to consider the actual aspects and features of the use of digital communication channels in the electric power sector of the economy, including their advantages and principles of organization.

Literature analysis has shown that relay protection in the electric power industry is a complex system consisting of a set of electric power devices, which is designed for automatic shutdown of damaged equipment in case of emergencies in the power system. Emergency automation is aimed at preventing the development of abnormal modes and ensuring the stability of the power system. Specialists note that for effective operation of RP and EA it is necessary to ensure reliable and fast transfer of technological data between power facilities, as well as between the designated devices and the dispatch center (DC) [1].

As mentioned, in today's world, digital technologies are actively penetrating all spheres of life, including the electric power industry. Studies show that in the last decade, digital communication channels have become an integral part of the relay and fault management infrastructure of the electric power industry, ensuring efficient transmission of event and alarm data. Digital links are data transmission systems based on the use of digital signals. They allow to transmit information in the form of a sequence of zeros and ones, which provides higher accuracy and reliability of its transportation compared to analog systems [2].

In the electric power industry, digital communication channels are used to transmit data on equipment status, network operation parameters, as well as to control and monitor the power system as a whole. Scientists emphasize that communication channels for RP and EA must meet the following requirements:

– reliable data transmission, including under conditions of interference and distortion;

– high-speed transmission of information for quick response to emergency situations;

– sufficient bandwidth to ensure transportation of large amounts of data;

– safety and security against unauthorized access and interference [3].

Today, one of the key standards governing the operation of RP and EA systems over channel communications is IEC 61850. The development of this international standard began in the 1990s with the aim of creating a universal protocol to streamline various solutions in the field of RP and EA. The standard describes important aspects of information transfer and key requirements for the operation of digital substations at different levels. This approach opens up the possibility of ensuring the compatibility of equipment from different manufacturers and simplifies the process of development and implementation of modern RP and EA devices [4].

The main advantages of IEC 61850 are:

– high-speed data exchange between microprocessor devices;

– reliability and stability of operation of protection and protection systems;

– belonging to the substation local computer system;

– guaranteed data delivery;
– compatibility of functions of equipment from different manufacturers;
– availability of file translation and oscillogram reading support;
– possibility of configuration and operation in automatic mode;
– support of high requirements to information security.

The IEC 61850 standard is widely used in power facilities under construction, where microprocessor-based RP and EA devices communicate via discrete signals. Implementation of the standard is governed by the MMS protocol, which enables data transmission via Ethernet using switches. In addition, IEC 61850 supports the possibility of data transmission via SV and GOOSE protocols [4].

According to the rules of this standard, two common approaches are used to exchange GOOSE messages between power facilities.

The first option for realizing GOOSE data transmission in digital substations (DSS) is called tunneling. It consists in organizing a so-called broadband communication channel between power plants, through which the relevant information is transmitted using routers.

The second option is a narrowband communication channel based on the Gateway/Proxy principle. In this case for GOOSE-data exchange it is supposed to use the devices of alarm and command transmission, which work as a gateway [5].

The researchers note that the transition to IEC 61850 substation automation (SA) requirements occurred in 2004. Until then, Hardwired SA and Legacy SA were universally used in the electricity sector (Figure 1) [6].

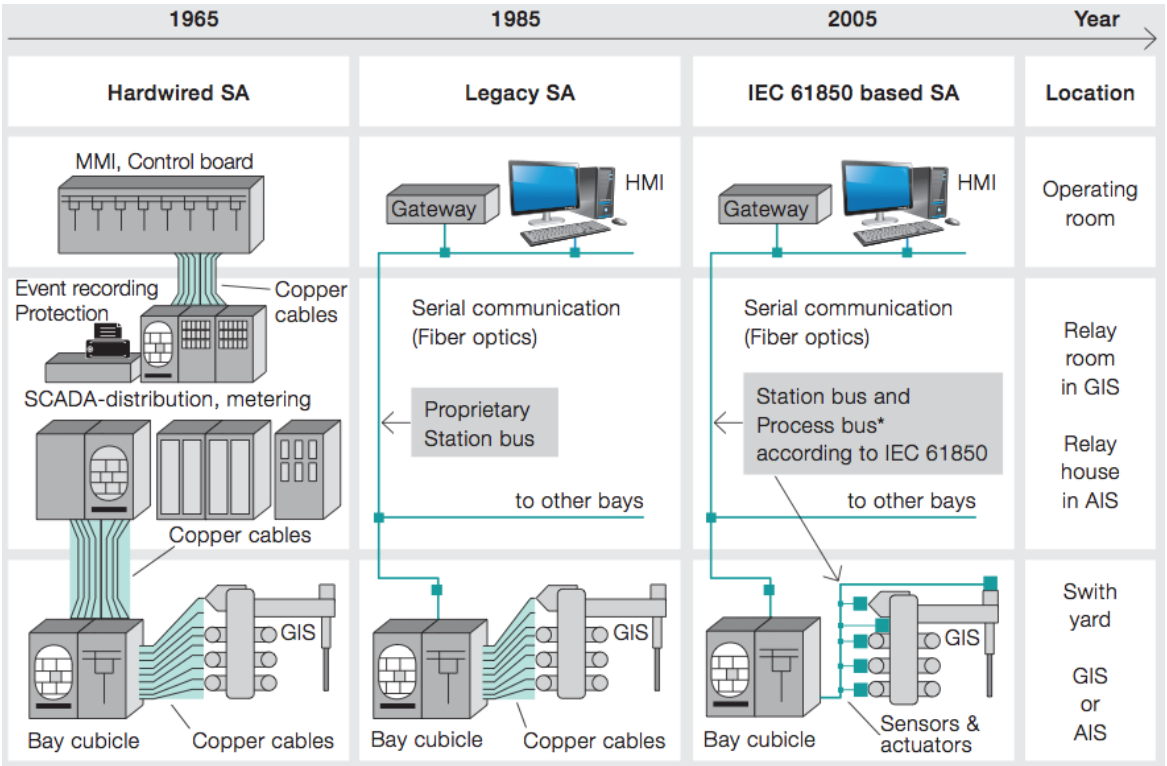

Figure 1. Traditional and modern SA architectures

Figure 2 shows the scheme of data transmission between electric power facilities using the IEC 61850 protocol [6].

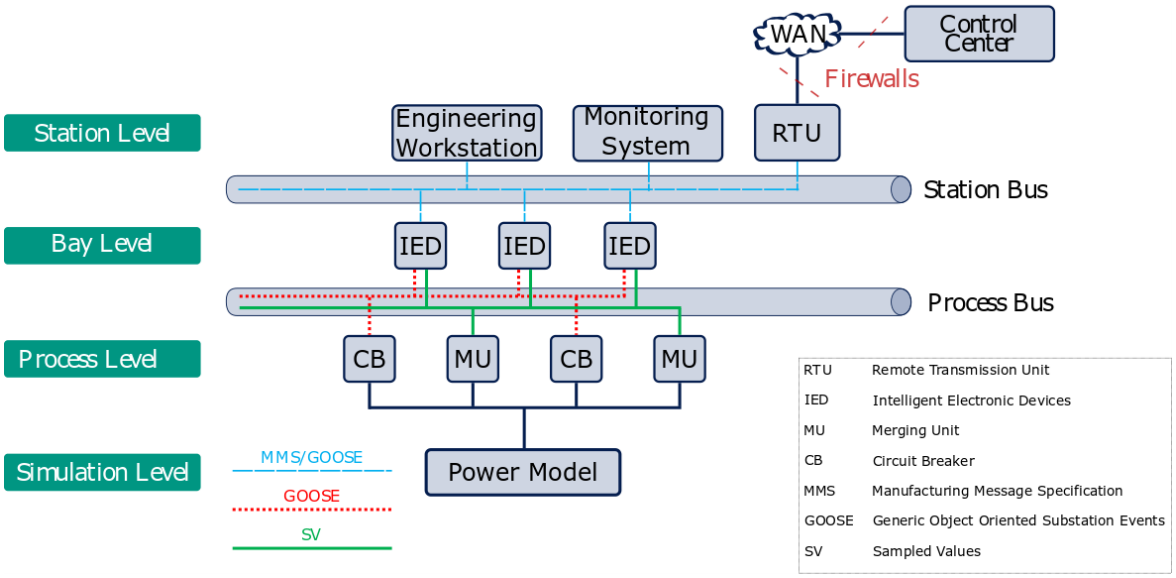

Figure 2. Information transfer in the electric power industry using the IEC 61850

Advantages of digital communication channels in general:

– provision of data transmission at high speeds, which makes it possible to promptly manage operation modes of electric power systems and monitor the state of interconnected electrical equipment;

– the delay of information transportation through digital communication channels is minimal, which is important for fast-acting emergency control systems and relay-type protections;

– digital approach of data transmission has high noise immunity [7].

It is worth noting that currently digital communication channels, in addition to transmission of RP and EA commands, are actively used in other areas of the electric power industry, including:

– SCADA-systems (Supervisory Control and Data Acquisition) for monitoring and control of operation modes of electric power facilities;

– telemechanics: digital communication channels are used to transmit telecontrol and tele-signaling signals between substations and DCs;

– in automated power control and metering systems for transmission of information on electricity and power consumption between meters and data collection centers [8].

As for the unique capabilities of digital data exchange, scientists note that modern communication channels can be integrated with many types of automated control systems, including automated process control systems. This approach already today makes it possible to create a unified control system for the electric power infrastructure. It is also important to mention the possibility of remote monitoring and control of equipment, which simplifies the maintenance and repair of operating power units with the availability of digital hardware and software solutions [9].

Thus, digital communication channels play a key role in modern electric power communication, providing high speed, reliability and security of critical data transmission. Literature analysis has shown that the use of modern technologies, protocols and devices for channel transmission of technological information is an

important and promising direction, contributing to the improvement of the efficiency of functioning of the facilities of existing and designed power systems. Active implementation and competent organization of digital communication for RP and EA will contribute to further development of the electric power industry and improve the quality of life of the population.

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USING A ROBOT MANIPULATOR FOR PROCESSING AND PACKAGING MEAT PRODUCTS

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Abstract. This article examines the use of robotic manipulators in the processing and packaging of meat products in the food industry. The key benefits of using robotic systems are discussed, such as increased productivity, product safety and compliance with sanitation standards. The challenges faced by enterprises in the implementation of robotic technologies and the prospects for the development of this area are also considered. In conclusion, the importance of robotization of production processes for improving the efficiency and competitiveness of the food industry is emphasized.

Keywords: robotic manipulator, food industry, production automation, cutting of meat products, robotization of slaughter.

ИСПОЛЬЗОВАНИЕ РОБОТА-МАНИПУЛЯТОРА ДЛЯ ОБРАБОТКИ И УПАКОВКИ МЯСОПРОДУКТОВ

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Аннотация. В данной статье рассматривается применение роботов-манипуляторов в процессах обработки и упаковки мясопродуктов в пищевой промышленности. Обсуждаются ключевые преимущества использования роботизированных систем, такие как повышение производительности, обеспечение безопасности продукции и соблюдение стандартов санитарии. Также рассматриваются вызовы, с которыми сталкиваются предприятия при внедрении роботизированных технологий, и перспективы развития данной области. В заключении подчеркивается значимость роботизации производственных процессов для повышения эффективности и конкурентоспособности пищевой промышленности.

Ключевые слова: робот-манипулятор, пищевая промышленность, автоматизация производства, разделка мясной продукции, роботизация убоя.

In today's world, the food industry faces a constant demand for innovative solutions that can improve production efficiency and ensure high product quality. In this context, the use of robotic manipulators for processing and packaging of meat

products is coming to the fore as one of the most promising areas of development. Robotic systems are demonstrating their effectiveness in automating production processes while ensuring high precision, safety and consistency in product quality.

The first industrial robot used in the food industry was introduced in 1950 at TetraPak (Sweden) to move baskets with pyramid bags. In 1970 the development of the first robotized areas for group packing of products began, and in 1986 the first robotized complex was used in the food industry in Russia. In 1989, Otto Hansell applied a vision system to its robotic machine for packaging chocolates, which made it possible to stack pre-oriented confectionery products. In 2007, the Smart Packer robot was developed to pack chicken eggs into special containers, which were then grouped into 15 pieces and placed in cartons. The robot filled the boxes with special foam to protect the contents during transportation.

In the food industry, about half of all robots are used to perform product packaging and palletizing operations. These robots are involved in loading and unloading bags, boxes and pallets. Modern robotics significantly improves the efficiency of order picking and product packaging processes.

Significant progress in primary livestock processing has been achieved with the advent of machines that can effectively cope with technological complexities. These include robots equipped with vision systems and touch sensors. The first significant step in this direction was made in the 1980s and 1990s in Australia, where a robotic line called “Fuce-Tech” was developed for slaughtering and processing cattle. On this line, robots automatically carried out the process of electric stunning of the animal, subsequent stabbing, skinning with a robotic unit, separation of the head, opening of the abdomen and chest, gutting and cutting the carcass into half carcasses [1]. The final stage was the automated evaluation of meat yield and quality, as well as the subsequent branding of the half carcass. In the process of work manually carried out only piercing of the sinker and whittling. The productivity of the line reached up to 350 heads per hour with the weight of the animals coming for slaughter from 400 to 700 kilograms.

There are several examples of robotized production in the meat industry in Russia [2]. For example, CJSC “Pork complex “Korocha” of APH “Miratorg” (Belgorod region) stands out for its unique level of robotization and depth of processing, which allows almost fully automated processing of pork carcasses and production of a wide range of products with minimal human participation. Modern European equipment is used at the slaughtering and cutting sections. First, automatic receiving and sorting of raw materials by category is carried out. Then robots scan the carcass and determine the place of cutting based on computer calculation, which eliminates the influence of human factor and reduces the time of the technological process. The robots work synchronously with the conveyor, cutting the carcass, after which the cutting parts are washed and disinfected. Packaging lines are also automated, which eliminates the work of personnel at low temperatures. Automation of production ensures constant control of product quality and compliance with sanitary norms. After cutting, bones, internal organs and blood are sent for further processing, which produces by-products and raw materials for sausage casings and other products. The waste is used to produce technical semi-finished products and meat and bone meal.

One of the key advantages of using robotic manipulators in the production of

meat products is the increase in productivity [3]. Robots are able to work at a constant rhythm without fatigue and observe a high speed of operations, which allows to reduce the production cycle time and increase the volume of output. Due to the use of robotic systems, it is possible to reduce the number of defects by eliminating the human factor from the production process.

The robot manipulator in the context of meat processing and cutting has the ability to carry out a number of key processes:

1. Cutting and slicing: The robotic system can perform precise and standardized cutting of meat into pieces or portions of a given size with a high degree of precision and repeatability.

2. Bone separation: The robot can programmatically perform precise separation of meat mass from bone structures, which includes cutting chicken fillets or removing bones from pork and beef.

3. Skin and fat removal: The robot can automatically remove skin and excess fat from the surface of meat products, ensuring a high standard of hygiene and finished product quality.

4. Sorting and classification: The robot can sort and classify meat products according to various parameters such as size, weight or quality, which helps to optimize production processes.

5. Packaging: after processing the meat, the robot can automatically package it according to the set parameters, which includes containers, packaging materials or film, ensuring a high level of efficiency and hygiene.

6. Labeling: the robot can carry out marking or labeling of the packaged products to ensure their identification and traceability in the further production cycle.

Another important aspect is to ensure the safety and sanitation of production processes. Employees involved in slaughtering and primary livestock processing operations are subjected to both physical and significant psychological stress [4]. These operations are associated with a high risk of injury and possible occurrence of occupational diseases caused by high humidity, temperature conditions and the danger of infection with animal diseases. Therefore, the development of automated primary processing technologies becomes an extremely important task for the meat processing industry. This will reduce the risk of microbial contamination of meat at the stage of slaughter and primary carcass processing, as well as improve the economic performance of production. Robots can be equipped with special tools and sensors to avoid product contamination and ensure product safety. In addition, automation of the packaging process can reduce product contact and minimize the risk of contamination by bacteria or other microorganisms.

Various technologies are used to ensure the efficient operation of such robots.

1. Machine vision systems: These systems allow robots to analyze the environment, determine the shape, size and color of meat products, and detect defects and contaminants on their surface [5].

2. Sensor technologies: Robots are equipped with force and resistance sensors that allow them to control the pressure and force applied to meat products during processing, minimizing the risk of product damage.

3. Flexible manipulators: These robots have the ability to adapt to different

shapes and sizes of meat products, making them ideal for cutting and packaging operations.

4. Control systems: The robots are equipped with software systems that ensure accurate and fast execution of tasks, and integrate with other production systems to automate the production process.

5. Collaboration robots: These robots are equipped with additional safety features such as proximity and stop sensors, allowing them to safely interact with humans and perform tasks in the presence of personnel.

The widespread availability of X-ray and volumetric scanning techniques have played a significant role in the development of data processing systems in the meat industry [6]. These techniques have the ability to produce images with sufficient completeness that can be easily processed. Based on this data, the robot trajectory is determined for each object to be processed individually.

In addition to the mentioned methods for recognizing the objects to be processed, ultrasonic scanning, magnetic resonance and infrared thermography, and various optical methods are also used in meat processing plants.

However, the introduction of robotic systems into meat production also faces certain challenges. One of them is the need to adapt robots to the specifics of each particular type of meat and production process [1]. In addition, high requirements for hygiene and sterility impose additional conditions on the design and materials used in the production of robot manipulators. The design should be without hidden corners and protrusions to prevent the accumulation of dust and dirt. Materials should be non-absorbent and corrosion resistant to avoid reacting with food or detergents. It is important that robots are easy to clean and sanitize, meeting food safety and hygiene standards.

Despite these challenges, the outlook for the use of robotics in the processing and packaging of meat products in the food industry remains very promising. With the continuous development of technology and engineering solutions, companies can save resources, increase productivity and ensure the high quality of their products. Thus, robotic systems are becoming an integral part of the innovation progress in the food industry, contributing to its development and modernization.

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УДК 504.054

ON THE ISSUE OF IMPROVING THE ENVIRONMENTAL SAFETY OF THERMAL POWER PLANT OPERATION

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Abstract. This work is devoted to the analysis of the occurrence of environmental pollution during the operation of a thermal power plant (TPP). The article also discusses measures to minimize the negative impact of thermal power plants on the environment. The main focus is on modern technologies for cleaning emissions, improving fuel efficiency and switching to alternative energy sources. The importance of land reclamation and enhanced environmental monitoring is also emphasized.

Keywords: thermal power plants, ecology, pollution, emission reduction.

К ВОПРОСУ О ПОВЫШЕНИИ ЭКОЛОГИЧЕСКОЙ БЕЗОПАСНОСТИ ЭКСПЛУАТАЦИИ ТЭС

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Аннотация. В статье проведен анализ причин возникновения загрязнения окружающей среды в процессе эксплуатации тепловой электростанции (ТЭС). Рассматриваются меры по минимизации негативного воздействия тепловых электростанций на окружающую среду. Основное внимание уделяется современным технологиям очистки выбросов, повышению экономичности эксплуатации оборудования. Также подчеркивается важность мелиорации земель и усиленного мониторинга окружающей среды.

Ключевые слова: ТЭС, экологическая безопасность, загрязнение окружающей среды, сокращение выбросов.

A thermal power plant (TPP) is a power plant based on a heat engine that converts thermal energy obtained by burning fuel (coal, fuel oil, natural gas or biomass) into electrical energy. However, their operation is associated with a number of environmentally adverse effects on the environment (Figure 1).

Fuel combustion at thermal power plants is associated with the formation of combustion products containing fly ash, particles of unburned pulverized fuel, sulfur dioxide and sulfur anhydride, nitrogen oxides and gaseous products of incomplete combustion, and during the combustion of fuel oil, in addition, vanadium compounds, sodium salts, coke and soot particles. The ash of some fuels contains arsenic, free silicon dioxide, free calcium oxide, etc.

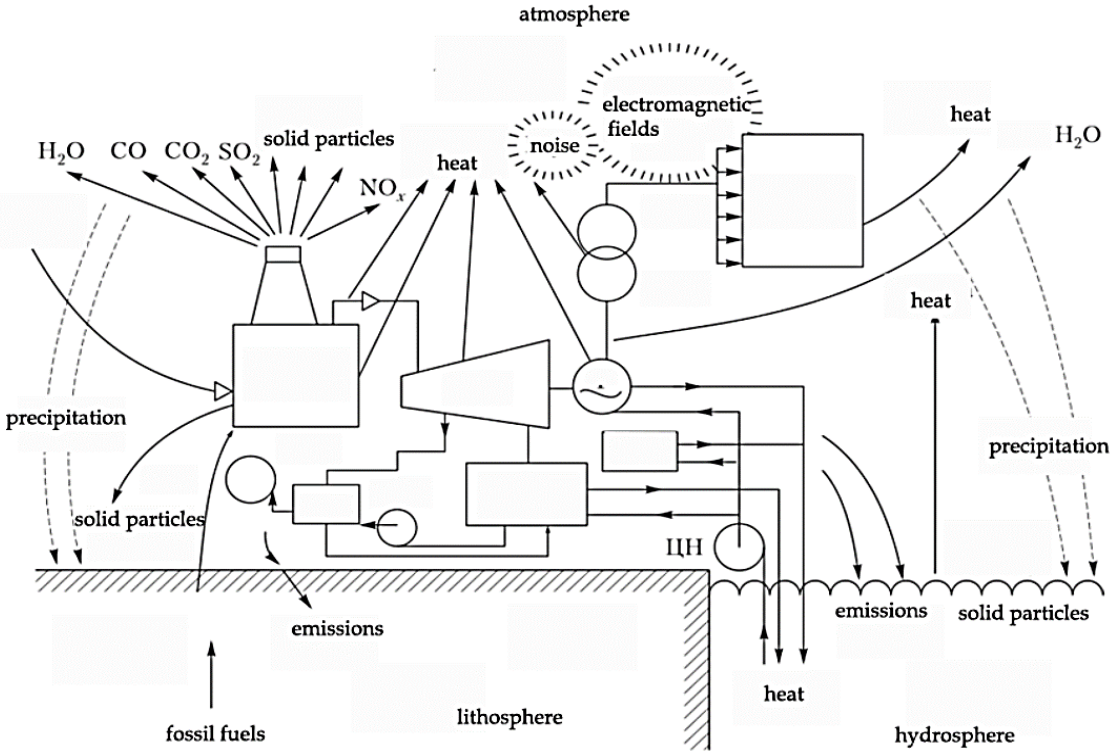

Figure 1. The impact of thermal power plants on the environment

Sources of atmospheric pollution are industrial effluents and emissions of combustion products. The main chemical element of solid organic fuels that is involved in the combustion process is carbon or hydrocarbons. Therefore, as a result of burning fossil fuels, such as coal, carbon dioxide is formed, which is emitted from thermal power plants and contributes to the "greenhouse effect"

Wastewater from thermal power plants includes the following water: containing petroleum products, after washing the heating surfaces of steam boilers, discharged after chemical treatment plants, conservation and flushing of equipment, as well as hydrosol removal systems.

It is also necessary to mention the noise pollution caused by the operation of thermal power plant equipment, which can have a negative impact on the lives of people and animals in the vicinity. Electromagnetic fields from high-voltage power lines can affect human health, although the exact consequences of such exposure have not been fully studied [1].

Taking into account all these factors, the operation of thermal power plants requires taking measures to reduce their negative impact on the environment. This includes upgrading emissions cleaning equipment, using cleaner fuels, introducing carbon dioxide capture and storage technologies, improving waste management systems, and improving the overall energy efficiency of plants. In addition, attention

should be paid to the restoration of lands affected by waste disposal and environmental monitoring in areas adjacent to thermal power plants [2].

To reduce carbon dioxide emissions, an effective method is the use of synthesis gas, in which a mixture of steam and gas undergoes chemical reactions, after which hydrogen H2 and carbon monoxide CO are formed. In this case, the synthesis gas used can be used in a gas turbine as a means of generating electricity. Thus, it is possible to reduce CO2 emissions in a significant amount, which is about 20-30 % [3].

Increasing the efficiency of the fuel combustion process is achieved through the use of highly efficient turbines and boilers that can burn fuel more fully, thereby reducing the amount of incomplete combustion and emissions into the atmosphere. In addition, the use of preheating technology for the air used for combustion can significantly improve combustion and reduce the emission of harmful substances.

Cleaning up emissions. Modern thermal power plants are equipped with gas purification systems such as electrofilters, scrubbers and catalytic converters, which capture and neutralize solid particles, sulfur oxides, nitrogen oxides and other harmful substances before they enter the atmosphere. It includes several technologies and methods aimed at reducing the amount of harmful substances released into the atmosphere during fuel combustion. The main methods of cleaning emissions include: desulfurization of gases (removal of sulfur), denitrification (removal of nitrogen oxides), filtration of solid particles.

Wet desulfurization. A lime or limestone solution is used to absorb sulfur dioxide (SO2) from flue gases. As a result of the reaction, calcium sulfate is formed, which can be used in construction or in landfills.

Dry and semi-dry desulfurization. These processes use sorbents such as lime or special catalysts to absorb SO2 without using water.

Selective catalytic reduction (SCR). This is the most effective method in which ammonia or urea is introduced into the flue gases before passing through a catalyst that promotes the reaction of ammonia with nitrogen oxides (NO), converting them into nitrogen and water.

Selective non-catalytic reduction (SNCR). In this process, ammonia or urea is injected directly into the combustion chamber at certain temperatures, where they react with NO, reducing their concentration.

The use of electrofilters to capture ash and other solid particles. Charged particles are attracted to oppositely charged electrodes and settle on them. Hot gases are passed through cloth bags (filter sleeves), which trap solid particles.

Reducing the use of fossil fuels by switching to alternative energy sources such as biomass, geothermal energy, solar and wind energy. This method not only reduces carbon dioxide emissions, but also reduces dependence on oil and coal.

Waste disposal. Ash and slag formed as a result of coal combustion can be used in the construction industry as fillers or for the manufacture of building materials. This makes it possible to reduce the volume of waste storage and the associated environmental risks.

Improvement of the water use system at thermal power plants. The introduction of closed water circulation systems makes it possible to reduce water consumption and pollution of reservoirs. Such systems involve the repeated use of water in the

technological process, thereby reducing the volume of fresh water intake and wastewater discharge [4].

The use of heat pumps and combined heat and power generation (cogeneration) systems, which makes it possible to use the heat generated in the process of generating electricity for heating and hot water supply, which significantly increases the overall efficiency of the energy system.

Creation of emission tracking and monitoring systems that ensure constant monitoring of the composition and amount of harmful substances released into the atmosphere. It allows you to quickly respond to excess standards and implement corrective measures. The development and implementation of regulations and standards that set maximum permissible concentrations of harmful substances in emissions also play a key role [5].

All these methods, applied in a complex, contribute to a significant reduction in the negative impact of thermal power plants on the environment, improve the environmental situation and contribute to the sustainable development of the energy industry.

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УДК 658.562

APPLYING THE KAIZEN METHOD TO IMPROVE THE EFFECTIVENESS OF QUALITY MANAGEMENT: A JAPANESE APPROACH TO CONTINUOUS IMPROVEMENT

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Abstract. This article addresses the issues of using the Kaizen methodology to improve the effectiveness of the quality management system. The philosophy of continuous improvement adopted in Japan is based on the continuous improvement of processes and the active participation of employees at all levels of the hierarchy. The advantages of using the Kaizen method to improve the quality of goods or services and optimize business processes are considered.

Keywords: quality management, Kaizen method, Nestlé S.A., consumers, managers.

ПРИМЕНЕНИЕ МЕТОДА КАЙДЗЕН ДЛЯ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ УПРАВЛЕНИЯ КАЧЕСТВОМ: ЯПОНСКИЙ ПОДХОД К НЕПРЕРЫВНОМУ СОВЕРШЕНСТВОВАНИЮ

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Аннотация. В статье затрагиваются вопросы использования методики Кайдзен для улучшения эффективности системы управления качеством. Философия непрерывного совершенствования, принятая в Японии, основывается на постоянном улучшении процессов и активном участии сотрудников на всех уровнях иерархии. Рассматриваются преимущества использования метода Кайдзен для улучшения качества товаров или услуг и оптимизации бизнес-процессов.

Ключевые слова: управление качеством, метод Кайдзен, Nestlé S. A., потребители, руководители.

The main thing that quality management in Japan is based on is the perfect technology in the field of production, management or service. Many Japanese companies are actively implementing computing and microprocessor technology, new materials, automated design systems, statistical methods are widely used, and computerization of production is used. A feature of the creation of a quality

management system in recent years is that it includes a communication system with the consumer and a communication system with suppliers.

Most Japanese executives strive to achieve cooperation and mutual trust between suppliers, manufacturers and consumers, as these factors have a great impact on the level of product quality. At the same time, it is necessary to analyze the causes of poor quality, as well as carry out joint measures to eliminate the identified causes in the shortest possible time [1].

Japanese management, based on collectivism, used all the moral and psychological levers of influence on the individual. First of all, it is a sense of duty to the team, which in the Japanese mentality is almost identical to a sense of shame. Given that the tax system works to average incomes and the material condition of the population with its emphatically progressive fiscal mechanism, there is minimal stratification of welfare in society, and this makes it possible to use the sense of collectivism as effectively as possible.

Japanese firms attach great importance to ensuring the high quality of their goods and services. First of all, this is due to the fact that in conditions of fierce competition prevailing in both domestic and foreign markets, high-quality products are more competitive. In addition, ensuring the quality of durable goods reduces the company's costs for after-sales service. However, one of the most important reasons why Japanese firms strive to ensure the high quality of their products is to maintain a good reputation of the company. In general, employees of almost every Japanese company realize that quality determines the fate of the enterprise [2].

Managers of Japanese enterprises attach paramount importance to quality control: the main task in production management is to ensure high quality of products; the level of productivity is of secondary importance. In 1946 America sent its best engineers to give lectures on quality and share their experience with Japanese industrialists. In 1950, lectures in W. Edwards Deming, the founder of the modern quality movement, read Japan. The Japanese embodied his ideas so effectively that after 20-30 years, American delegations came to learn from the Japanese experience [3].

William Edwards Deming is an American scientist, developer of statistical quality control methods, consultant on management and quality management. Co-author of the Shewhart-Deming Cycle (PDCA). It is directly related to the revival of the Japanese economy [1].

The approaches of kaizen management differ sharply from the management methods adopted in the West. In Japan, people and the production process are given special importance, and in In the West, the management of companies focuses on the product and the result. Let's look at the basic principles of kaizen [3].

The term “kaizen” as a management direction became widely known in 1986, after the publication of the book Masaaki Imai “Kaizen: the key to the success of Japanese companies.” Then the whole world learned what kaizen was and that Japan owed its success to him [4].

The most important link in the production chain, and all the efforts of the company are aimed at ensuring that he receives a high-quality product at a low price. It is important to anticipate market demands and adapt production to changing needs.

Customer feedback is one of the important components of kaizen.

The company's most valuable asset, kaizen is impossible without their support. Relations with staff at Japanese enterprises are built in such a way that employees themselves are interested in producing high-quality and competitive products. Here, the welfare of the enterprise means the welfare of the employee.

The pursuit of excellence is supported by five systems of forming relationships between a person and an organization:

- Lifetime Employment System
- On-The-Job Training System
- Rotation System
- The System Of Advantages
- The Reward System [4].

Kaizen prefers leadership as opposed to Western formal superiors. Japanese managers deserve authority not by a sign on the office door, but by their knowledge, experience, decisions made, and personal example. They are open to subordinates, spend a lot of time at work, and communicate freely with employees of any level.

Without the support of top management, it is impossible to deploy kaizen in the company: improvement goals are set at the top level and unfold from top to bottom. The implementation of the planned plans requires decision-making and investment. The higher the manager is in the hierarchy, the more improvement actions are expected from him [2]

Kaizen is based on process thinking, because process improvement leads to better results. In Japan, employees' efforts to optimize the work process are appreciated, even if this does not directly save the company.

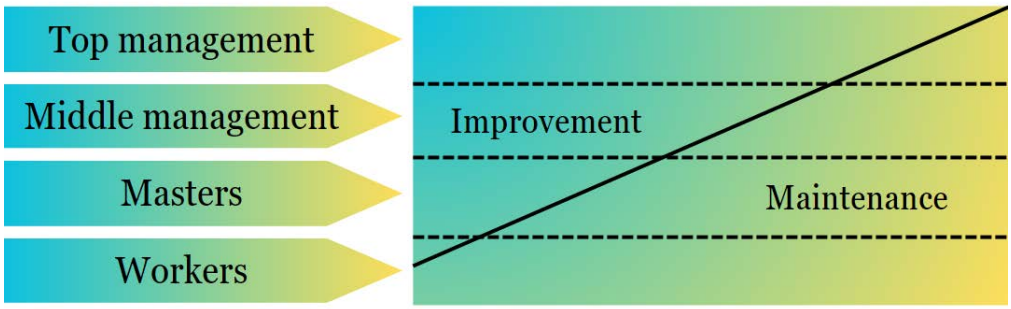

Figure 1. The ratio of maintenance and improvement activities at different levels of employees [4]

In the West, employees are focused on getting results at any cost. Any rational proposal is considered from the perspective of making a profit in the next quarter.

Western companies prefer rapid development through the introduction of innovations, not caring about minor improvements. The Japanese combine kaizen and innovation and achieve long-term growth.

Quality is an important element of kaizen. The Japanese realized that checking finished products for defects is a waste of time and money, because it does not lead to quality improvement. Therefore, they began to integrate quality into all stages of production, from product development and supplier selection to the delivery of goods

to consumers [4].

Any production of goods or services can be decomposed into a chain of processes. In kaizen, it is customary to consider each subsequent process as an end user. Therefore, the next production unit will never receive defective parts or inaccurate information.

The kaizen philosophy is supported by many Japanese corporations — Toyota, Mitsubishi, Nissan, Philips. As an example of a Kaizen follower, I would like to cite a Western company – Nestlé S. A [4].

Swiss multinational manufacturer of food and beverages. Its product line includes baby food, medical nutrition, bottled water, breakfast cereals, coffee and tea, sweets, frozen food, snacks and pet food.

Nestlé Corporation has not left the list of Fortune 500 companies for 22 years, in 2016. she took 66th place with a profit of $9,423 million. In the previous year, she was ranked 70th, and a year earlier – 72nd [4].

Lean manufacturing and the absence of losses are Nestle's primary mission. Kaizen's ideas are clearly visible in Nestlé's corporate principles of operation and Nestlé quality Policy.

The top management of the company undertakes to strive for the highest quality and safety of products in the following ways:

– Nurturing a culture of quality in order to develop, manufacture and supply zero-defect products and services that consumers trust.

– Compliance with current legislation and international requirements.

– Continuous improvement of the quality management system to ensure the safety of products, prevent quality incidents and eliminate defects (Example, Figure 2)

– Encouraging participation and spreading responsibility for quality among employees and partners through standards, education, training and mentoring, control and effective communication [4].

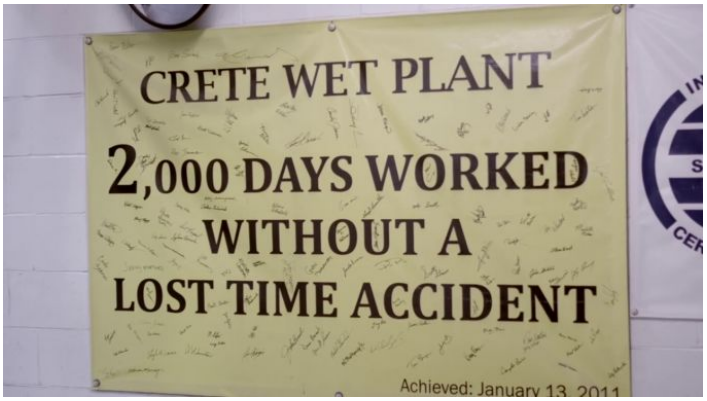

Figure 2. Poster in the workshop of Nestlé Purina factory [4]

Nestlé Waters uses different techniques to understand where it is best to open a new factory. Techniques such as Value Stream Mapping illustrate the flows of materials and information needed to deliver the final product to the consumer. Thus, new plants are being opened where they will initially work most efficiently.

In order to create value and earn the trust of consumers, Nestle implements the 4 principles shown in Figure 3:

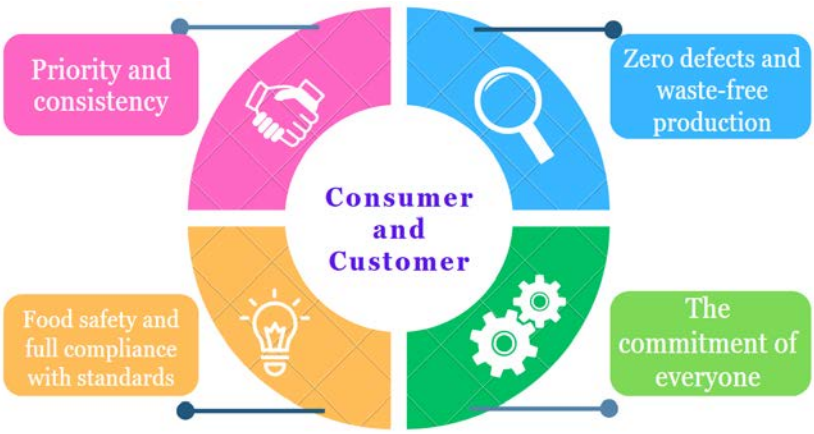

Figure 3. Nestlé Company Principles [4]

The conclusions that can be drawn when considering the Japanese management system are as follows:

The main task of the manager is to support the corporate spirit in the team, unite employees with common interests and an understanding of common work goals;

When an environment is created that ensures group decision-making, all members of the team can contribute to the achievement of the goal to the fullest extent of their abilities.

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USING VIDEOS IN TEACHING FOREIGN LANGUAGES TO DIGITAL GENERATION: OBSERVING DIGITAL DIDACTIC PRINCIPLES

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Abstract. The article describes the learning characteristics of Generation Z and examines new methods which can be effectively used while teaching them. As a result of the analysis, using educational videos from Internet resources observing digital didactic principles is considered to be one of the effective methods of teaching English to today's students. In addition, some examples of applying these videos in the classroom as well as designed exercises to them are given in the paper.

Keywords: digital generation, digital didactic principles, using videos, exercises.

ИСПОЛЬЗОВАНИЕ ВИДЕОМАТЕРИАЛОВ В ОБУЧЕНИИ ИНОСТРАННОМУ ЯЗЫКУ ЦИФРОВОГО ПОКОЛЕНИЯ: РЕАЛИЗАЦИЯ ПРИНЦИПОВ ЦИФРОВОЙ ДИДАКТИКИ

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Аннотация. В статье описываются особенности студентов поколения Z и анализируются новые методы, которые могут быть использованы в процессе их обучения. Анализ показал, что использование видеоматериалов согласуется с принципами цифровой дидактики и является одним из эффективных методов обучения английскому языку современного поколения. В статье приводятся примеры применения обучающих видеосюжетов из сети Интернет и разработанные к ним упражнения.

Ключевые слова: цифровое поколение, принципы цифровой дидактики, использование видео, упражнения.

The digital generation, or Generation Z, which refers to young people born in the early 2000s, is now actively entering the professional world. They have unique psychological characteristics that must be taken into account when teaching them English for specific purpose.

Members of digital generation grew up during the era of digital technologies, which has significantly influenced their thinking and behavior. They have high digital

literacy, prefer visual information, focus on results, strive for independence and self-realization. Traditional passive methods of learning information are not effective for this new generation of students. Interactive and dynamic forms of learning that allow them actively to participate in the learning process and acquire practical skills are more in demand [1].

Many researchers from various fields such as psychology, sociology, and education (T. N. Gorobets, L. V. Sergeeva, A. V. Erakhtin, A. N. Alyohina, L. B. Aksyonov, S. A. Bezgodova and others) have noted the so-called "clip thinking" among today's students [2]. This type of thinking is characterized by information perception in small portions through short articles, news feeds, or short video clips.

In addition, students now have higher expectations for electronic learning, actively using gadgets and other digital tools that have become an integral part of their lives. With their high digital literacy, inclination towards multitasking, and preference for interactive and digital methods of learning, using digital teaching methods for foreign languages based on the principles of digital didactics becomes extremely important.

Digital didactics is a new branch of educational science that deals with organizing the learning process in a digital educational environment. It focuses on the possibility of using digital learning technologies in the educational process and the development of modern educational systems [3].

One of the key principles of digital didactics in teaching foreign languages is *the principle of visibility*. Digital technologies allow to create interactive teaching-learning materials that make the learning process more visual and understandable for students. For example, using videos, PowerPoint presentations and interactive learning applications helps students better understand and remember new lexical and grammar material, satisfying their interests and needs. Besides, using various channels for receiving information positively impacts the retention of foreign language.

In the process of teaching disciplines such as "Foreign Language," "Foreign Language in the Field of Jurisprudence," and "Foreign Language in Business Communication" at the Law Faculty, we incorporate educational videos that visualize different aspects of the English language on phonetic, lexical, and grammatical levels. Each video is accompanied by detailed linguistic commentary and exercises developed by the authors of this article in order to effectively reinforce the newly learned vocabulary. Using digital means to provide visibility during vocabulary introduction, reinforcement or evaluation aligns with the didactic *principle of multimedia* [4].

Video materials from internet resources such as TED-Ed and Business English Pod, educational videos from YouTube channels, and their transcript can be used. For instance, when introducing vocabulary on the topic "Intellectual Property Law," we use the video *"Intellectual Property Law (1) | Business English Vocabulary"* from the resource Business English Pod. Having introduced the students with the new vocabulary on the topic from the video sequence, students are supposed to do the following task:

You will hear a series of sentences with a word replaced with a beep. Repeat each sentence including the missing word:

1. I've applied for a _____ on my new sneaker design.

2. The Nike swoosh is a registered _____ of Nike Inc.

3. We don’t actually own the technology, we just _____ it from another company.

4. The algorithm Google uses to rank websites is a very valuable trade _____.

After watching the video, students read the texts about these new terms and select headings for them, for example:

1. _____ _____ the distinct appearance of a product.

2. _____ _____ involves taking something apart, such as a machine or software, to learn how to make it.

3. _____ _____ refers to creations of the mind: inventions, literary and artistic works, confidential information, and symbols, names, images, and designs used in commerce. _____ _____ includes patents, trademarks, trade secrets, and copyrights.

Taking into account the "clip thinking" of the modern generation, the selected videos are relatively short in duration, anywhere between only 2 and 5 minutes long. This allow them to be used as supplementary materials during seminars or as homework on condition that educators place the videos and exercises in the electronic educational platform Moodle. Thus, the *principle of individualizing learning* is implemented, providing students the opportunity to independently choose the pace, content, and learning methods according to their interests and needs [4].

Thus, for instance, while learning the topic “Tort Law”, students are offered to watch the video *What is the tort of assault?* which can be found in YouTube and then, they are supposed to do the following tasks:

1. Watch and tick the torts of assault:

a. throwing a rock towards plaintiff's head

b. throwing a rock towards plaintiff's head when the plaintiff is daydreaming, looking in the other direction

c. running at a stranger to hug him

d. threatening to steal the plaintiff’s birthday presents

e. threatening the plaintiff with a kick next week

2. Read the text or watch the video again and answer the questions:

1. What is the tort of assault?

2. What will the plaintiff have to prove?

3. What does apprehension here mean? и т.д.

When developing exercises for educational video, all stages of working with video materials, such as understanding the content heard, creatively reprocessing the information received, and using the acquired information in speech activities, should be taken into account [5]. A variety of forms of tasks can be applied, such as closed form tasks (where the student selects the correct answer from a provided set of answers), open form tasks (requiring independent retrieval of answers), matching tasks and tasks for determining the correct sequence.

The application of different educational videos on the professional topics in

teaching the English language contributes to the implementation of the *principle of knowledge integration*. Alongside developing communicative skills, there is enhancement in informational, academic, professional-communication and social skills. Besides, using videos increases the level of students' motivation and helps them succeed in both learning general English and learning English for professional purposes.

Thus, for the topic "Commercial Law", the introduction of new vocabulary is facilitated through the video material "Commercial Law" available on the BusinessEnglishPod website. Students are introduced with new concepts, practice phonetic skills by repeating new words and expressions after the speaker, observe the usage of words and expressions in the context, and then complete designated exercises.

1. Listen to the sentences and complete the missing word or phrase.

2. Match the terms and the definitions.

Later, while learning this topic on the following seminar, students watch the video *What is Commercial Law?*: and do the following tasks:

Before watching:

1. Answer the questions:

1. What kinds of lawyers are there within Commercial Law?
2. What are the two main practice areas of Commercial Law?
3. Choose the items, which describe Court based approach.
4. Choose the items, which describe Alternative dispute resolution methods.

While watching the video:

1. Watch the video and check your answers.

After watching the video, students are supposed, to answer the following questions, for instance:

1. What is a contentious lawyer?

2. What are transactional lawyer's responsibilities?

3. What are the different practice areas?

4. What other lawyers are mentioned?

Engaging in tasks related to these short professionally related videos enables students to develop skills in:

– understanding and analyzing authentic monologic and dialogic speech based on learned vocabulary, sociocultural knowledge, and linguistic and contextual guessing skills:

– extracting different types of information (factual, conceptual, and subtextual);

– understanding the language norms of English, norms of intercultural communication, and legal terminology for successful professional communication.

The didactic *principle of flexibility* allows to adapt the learning process to changing environments and students' needs. Presenting information in the form of videos, considering the visual thinking of Generation Z, aids in effective learning experience of undergraduates.

The principle of interactivity involves active interaction between students and educational content as well as among each other. Placing such learning materials as videos and exercises to them in online educational platform Moodle where students can access these resources at home frees up time for discussions during seminars.

Topics and a list of issues for upcoming discussions, based on the performed videos, as well as metacommunication tools and clichés, can be also posted in the electronic system. Collaborative work in creating dialogues, group activities during discussions and debates foster active student interaction.

Continuous access to the university's digital educational environment, educational video resources on the Internet, and the ability to learn anytime, anywhere using digital gadgets promote *the principle of accessibility*.

The main principle of foreign language teaching is the principle of *systematization.* It entails repetitive practice of grammatical and lexical constructions through various language exercises. This routine and time-consuming process, which takes longer than explanation and control, can be tedious for learners when completing monotonous exercises in textbooks. However, employing multimedia technologies helps to avoid the monotony of repetitive practices. Various forms of exercises based on the video and replaced in Moodle, differing in complexity and involving gamification elements, can be used for organizing repetition and reinforcement activities.

In conclusion, we believe that modern educators should select and provide teaching materials in a way that maintains undergraduates' motivation and considers new realities. This, in our view, is achievable through the use of digital technologies in the learning process, taking into account the principles of digital didactics.

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THE ROLE OF ARTIFICIAL INTELLIGENCE IN HEAT AND POWER ENGINEERING

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Abstract. The article is aimed at assessing the role of artificial intelligence (AI) in the heat and power engineering industry. It considers modern technologies and methods of AI application for optimising the operation of heating, ventilation and air conditioning systems in buildings, managing the load on power systems, issues of forecasting energy consumption and improving energy efficiency in the industry. The authors discuss the perspectives of development of control processes and energy efficiency improvement of thermal power plants (TPPs). The advantages and disadvantages of AI implementation are analysed.

Keywords: artificial intelligence (AI), energy industry, thermal power plant, energy consumption, energy efficiency, data collection.

РОЛЬ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В ТЕПЛОЭНЕРГЕТИКЕ

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Аннотация. Статья посвящена оценке роли искусственного интеллекта (ИИ) в теплоэнергетике. В ней рассматриваются современные технологии и методы применения ИИ для оптимизации работы систем отопления, вентиляции и кондиционирования в зданиях, управления нагрузкой на энергосистемы, вопросы прогнозирования потребления энергии и повышения энергоэффективности в данной отрасли. Авторы обсуждают перспективы развития процессов управления и повышения энергоэффективности работы тепловых электростанций (ТЭЦ). Анализируются преимущества и недостатки внедрения ИИ.

Ключевые слова: искусственный интеллект, ИИ, энергетика, тепловая электростанция, энергопотребление, энергоэффективность, сбор данных.

The use of AI in the energy industry is becoming increasingly popular, as it enables more precise optimisation of energy consumption, facilitates the automation of work processes, reduces the impact of human factor risk and minimises the possibility of errors, which in turn increases the efficiency of systems and reduces energy consumption and financial costs. Thermal power plants currently produce up to 60 percent of the world's energy. Thermal power plants take a significant part of energy consumption worldwide, and therefore improving their efficiency can lead to significant reductions in energy consumption and emissions [1]. It should be noted that up to 30 % of the electricity generated by a thermal power plant can be used for its own consumption.

One of the main methods of using AI to improve the energy efficiency of thermal power plants is to create a system for collecting and analysing electrical data. By monitoring the dynamics of electricity consumption, operators can determine the time of peak demand and adjust generation schedules accordingly. This will help reduce the need for costly peak-load power plants and minimise irrational energy use.

In recent years, advances in technology have made it easier to collect electrical data from power plants. Smart meters, sensors and automation systems allow for real-time data collection and instant insight into plant operations. This data can be stored and analysed using advanced software and AI algorithms to identify trends, patterns and areas for improvement.

In addition, collecting electrical data can help identify where energy is being wasted or lost. By analysing voltage levels, power factor and other metrics, operators can identify inefficiencies in the electrical grid and take corrective actions to improve overall efficiency [2].

AI can also be used to optimise the processes of controlling TPP operating modes, adjusting equipment parameters and controlling technological processes. This allows to significantly reduce the cost of electricity generation, increase the efficiency of fuel utilisation and reduce the harmful impact on the environment [3].

In addition, AI can be used to create predictive models of energy consumption that will save resources and prevent the need to use excessive production capacity [4]. Such models can be used to optimise TPP schedules, manage loads and coordinate operation with other energy sources.

AI systems contribute to early detection of potential problems, correct automatic process control and prevention of emergency situations. This not only improves the safety and reliability of the TPP, but also contributes to increased productivity.

In general, the use of artificial intelligence to improve the energy efficiency of thermal power plants has great potential and can bring significant benefits for both energy companies and the environment. The introduction of modern AI technologies in the energy sector is becoming an increasingly relevant and necessary step towards sustainable development and reduction of greenhouse gas emissions.

There are both domestic and foreign (USA, China, Germany, Japan, Great Britain, Australia) examples of AI implementation in heat supply systems. For example, PJSC T Plus installed a predictive analytics system in 7 branches located in the Central, Volga and Urals Federal Districts, based on the Russian digital platform for production management ZIIoT developed by Zyfra Group.

The prognostics module is based on benchmark models of equipment operation under different conditions and modes. The models are built using neural networks and the results of analysing data on the operation of the power facility and are constantly correlated with real-time information. For this purpose, about 8 and a half thousand different sensors are installed on the main (boilers, turbines) and auxiliary (e.g. pumps) equipment of the TPP, which analyse the state and operation of each element of the plant. The indicators collected by the ZIIoT platform are fed directly into the prognostics system. This, in turn, signals various deviations to the operating personnel.

The predictive analytics module monitors the dynamics of changes in the technical condition indices of the units and the degree of deviation of the unit parameters from the normative values. A sharp change in the technical condition index allows to predict with high probability the approaching failure of the unit, and exceeding the permissible deviation of certain parameters allows to identify the unit and the reason causing the failure. The system helps to save time in identifying the problem and prevent breakdowns and stoppages.

AI has already prevented three incidents at TPP Akademicheskaya, which could have put the plant out of operation for 24 hours in total. As a result, the company would not have supplied 5.5 million kWh of electricity to the grid and would not have supplied 3,360 Gcal of heat to consumers [5].

To summarise, we can say that the development and use of AI in industry and, in particular, in the operation of TPPs can present both risks and opportunities.

Risks of using AI in TPP operations include:

1. Unforeseen system failures and errors that can lead to plant downtime and accidents.

2. Cybersecurity threats such as hacker attacks on the TPP control system [6].

3. Job cuts: Automation and introduction of artificial intelligence can replace routine and monotonous tasks that were previously performed by humans. This may lead to job cuts in some areas [7].

4. Need for retraining: As technology advances, new jobs may arise, but for many employees, retraining and training may be required to work with automated systems and artificial intelligence [8].

5. High initial costs: The development and implementation of AI systems in the energy sector requires significant financial investment during the research and development phase

However, the use of AI in TPP operation also offers opportunities:

1. Improving the predictability and efficiency of TPP operations by analysing large amounts of data and intelligent forecasting.

2. Optimisation of control processes and monitoring of the technical condition of equipment, thus reducing maintenance costs.

3. Increasing safety and reducing the probability of human error in plant operation.

In order to successfully realise the potential of AI in the energy sector, and in the operation of TPP in particular, it is necessary to consider the risks and take appropriate measures to ensure the safety and reliability of the system. It is also important to ensure that personnel are trained to work with new technologies and that AI is integrated into

existing processes and management structures.

These innovations will ensure a more sustainable and modern energy infrastructure for the industry, contributing to its development and increasing its competitiveness in the global market.

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УДК 332.8

DIGITALISATION OF HOUSING AND UTILITIES: PROMISE FOR REVOLUTIONISING URBAN LIFE

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Abstract. This article discusses the current situation in the field of digitalisation of the housing and utilities sector. The advantages of digitalisation are highlighted. It considers the impact of IoT technologies in the housing and utilities sector. At the same time, attention is drawn to the modern achievements of large cities in this area, the impact of digitalisation projects on the population. Despite the advantages of integrating modern technologies, it is also worth paying attention to potential problems: data privacy, digital inequality, etc.

Keywords: digitalization, housing and utilities, IoT, integrating modern technologies, digitalization projects.

ЦИФРОВИЗАЦИЯ ЖИЛИЩНО-КОММУНАЛЬНОГО ХОЗЯЙСТВА: ПЕРСПЕКТИВЫ РЕВОЛЮЦИОННОГО ИЗМЕНЕНИЯ ГОРОДСКОЙ ЖИЗНИ

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Аннотация. В данной статье рассматривается влияние IoT технологий в сфере ЖКХ. Отмечаются преимущества цифровизации. При этом обращается внимание на современные достижения крупных городов в данной сфере, влияние проектов по цифровизации на население. Несмотря на преимущества современных технологий, отмечаются потенциальные проблемы: конфиденциальность данных, цифровое неравенство и т. д.

Keywords: цифровизация, жилищно-коммунальное хозяйство, IoT, внедрение современных технологий, проекты по цифровизации.

The digitalisation of housing and utilities marks a transformational shift in urban life, enabling the use of technology to improve efficiency, sustainability and convenience. Through the integration of smart technologies, data analytics and automation, digitalisation promises to optimise the use of resources, improve service

quality and encourage greater resident participation.

The rapid development of digital technologies is changing all aspects of life in modern society, and the housing and utilities sector is no exception. Traditionally, the management and delivery of basic services such as water, electricity, heating and waste disposal have been fraught with inefficiencies, administrative burdens and inadequate infrastructure. However, the emergence of smart technologies and the Internet of Things (IoT) has opened up new opportunities to optimise resource allocation, improve service quality and empower residents to actively participate in the management of their communities. As of 2023 Tech Sciences, the global Internet of Things market is valued at approximately $800 billion and is expected to exceed $1.6 trillion by the end of 2025 [1].

The digitalisation of the housing and utilities sector encompasses a wide range of technological innovations aimed at improving efficiency, sustainability and usability. One of the key aspects of this digital transformation is the introduction of IoT devices and sensors to monitor and control various systems in residential buildings. For example, smart meters can track energy and water consumption in real time, allowing for more accurate billing and early detection of leaks or inefficient spending. The economic benefits of the digitalisation of the housing and utilities sector can be seen in reduced operating and capital costs. Advances in information technology improve the efficiency and rationality of resource management, resulting in lower utility bills for residents and reduced costs for residential complexes and utility administrators. In addition, predictive analytics can identify maintenance needs before they become costly repairs, extending the life of infrastructure and ensuring uninterrupted service delivery.

In addition, the integration of artificial intelligence (AI) and data analytics enables predictive maintenance and infrastructure optimisation, reducing downtime and minimising service disruption. Intelligent thermostats and energy management systems optimise the use of heating and cooling systems based on operating conditions and weather forecasts, resulting in significant energy savings and reduced environmental impact.

For residents, digitalisation increases convenience and transparency by allowing them to monitor resource use, access personalised information and remotely control various aspects of their living environment. Technology will also enable residents to monitor and control their energy and water consumption. Data from meters can provide detailed information on energy consumption. Tenants and building managers can see where and how energy is being used, allowing them to optimise processes. This allows energy consumption to be regulated, reducing energy consumption and cutting costs for tenants and building managers. Thus, the digitalisation of the housing and utilities sector opens up new perspectives for more efficient energy consumption and resource management, contributing to sustainable development and reducing negative environmental impact.

At this point, it is already possible to assess the level of digitalisation in the housing and utilities sector. In the "Largest Cities" category, the leaders were:

Moscow – 117.16 points;

St. Petersburg – 98.13 points;

Nizhny Novgorod – 88.26 points;

Ufa – 86.7 points;

Kazan – 85 points.

The assessment was based on 47 indicators divided into 10 areas: urban management, smart housing and utilities, innovations for the urban environment, smart urban transport, smart public and environmental safety systems, tourism and service, smart social service systems, economic condition and investment climate, and communication network infrastructure [2]. According to the rating of the level of digitalisation of the urban economy of Russian regions for 2021, the average value of the digitalisation index (IQ of the city) reached 52.6 points out of 120 possible points, the increase by 2020 was more than 16 %, which indicates the development of the application of modern technologies in the housing and utilities sector.

At the end of 2023, a methodology for calculating digital development for housing and utility companies was created and tested. The methodology makes it possible to assess the digital development of housing and communal sector enterprises according to a specially developed formula based on 166 indicators, including the level of personnel training, integration landscape and work with data, and industrial Internet of Things technologies. The methodological recommendations will appear in the public domain as early as 2024. The methodology was tested in Yakutsk, Kazan, Yaroslavl and Nizhny Novgorod. According to the data obtained, the average digital maturity of the surveyed enterprises is 51 %, and the share of Russian software used in production is 61 %. The pilot regions showed that companies need expert support. Methodological recommendations will help companies to comprehensively approach the process of digital transformation, assess the current level of development, and develop or adjust the enterprise development plan [3]. The emphasis on determining the level of Russian technology use is explained by the current problems associated with the supply of foreign technologies in the Russian Federation.

In 2023, the results of the All-Russian contest "Best Municipal Practice" were presented. 118 were submitted for participation in the competition. In accordance with the Resolution of the Government of the Russian Federation dated 18.08.2016 N 815 "On the All-Russian contest "Best Municipal Practice", municipal districts, urban districts (urban districts with intracity division) and urban settlements (I category); rural settlements (II category) participate in the contest. Compared to 2020 (59 applications), the growth in the number of applications was 100 per cent [4]. In the nomination "Modernisation of urban economy through the introduction of digital technologies and platform solutions (smart city)" The assessment was based on such indicators as:

– Compliance with one of the areas of the "Basic and Additional Requirements for Smart Cities (Smart City Standard)" approved by the Russian Ministry of Construction.

– Replication capability.

– Use of innovative technologies and digital technologies.

– Synchronisation of activities of national and federal projects and municipal programmes/

– Involvement of residents as participants in the practice.

– Degree of impact of the implementation of practices on the growth of the IQ index of cities.

The winners in Category 1 were: Novosibirsk, Sarov, Innopolis, Voronezh and Murmansk. One of the most innovative was the project of the city of Innopolis "Close to Home", a Smart City concept focused on pedestrian accessibility and quick access to city data and digital services in a convenient digital environment. The system contains 3 modules: for the citizen, for the entrepreneur and for the government representative. The citizen module includes, for example, analyses the availability of 12 categories of infrastructure facilities within a 15-minute walking distance from residential buildings, as well as comparative analyses of residential buildings in a three-dimensional model. The entrepreneur's module provides analyses of population density and solvency, points of attraction and main interests of the population, pedestrian and car traffic, etc. The entrepreneur's module also provides analyses of population density and solvency, points of attraction and main interests of the population, pedestrian and car traffic, etc. The representative of the authorities through the module of the system "Close to Home" has the ability to interact with residents, access to visual display of the location of underground and above-ground utilities, etc. The system "Close to Home" is an innovative platform that allows using modern technologies to analyse problems not only from the point of view of public administration, but also from the position of the entrepreneur and the population.

However, despite the potential benefits of digitalisation, a number of challenges need to be addressed in order for it to continue to be successfully implemented and widespread. Privacy issues related to the collection and use of personal data must be carefully addressed to protect the rights of residents and prevent unauthorised access or misuse. In addition, inequalities in access to technology and digital literacy skills can exacerbate existing inequalities by preventing marginalised communities from benefiting from digital services.

In addition, cybersecurity threats pose a significant risk to the integrity and reliability of digitised systems, requiring robust security measures and continuous monitoring to protect against potential breaches or attacks. As such, policymakers, industry stakeholders and community leaders must collaborate to develop comprehensive frameworks and regulations that foster innovation while ensuring privacy, security and fairness.

The digitalisation of housing and utilities holds tremendous promise for revolutionising urban life, offering unprecedented opportunities to improve efficiency, sustainability and resident satisfaction. Using smart technology, data analytics and automation, stakeholders can optimise the use of resources, improve service quality and empower residents to actively participate in the management of their communities. However, addressing challenges such as data privacy, digital inequality and cybersecurity threats are necessary to ensure equitable access and maximise the potential benefits of this technological revolution. Through collaborative efforts and innovative solutions, the digitalisation of housing and utilities has the potential to transform cities into smarter, more sustainable and inclusive communities for all.

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УДК 656

SUSTAINABILITY AS THE KEY PROPERTY OF AN EFFICIENT SUPPLY CHAIN

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Abstract. This paper explores the concept of environmental sustainability as a key property of an effective supply chain. By integrating sustainable practices into supply chain operations, organisations can achieve economic, environmental and social benefits. The importance of environmental sustainability in improving supply chain efficiency, reducing waste and optimising resources, creating competitive advantage, reducing risk and contributing to a more sustainable and environmentally friendly future is examined.

Keywords: sustainable supply chain, ecology, logistics, stability, resilience, sustainability, important properties.

ЭКОЛОГИЧЕСКАЯ УСТОЙЧИВОСТЬ КАК КЛЮЧЕВОЕ СВОЙСТВО ЭФФЕКТИВНЫХ ЦЕПОЧЕК ПОСТАВОК

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Аннотация. В данной работе исследуется концепция экологической устойчивости как ключевое свойство эффективной цепочки поставок. Благодаря интеграции экологически устойчивых методов в операции цепочек поставок организации могут достичь экономических, экологических и социальных выгод. Рассматривается важность устойчивого экологического развития в повышении эффективности цепочки поставок, сокращении отходов и оптимизации ресурсов, в создании конкурентных преимуществ, снижении рисков и содействии более устойчивому и экологичному будущему.

Ключевые слова: экологически устойчивая цепочка поставок, экология, логистика, стабильность, жизнестойкость, экологическая устойчивость, важные свойства.

A sustainable supply chain is one that fully integrates ethical and environmentally responsible practices into a competitive and successful model. The supply chain can be defined as a complete life cycle of a product: from its raw material state to its final sale. It involves the supply, production, storage and distribution processes, and requires coordination between every link in the chain. A supply chain is structured and has a number of characteristics and properties. The most important characteristics of an efficient supply chain are: stability, resilience, sustainability.

The structure of the supply chain system is determined by the composition of its links – entrepreneurs, enterprises and organizations and their divisions – and the links

between them. The ability of the supply chain to maintain its structure for a long time and perform its functions affects its stability. Stability is “the ability of the system to restore the initial state after any disturbance, manifested in the deviation of the system parameters from the nominal value”. An efficient supply chain must be stable. Companies must understand what is holding back their current structure from becoming more resourceful and stable. With competition rising, especially within the commodity market, it is important to stay ahead of the curve by incorporating principals into the supply chain that will make the process more efficient [1].

Our century is a century of the scientific and technological progress. But at the same time, this progress gave birth to a very serious problem – ecology. The protection of environment is becoming a political programme in every country. But the environmental problems have grown beyond the concern of a single country. Their solution requires the co-operation of all nations. Environmentally-conscious approach is applied now not only to individuals, but to business and countries.

Accordingly, one of the most important properties and burning issues of an efficient supply chain nowadays is its sustainability. For this reason, the importance of supply chain sustainability approach leaves no doubts for businesses.

Supply chain sustainability refers to companies’ efforts to consider the environmental and human impact of their products’ journey through the supply chain, from raw materials sourcing to production, storage, delivery and every transportation link in between.

The goal is to minimize environmental harm from factors like energy usage, water consumption and waste production while having a positive impact on the people and communities in and around their operations. These concerns are in addition to traditional corporate supply chain concerns around revenue and profit.

In recent years, customers, employees, investors and governments have put increasing pressure on companies to demonstrate greater environmental stewardship and social responsibility. This comes at a time when the business case for sustainable operations grows stronger every year.

For many businesses, supply chains have come into focus because they use a lot of resources and money and are frequently a source of unnecessary waste. Thus, supply chain sustainability has emerged as a key corporate goal. Companies have started to measure the environmental and societal impact of their goods and services, from the beginning to the end of their life cycles [2].

In the new reality the logistics sector stands at a pivotal junction, facing a now-or-never moment. With rising sustainability pressures and radical technological shifts, businesses must transform operations to meet stringent emissions regulations and growing customer expectations around eco-friendly deliveries.

Logistics is under growing pressure to adopt sustainability measures. Key regulations are mandating reductions in transport emissions, notably in major markets such as the EU. Under the Paris Agreement, companies must cut carbon emissions by 55 % by 2030 compared to 1990 levels to meet climate targets.

By 2030, the global logistics market will reach a value of $570.9 billion compared to $261.5 billion in 2022, according to Vantage Market Research [3]. With exponential business growth comes immense pollution. DHL states that approximately

80 %-90 % of a product's emissions come from the supply chain, which accounts for around 60 % of all global carbon emissions. On average, a truck that travels approximately 120,000 miles per year emits 223 tons of CO2. Presently, over 6.2 million trucks are in operation across the EU, responsible for transporting 77 % of all land freight in the region. Therefore, strategic sustainability efforts are indispensable.

The path to sustainable logistics is clear, with guideposts like European regulations, emissions reduction targets and compliance deadlines. Success might be achievable with green fuels, eco-friendly packaging, robust recycling protocols and more.

As the carbon price is projected to reach $50-$100 per ton by 2030, non-compliant logistics providers risk facing substantial financial penalties. Customer preferences are also shifting, as eco-conscious shippers and consumers increasingly favor low-emissions providers.

Inactive companies may struggle with declining competitiveness and profit margins. In turn, leading providers who optimize routes, upgrade fleets and integrate green practices can gain advantages as policies tighten.

Therefore, modern companies can no longer ignore sustainability if they want continued success.

Sustainable logistics is becoming more and more relevant in the transition from a linear economic model (based on extraction, transformation, distribution and consumption cycles) to a circular model of economy, whose main goal is to extend the products life and rationalize the use of resources over time.

It is generally accepted that sustainability is made up of three pillars: the economy, society, and the environment. These principles are also informally referred to as “the 3 Ps” - Profit, People and Planet. By finding a balance among them, logistics can provide the best service while still enforcing and assuring a more conscious resources use.

Sustainable or green logistics applies a three-dimensional life cycle approach, as opposed to the traditional one-dimensional, economics only focused approach. Following the three-dimensional approach does not necessarily mean that the level of effort and times will increase by three. However, as the organisation reduces its impact on the environment and support positive social behaviours, there may be a return on overall “value for money.”

More recent evidence highlights that digital transformation and the growing sophistication of digital supply chain technologies are playing a major part in the evolution of supply chain sustainability. Big Data management, advanced analytics, artificial intelligence (AI), and security tools, such as blockchain and RFID sensors, have brought unprecedented visibility and accountability to modern supply chains. Companies now have a much greater ability – and obligation – to demonstrate corporate social responsibility and to share best practices for green supply chains and sustainable logistics.

It has now been suggested that there are three components of sustainable supply chains. Twenty years ago, the word sustainability was almost completely synonymous with eco-friendliness. Today, it is a much more holistic term. Green, transparent, and circular supply chains are all components of a modern sustainable supply chain.

What is a green supply chain? A green supply chain is achieved by successfully integrating environmentally responsible principles and benchmarks into supply chain management. This includes product design, materials sourcing, manufacturing, logistics, and end-of-life product management. With the rise of e-commerce, there are more product and shopping choices than ever. To compete, businesses need to find resilient solutions to greening their supply chains while still growing profit. Supply chain technologies such as AI and machine learning can help businesses spot risks, patterns, and opportunities – allowing them to minimize waste and improve efficiency.

What is a transparent supply chain? Supply chain transparency refers to the ability and willingness of a business to openly disclose information about the provenance of goods and labor and end-to-end supply chain practices. Many businesses invest significant time and resources into establishing and maintaining ethical and environmentally responsible standards. The problem is, even with the best of intentions, this has traditionally been very difficult to enforce and reliably implement. Fortunately, through the use of digital technologies such as blockchain and RFID sensors, supply chain managers can now obtain an accurate and irrefutable record of all the products and suppliers along the entire supply chain journey.

What is a circular supply chain? In a circular supply chain, products are disassembled or reduced to their raw materials form, and remade into sellable products – thus allowing businesses to achieve the environmental benefits of recycling while recouping costs in the process. Some of the modern technologies that support these initiatives include the use of recycled plastics in 3D printing, and the ability for advanced analytics to map out the most efficient logistics journeys for returning products into the supply chain loop. Furthermore, businesses are increasingly using circular product design principles to incorporate waste reduction into the very DNA of products and their component parts.

As mentioned by several experts and authors sustainable supply chains work in the following ways:

- by collaborating. A surprising number of the world's largest companies use the same raw materials and low-tier suppliers. Often, it's been difficult to prove that these suppliers adhere to green and ethical operating standards. If supply chain managers are to combat this, they can best do so by working together, sharing information, and sending a message that sustainability compliance is essential to doing business. The Fashion Revolution movement began in 2013 and is a great example of many major – and highly competitive – fashion brands choosing to work together to combat unethical suppliers in their industry.

Despite some initial skepticism, a 2023 Fashion Transparency Index report shows that 10 years on, supply chain transparency has overwhelmingly improved in the fashion industry, and that far from damaging their competitiveness, the collaboration and sharing of data allowed all players in the industry to benefit from the improved public sentiment this brought to their brands. Though progress on transparency in the global fashion industry is still too slow among 250 of the world's largest fashion brands and retailers, with brand performance varying greatly [4].

- they work by leveraging the best available technologies. Supply chain sustainability presents a challenge due to the complexity and wide distribution of the many links in the chain. Agile sustainability is driven by a connected network of

systems, people, and technologies that are brought together in the cloud - allowing for the integration and analysis of multiple data sets and real-time access to insights and customized reports. The best systems start with cloud ERP and leverage AI-powered supply chain solutions to manage end-to-end tasks, from sustainable sourcing, to greener manufacturing and logistics.

- they work by setting consistent standards. In order for a strategic supply chain sustainability plan to work, it's important that benchmarks, targets, and guidelines are clearly spelled out. They must then be shared – and agreed to – among all the stakeholders and suppliers across the chain. Fortunately, today there are numerous bodies that help businesses set these goals and criteria, and digital technologies that make it easier than ever to track and manage compliance. There are also growing amounts of data and intel to demonstrate the bottom-line value of sustainability benchmarking. A recent paper from the Harvard Law School Forum on Corporate Governance suggests a positive correlation between companies' improved ESG (environmental, social, and governance) records, and their profit and growth.

- they work by communicating their successes. Potential customers can't know what you don't tell them. When you attain your sustainable supply chain goals, it's important that you share the good news, or you risk wasting the powerful reputational benefit of that news. A deserved reputation as a green corporation is always good for your brand and can help to improve your reviews and customer loyalty. But that's only part of it. Businesses have the opportunity to lead their industry by example, and to demonstrate how supply chain sustainability initiatives can bring measurable benefit – both financially and environmentally. By sharing your accomplishments and best practices, you associate your brand with innovation and thought leadership in the sustainability space.

Investing in more sustainable and transparent supply chains has gained much importance in recent years because there are more potential benefits across the entire business. Given that let's have a closer look at some of them.

- Cost control. At the heart of any sustainability initiative, is a commitment to increasing efficiency and decreasing waste. And of course, using raw materials more efficiently, recycling, and reducing packaging, helps you reduce both your carbon emissions and your costs. But with smart, cloud-connected supply chain and business solutions, you can go one step further by building greener methods into the products and manufacturing process all the way from the designer's drawing board to the customer's front door. Sustainable product design helps to control costs and reduce waste by.

- Building brand loyalty and reputation. It is highlighted in many sources that customers are more likely to be loyal when they see that businesses demonstrate strong social and environmental responsibility. Consumer awareness and preference for sustainable businesses had been steadily increasing for decades – but now, public demand for transparent supply chain and business practices is at an all-time high. A recent report from the US Environmental Protection Agency (EPA) digs into this issue to determine a growing correlation between competitiveness and profitability, and a company's proven reputation for taking a stance on ethics and sustainability.

Minimizing risk and vulnerability. Every few years, there are stories about how a tainted or dangerous product slipped through the cracks and made it into the supply

chain. Quite apart from the devastating consequence of anyone getting hurt, a product recall has the potential to damage a company – sometimes beyond repair. Often what isn't lost in costs and legal fees is taken away via reputational damage. When supply chain transparency is enforced and implemented with digital security solutions, unscrupulous suppliers and manufacturers have nowhere to hide. Not only can these measures protect businesses from unethical and environmentally irresponsible partners, they can track and document all the labor, handling, and materials components from source to destination.

Last years of our century was considered to be the era of digitalization. So, it's worth mentioning about the importance of digital transformation in the supply chain. It allows to meet and exceed sustainability benchmarks while also innovating and growing your business.

Moreover, it seems undeniable that the future of green logistics depends on supply chain automation, a trend that has been widely observed in recent years. Logistics 4.0 is likely to continue to develop, with the use of artificial intelligence, digitisation of information and robotisation, robotic arms and robotic racking.

All these automated solutions favour green logistics by limiting the use of polluting energies. It is therefore likely that green logistics, already established today, will continue to develop more in the future with the development of logistics 4.0 and the current environmental situation [5].

Furthermore, an emerging sustainability trend suggests that to create an effective and successful sustainability strategy, businesses should prioritize meeting government compliance by 2030, establish long-term technology partnerships, adhere to budget constraints, maintain high-value logistics services, ensure measurable environmental impact and implement cutting-edge technologies for strategy execution. Supply chain sustainability is also a reflection of our collective responsibility towards the planet and future generations. Supply chain sustainability benefits not only companies' own interests and those of their stakeholders but also society and the planet at large. Companies have realized that climate change, for example, can put their business continuity at risk with extreme weather disruptions and growing resource scarcities.

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ANALYSIS OF STRENGTH OF UNITS OF HULL STRUCTURES USING THE FINITE ELEMENT METHOD

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Abstract. The article examines the effect of the parameters of the section and reinforcement on the stress-strain state in the area of the section. As part of the work, the bottom beam p/bulb 20b was selected, VAT calculations were performed for different node variants, and two schemes with node reinforcements were compared. Based on the results obtained, it was concluded that the “butt” joint considerably affects the reduction of node stress more than the “overlap” joint.

Keywords: cutout, reinforcement, finite element analysis, butt joint, overlap joint.

АНАЛИЗ ПРОЧНОСТИ УЗЛОВ КОРПУСНЫХ КОНСТРУКЦИЙ МЕТОДОМ КОНЕЧНЫХ ЭЛЕМЕНТОВ

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Аннотация. В статье исследуется влияние параметров разреза и армирования на напряженно-деформированное состояние в области разреза. В рамках работы был выбран днищевой балок п/бульб 20б, проведены расчеты НДС для разных вариантов узлов, а также произведено сравнение двух схем с усилениями узла заделками. На основании полученных результатов был сделан вывод, что заделка «встык» оказывает большее влияние на снижение напряжений узла, чем заделка «внахлест».

Ключевые слова: вырез, усилений, напряженно-деформированные состояние, заделка встык, заделка внахлест.

In shipbuilding, profiled sections such as the asymmetric bulb flats have become the most widely applied for primary structural beams. The main advantages of this profile include [1]:

1. The presence of a "web" in the profile, which facilitates connection with the frame walls.

2. A relatively small notch area that weakens the frame wall less.

3. Comparatively high lateral stability (relative to angle profiles).

Such beams form hundreds and thousands of critical structural nodes on every vessel, operating under complex conditions of force transfer from the beams to the frame walls [2, 3]. Notches for beam passage have comparatively complex configurations, leading to stress concentration and increased stress levels. The shipbuilding experience includes instances where thousands of fatigue cracks were identified in such nodes on a single ship within the first years of its operation [4]. Solutions for addressing such issues have included modifications to the initial designs of the notches, adding new elements to the nodes, and certainly changing the welded connections.

The standardization of typical notches and nodes to enhance shipbuilding efficiency is undeniably important. In the 1960s, when automated (programmable) gas and plasma cutting lines were not yet widespread, the main technological process for forming beam notches was stamping (punching). For this operation, the enterprise had hundreds of standardized stamping sets corresponding to various profiles and notch shapes [5].

Figure 1 illustrates a fragment of this document that addresses the most commonly used cutouts for asymmetrical strip bulbs. For 19 profile numbers, 13 solutions for cutouts are proposed. As indicated, each cutout is defined by 5 parameters that are adjustable in increments, along with a single fixed parameter of 5 mm, which remains constant across all solutions. The leg of the weld seam varies from 3 to 6 mm, also adjustable in 1 mm increments. All dimensions are set in multiples of 5 mm, and their increments follow suit.

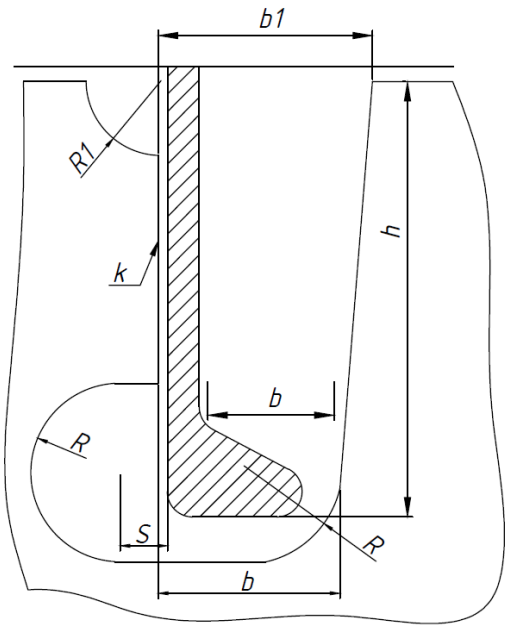

Figure 1. The flat bulb steel [5, p. 162]

Table 1 – Flat bulb steel size [5, p. 162]

designated element	№	h, mm	b, mm	b1, mm	R, mm	R1, mm	k, mm	area, cm^2
31.312-24	24a 24d	255	65	75	25	30	6	180
31.312-22	22a 22d	230	60	70	20	30	6	155
31.312-20	20a 20d	210	50	60	20	30	6	121
31.312-18	18a 18d	190	50	60	15	30	6 5	110
31.312-16	16a 16d	170	45	55	15	20	6 5	91
31.312-14	14a 14d	150	40	50	15	20	5	74
31.312-12	12	130	35	45	15	20	5	54
31.312-10	10	110	30	40	15	20	4	40
31.312-9	9	95	30	35	10	15	4	33
31.312-8	8	85	25	30	10	15	4	26
31.312-7	7	75	25	30	10	15	4	23
31.312-6	6	65	25	30	10	10	4	19
31.312-5	5	55	20	25	10	10	3	14

The analysis of the logic behind this unification suggests that it is largely geometric, without a direct connection to the integrity of the joints. The relative cutout heights (relative to the profile height) oscillate between ratios of 1.045 and 1.100. The relative cutout widths (relative to the head width) vary in a range from 1.94 to 2.19 as the profiles diminish. These cutout dimensions do not correspond to the 2mm profile wall thicknesses classified under index "b".

Viewed from a structural standpoint, a joint should ideally transfer an interaction reaction roughly equal to the load applied to the beam. During this transfer, tangential stresses that are tied to the cross-sectional area of the profile wall play a significant role. If this area increases by a factor of 1.25, logically, the cross-sectional areas of the weld seams along the profile "back" should also increase. However, this inference is not apparent from the table in Figure 1.

Aside from cutouts, such joints usually incorporate stiffeners (see Figure 2). The dimensions of these stiffeners are in no way related to the beam profiles, even though significant stresses and cracks along the welding seams emerge at their junction. To alleviate the stress levels, the joint needs to be augmented with extra components (see Figure 3). Reinforcements (see Figures 4 and 5) are deemed especially fruitful for this task, enabling the reliable force transfer from the beam to the frame wall. This method can expand the zone of contact by up to five times.

Therefore, analyzing the parameters of the cutouts and the nodes of beam

passage from a durability standpoint is a timely endeavor, given the present-day capacities of the Finite Element Method (FEM) and the technologies for automated component and even node creation.

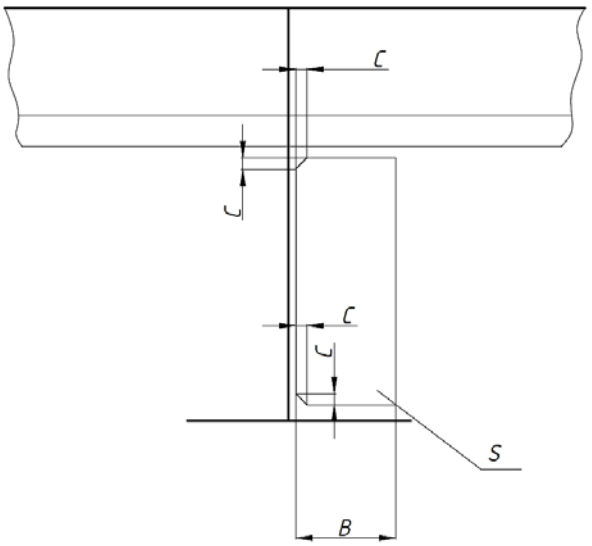

Figure 2. The stiffening ribs of frame tie walls [5, p. 122]

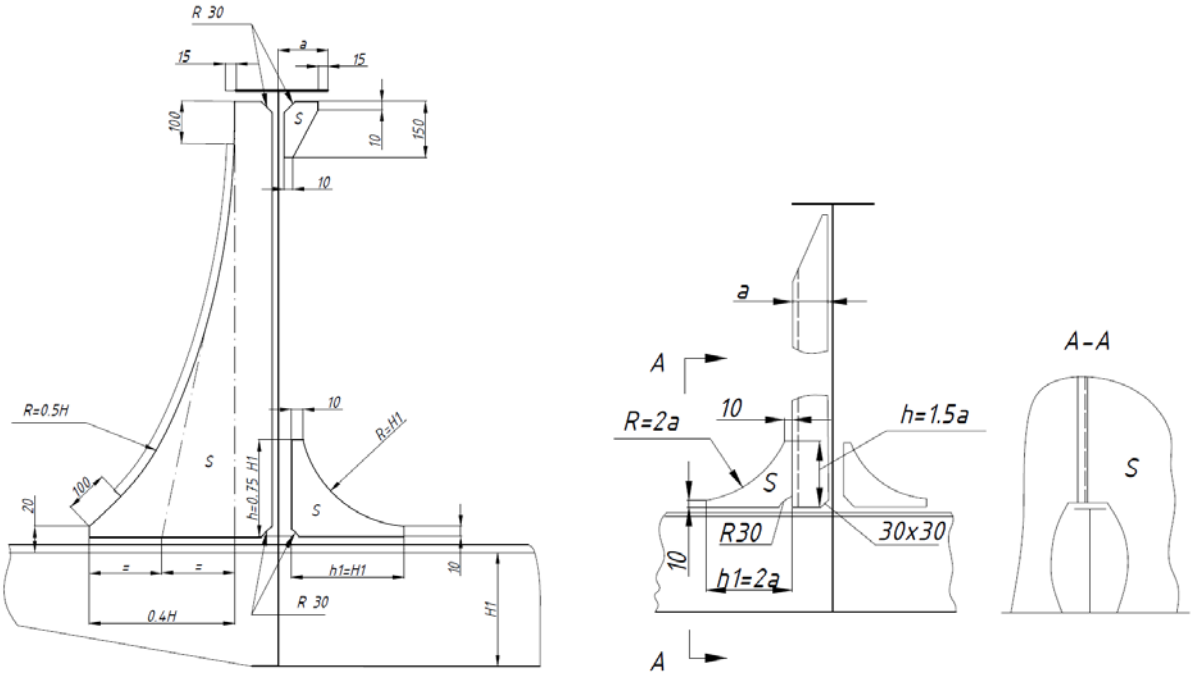

Figure 3. Solutions with additional elements in the girder passageway assembly [5]

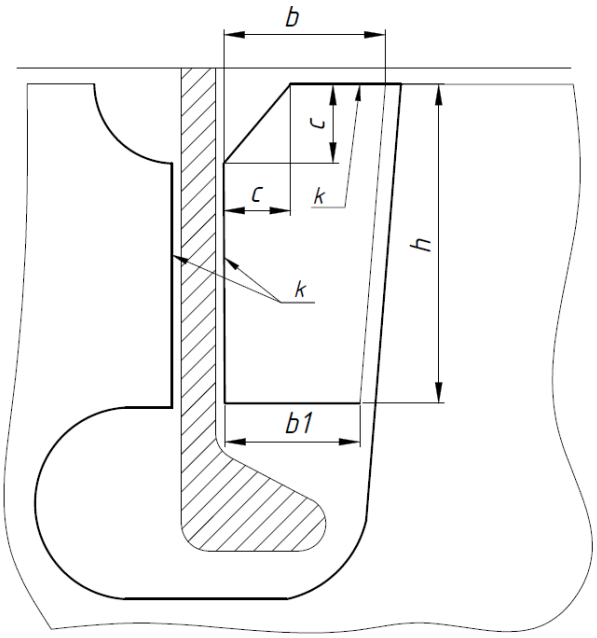

Figure 4. Filling cutouts for the flush passage of flat bulbs [5, p. 93]

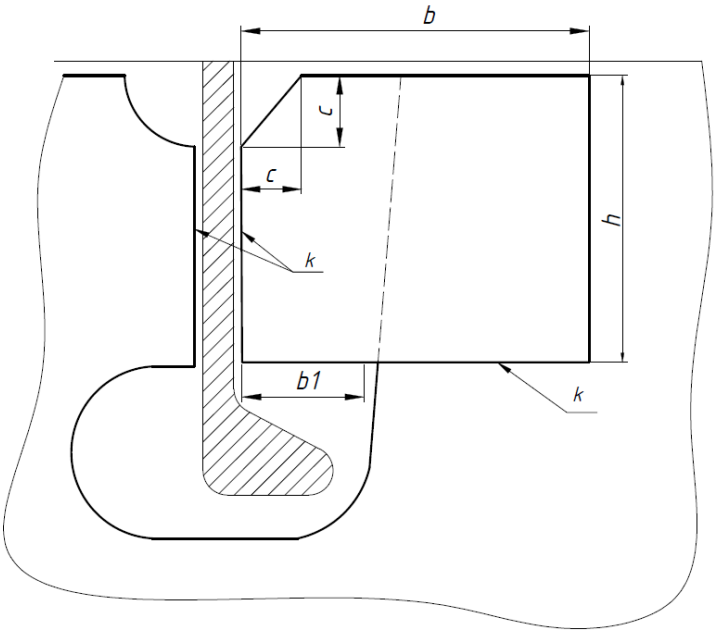

Figure 5. Sealing of cutouts for the overlapped passage of strip bulbs [5, p. 95]

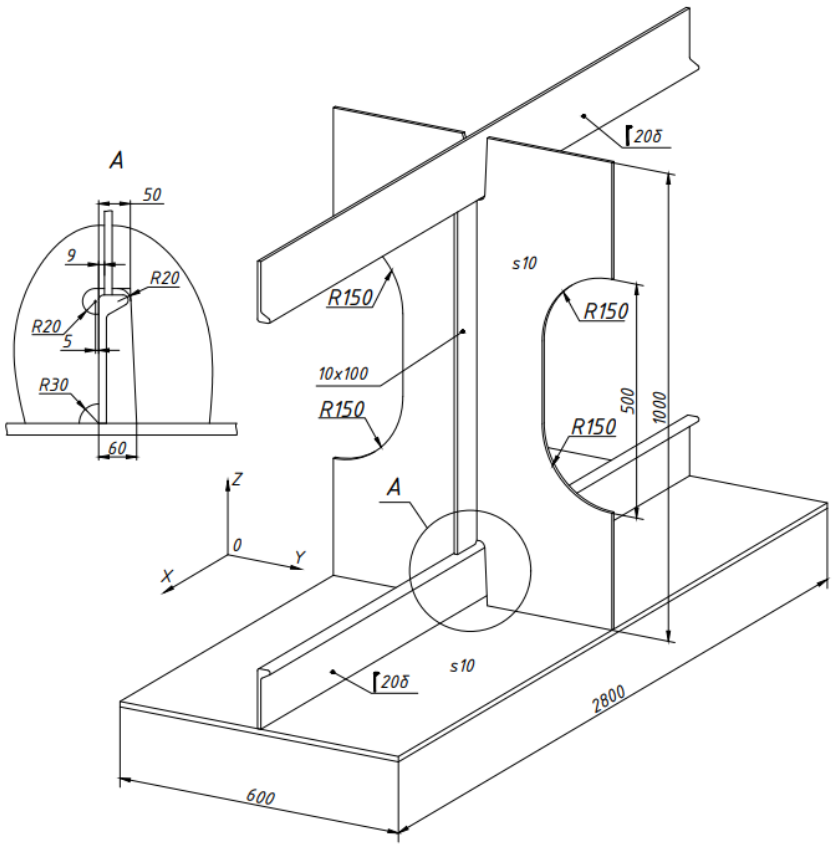

Figure 6. The schematic model for the analysis of joint A

The conditions for the model are as follows:

- The external siding takes pressure of 49 kPa;
- Grid of elements with a basic limitation of 50x50 mm and taking into account the curvature;
- The material of all elements is ordinary carbon steel;
- Contact of components is linked;
- No flooring is provided for the 2 bottoms, the top edges of the beam and the floor are not displaced along Z;
- Vertical edges of the floor are not displaced along the Y-axis;
- The edges of the outer cladding are correspondingly not displaced along the X and Y axes;
- The ends of the beams are not displaced along the X-axis.

The model object with the listed conditions is shown in Figure 7.

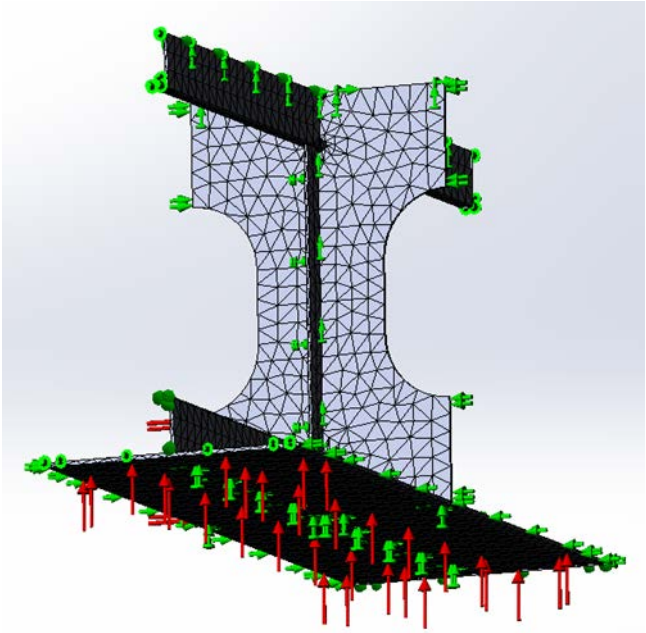

Figure 7. Model image with imposed boundary conditions (green) and applied pressure force (red)

In similar physical experiments [4], the following areas of the object were monitored (see Fig. 8): Area A – the edge of the cutout near the back of the profile; area B – at the point of contact of the straight edge of the cutout with the cladding; area C – in the area of the joint of the stiffening rib with the beam.

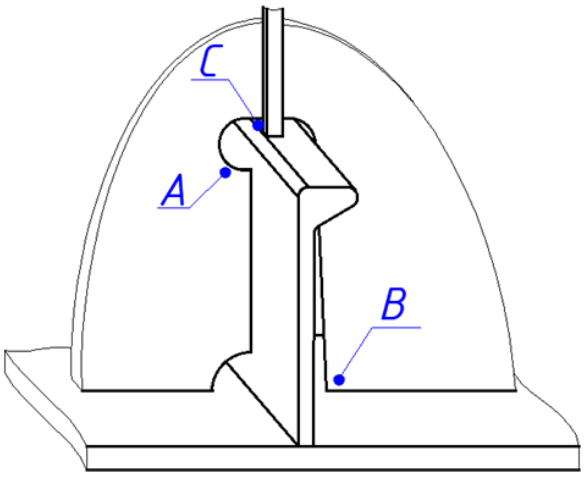

Figure 8. The placement of "indicator" zones in the node of the object

In addition to the mentioned "indicator" zones, the highest stresses in the external cladding (EC) were recorded. The stress value of 49 MPa (as for a single-span beam in the support section taking into account the post in the middle of the span) was taken for comparisons of relative stress levels. Figure 9 presents the calculation results for the base model. Figure 10 shows the stresses in the "indicator" zones for the same model, and Figure 11 shows the stresses in the EC.

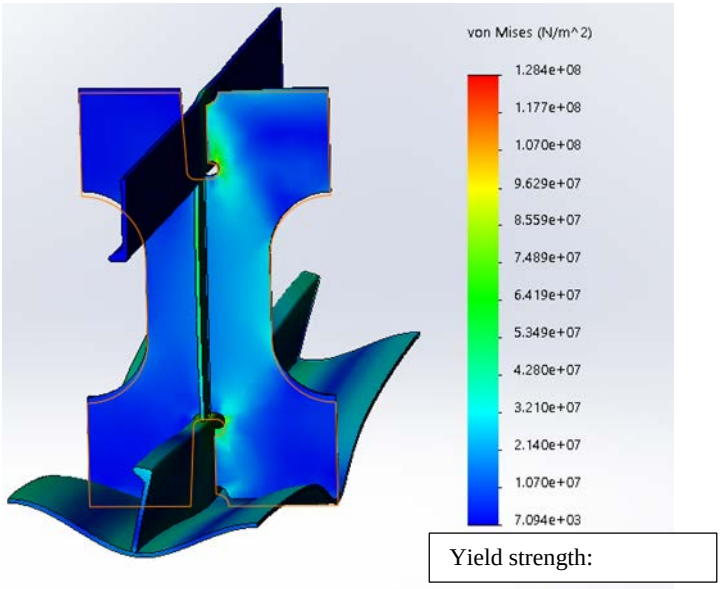

Figure 9. Deformations of the model and stress distribution (display scale 1:132)

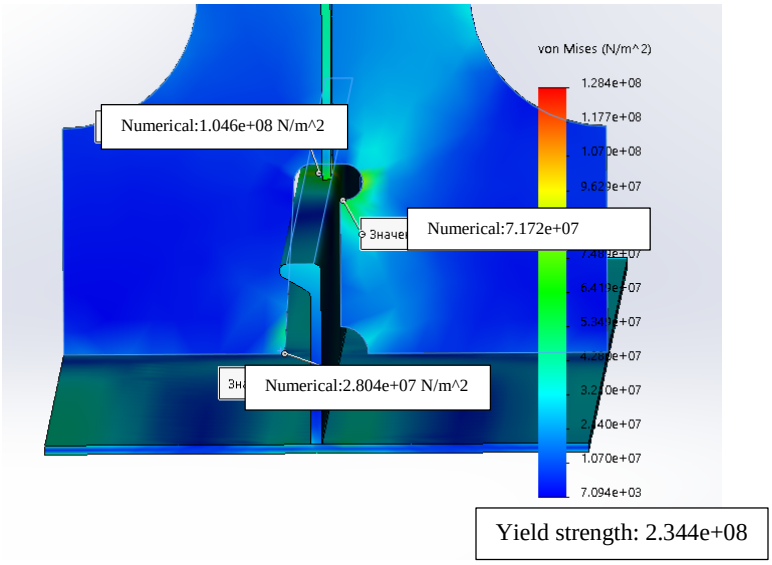

Figure 10. Stresses in the "indicator" zones of the base model

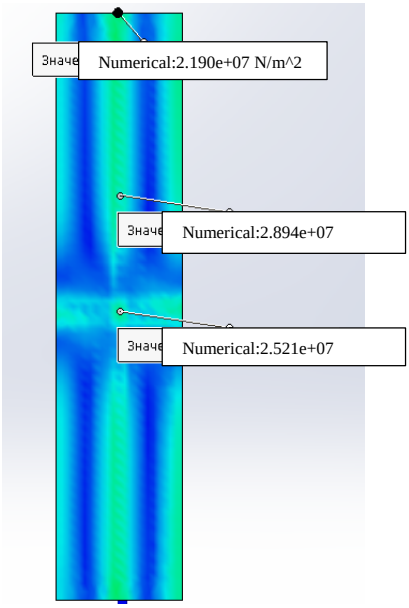

Figure 11. Stresses in the External Cladding (EC)

It can be seen that the highest stress level is on the beam (zone C = 104.6 MPa). Next is the stress at the joint where the cutout connects to the wall of the strip bulb (zone A = 71.2 MPa), and the smallest stress is experienced by zone B (28.04 MPa). The first part of the analysis consists of varying six parameters of the cutout for the beam passage (h, b, b1, R, R1, k - see Fig. 12). In addition to the base value of the size, three more variations were considered. In each case, a calculation was made, a stress distribution was constructed, and the maximum stresses in zones A, B, and C were measured.

The second part involves sequentially adding two types of joints (butt and lap) to the model, after which the model's finite element analysis is studied and compared with the base case. The joint schematics are shown in Figure 12.

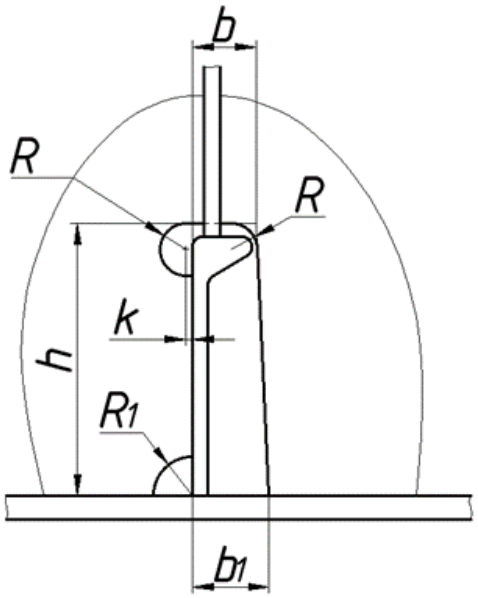

Figure 12. Notations of the cutout parameters

The main results of the calculations are presented in Table 2. They show that variations in the parameters of the cutout width (b and b_1) have little effect and do not significantly allow for the reduction of high stresses in zones A and C. The parameters of the cutout height (h) and the radius of the fillet (R_1) are not very significant. These parameters can, in principle, be recommended to be kept at the minimum level - according to the album [5].

Table 2 – Main results of finite element analysis calculations with variations of cutout parameters.

Parameter/base, mm	Variation, mm	Stresses (relative to yield 235 MPa)		
		Zone A	Zone B	Zone C
h/210	215	0,30	0,12	0,44
	220	0,36	0,11	0,46
	225	0,35	0,11	0,46
b/50	55	0,32	0,10	0,42
	60	0,33	0,10	0,41

	65	0,33	0,11	0,41
b_1/60	50	0,30	0,05	0,40
	70	0,30	0,04	0,41
	80	0,30	0,04	0,38
R/20	25	0,46	0,11	0,42
	30	0,42	0,08	0,43
	35	0,39	0,09	0,40
R_1/30	20	0,51	0,09	0,31
	40	0,48	0,10	0,31
	50	0,46	0,08	0,32
k/5	2	0,47	0,13	0,44
	8	0,44	0,11	0,51
	12	0,51	0,11	0,47

The parameters of the top cutout at the flange of the flat bulb – the radius of the semicircle (R) and the shift of the center from the flange of the flat bulb (k) – have a more significant, but twofold effect. Thus, an increase in the radius R in the range considered reduces the stresses on the edge of the cutout (zone A) by 46 %, but increases stresses in the area of the stiffener junction by up to 6 %. Increasing the offset (k) also significantly reduces stresses in zone A by 20 % compared to the base, while the increase in stresses in the area of the stiffener junction is insignificant (by 8 %).

After including the "overlap" fixture in the model, the maximum stress in zone A decreased approximately to the level of the others.

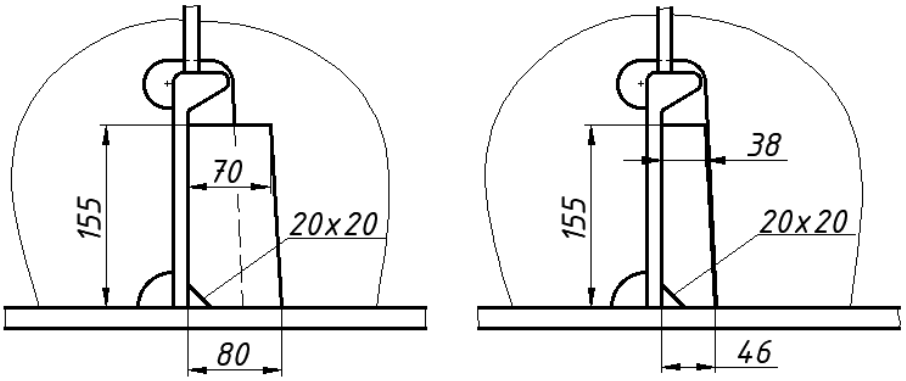

Figure 13. Diagrams with strengthening of the node by fixtures:
Left – "overlap"; Right – "butt"

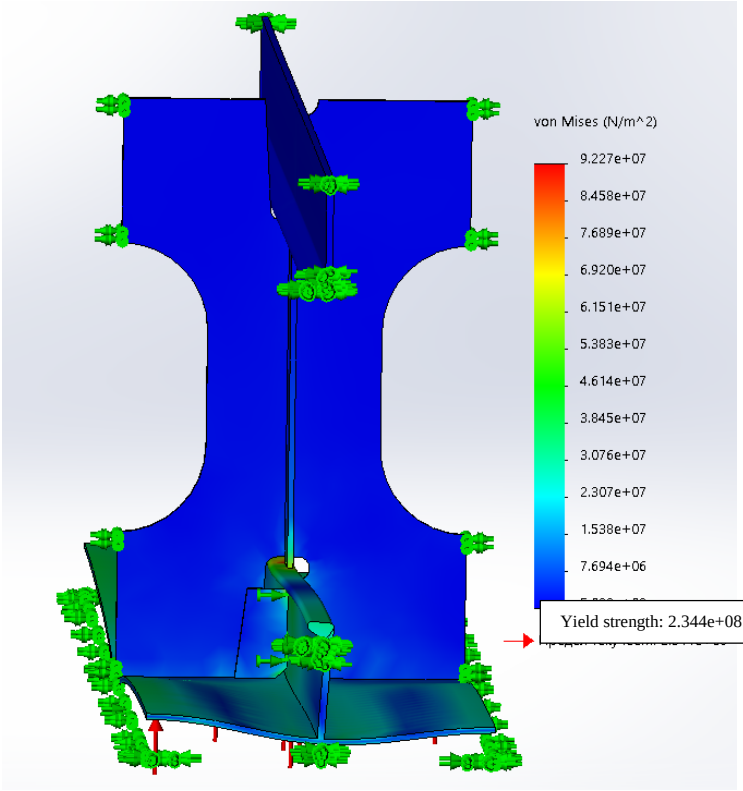

Figure 14. Reinforcement of the node by an overlapping fixture

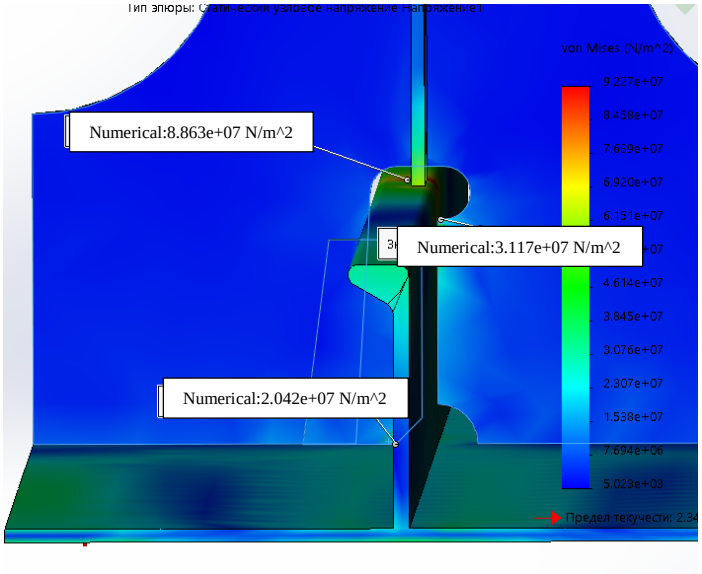

Figure 15. Measurements of stresses in a model that includes an overlapping fixture

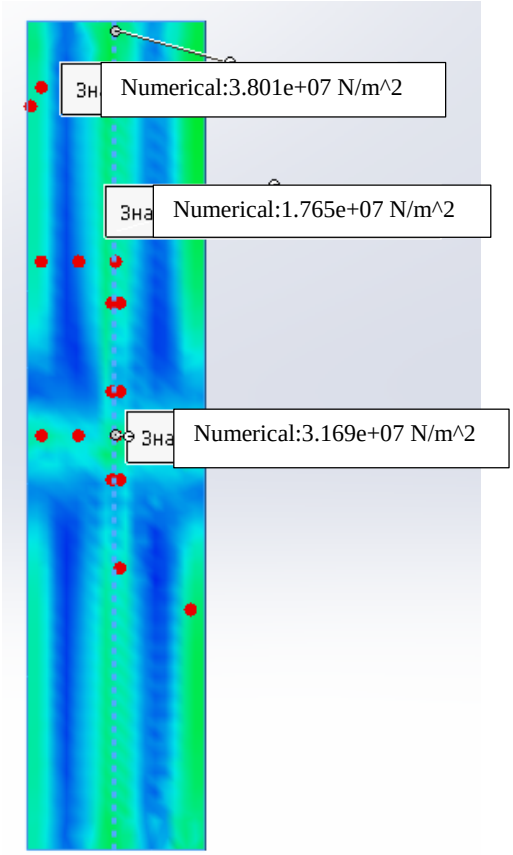

Figure 16. Stresses in the External Cladding (EC)

The measurements indicate that the stresses acting on the node have decreased, meeting strength requirements. In zone C, the stress was 86.3 MPa, which represents a reduction of 20.4 % compared to the variant "without fixture." At point A, the stress was 31.2 MPa, while in zone B it was 20.4 MPa, indicating a decrease of 56.1 % and 28.5 %, respectively.

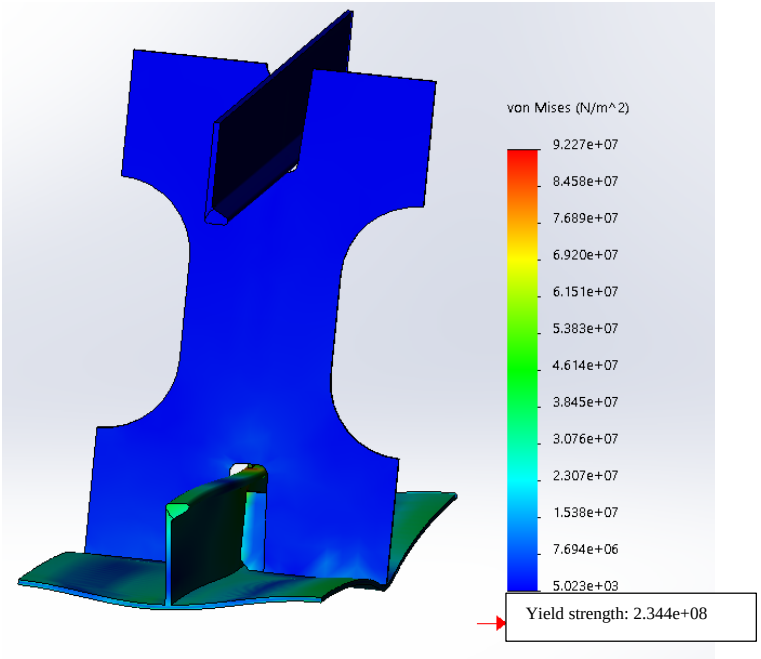

Figure 17. Reinforcing a joint by butt fastening

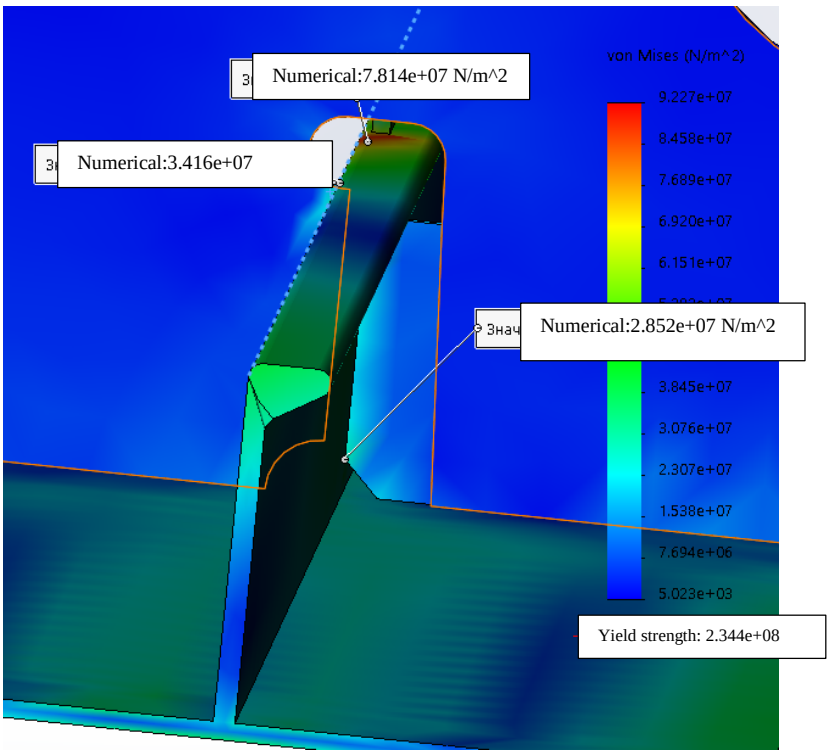

Figure 18. Stress measurements of a model including butt sealing

The "butt joint" fastening variant not only reduces stress levels compared to baseline measurements but does so significantly. For instance, in the "C" zone, stress is recorded at 78.1 MPa, showing a reduction of 22 % compared to the "no-fastening" scenario. Although there's a marginal decrease in stress at points A and B, this method is deemed more labor-intensive and less effective compared to the "overlap" fastening technique. Consequently, this approach is considered impractical due to the disproportional increase in labor intensity compared to the benefits derived from the "butt joint" fastening.

1. The analysis confirms that the cutout parameters for beam passage, as regulated in the album [5], meet the satisfactory levels for practical application. Of the six parameters governing the cutouts, four nearly reach the optimal range in terms of strength. The remaining two parameters (R and k) are identified as the most promising for further enhancement, particularly since the cutout section can be elliptically modified in automated cutting processes.

2. Implementing fastenings can reduce the highest stress levels by more than 20 %.

3. A comparative evaluation between different fastening techniques revealed that the "butt joint" fastening significantly impacts stress reduction at the joint more than the "overlap" fastening, despite their similarities.

4. A notable limitation identified in the joints from album [5] is the oversimplified approach towards specifying the dimensions of the fillet weld legs. This issue is particularly pronounced in the specification of the weld at the juncture where the stiffness rib and beam converge, which is the region of highest stress concentration.

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ANALYSIS OF THE APPLICATION OF AN ELECTRIC POWER STORAGE SYSTEM IN RESIDENTIAL COMPLEXES

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Abstract. The paper considers the reasons for the use of alternative energy sources and the transition to carbon-free power supply systems. The types of energy sources and the integration of alternative and traditional sources of electricity are considered. The general classification of electricity storage systems is given, the experience of application in residential neighborhoods is given, technical and economic indicators are indicated.

Keywords: energy storage system, power supply systems, lithium-ion chemical batteries.

АНАЛИЗ ПРИМЕНЕНИЯ СИСТЕМЫ НАКОПЛЕНИЯ ЭЛЕКТРОЭНЕРГИИ В ЖИЛЫХ КОМПЛЕКСАХ

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Аннотация. В работе рассмотрены причины применения альтернативных источников энергии и переход на безуглеродные системы электроснабжения. Рассмотрены виды источников энергии и интеграция альтернативных и традиционных источников электроэнергии. Дана общая классификация систем накопления электроэнергии, приведен опыт применения в жилых микрорайонах, указаны технико-экономические показатели.

Ключевые слова: системы накопления электроэнергии, системы электроснабжения, литий-ионные химические аккумуляторы.

The increase in the world's population, especially in urban areas with high population density, is one of the reasons for the exponential improvement in socio-economic conditions, including energy security issues. The increase in greenhouse gas

emissions, the rapid depletion of traditional fossil energy sources and the global mismatch between increased needs and available resources are the main problems. All branches of modern society must make significant efforts to improve the current situation. Several industries are trending towards greater electrification, and widespread electrification is expected to lead to increased demand for electricity.

Due to the increasing pace of electrification, the energy industry is projected to become more important in the energy supply system of the future. Finally, the energy system must be completely decarbonized. The transmission and distribution network infrastructure capacity must be guaranteed, as well as sufficient installed generating capacity and energy supply. Most power producers are large generators with a large mass, which provide greater inertia of the station.

At the same time, the architecture of the energy system has undergone a significant transformation as a result of the introduction of various types of renewable energy sources (RES). One of the main sources of energy on the planet is energy that reaches the Earth's surface using solar radiation. Among the advantages are easy accessibility, environmental friendliness and extremely efficient. In addition, it is currently widely used for the production of photovoltaic (PV) energy and the use of solar thermal energy. In order to reduce dependence on fossil fuels, efforts have focused on increasing the role of renewable energy sources in the traditional electricity grid. According to the Kyoto Protocol, an international agreement ratified by most countries, the goal of which is to reduce greenhouse gas emissions through increased use of renewable energy sources, should be achieved in the near future.

The integration of renewable energy systems poses challenges for traditional energy systems because they were not designed to provide such a high level of integration of renewable energy sources. Among the disadvantages of renewable energy sources is the instability of electricity generation, which is caused by the stochastic nature of solar, wind or other types of renewable energy sources. For example, solar panels may not work properly in cloudy conditions, wind turbines may not work properly when the air flow rate drops in windless conditions, and renewable energy sources can sometimes produce too much electricity, overloading the distribution network. Moreover, the integration of renewable energy sources can affect the voltage characteristics of the distribution network and the flow of electricity, which can lead to other catastrophic consequences.

To solve these problems and mitigate fluctuations in output power, frequency stabilization, voltage bias reliability and improve power quality, energy storage systems (ESS) can be a good solution. Energy storage systems are used to store energy generated by renewable energy sources when there is an oversupply of generating capacity, and use the saved energy to cover load requirements at its peaks. Another advantage of the ESS is that the electricity distribution network can integrate more renewable energy sources. The main ESS are discussed in the proposed article and the possibilities of their application in residential complexes and neighborhoods.

Many scientific and research papers are dedicated to the effects of energy storage system integration with large-scale renewable energy sources on system reliability, operation, optimization, and sizing in the literature. By transforming electrical energy into mechanical, thermal, and chemical energy, the energy storage

system retains electrical energy. There are various types of energy storage systems based on different principles, Fig. 1.

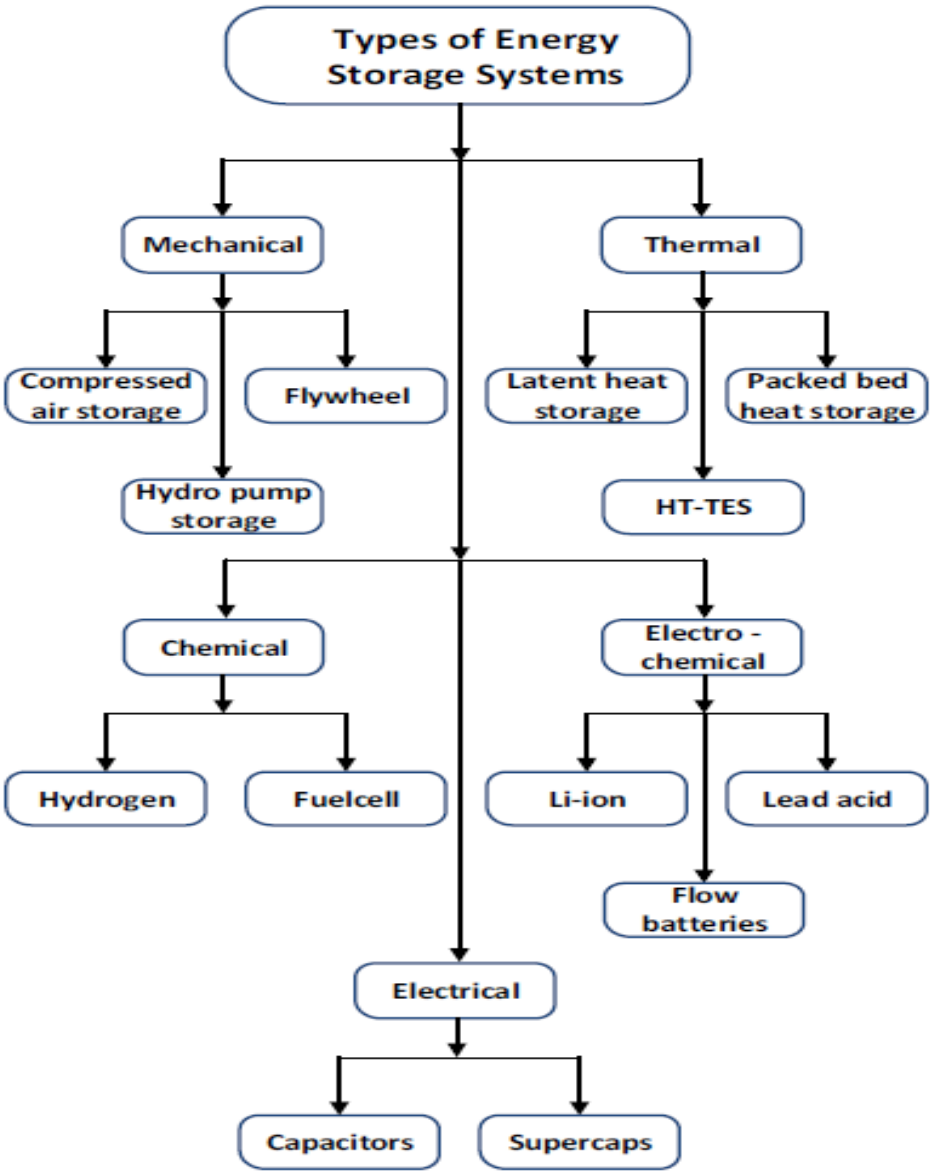

Figure 1. Some of the major types of ESS

After transforming electrical energy into any type of energy, it is initially kept in the storage device. Then at the next level the system that interfaces the distribution networks with the first stage, allows a bidirectional flow of electricity. Using sensors and other measurement equipment, the final stage establishes the charge or discharge degree of the energy being stored, Fig. 2.

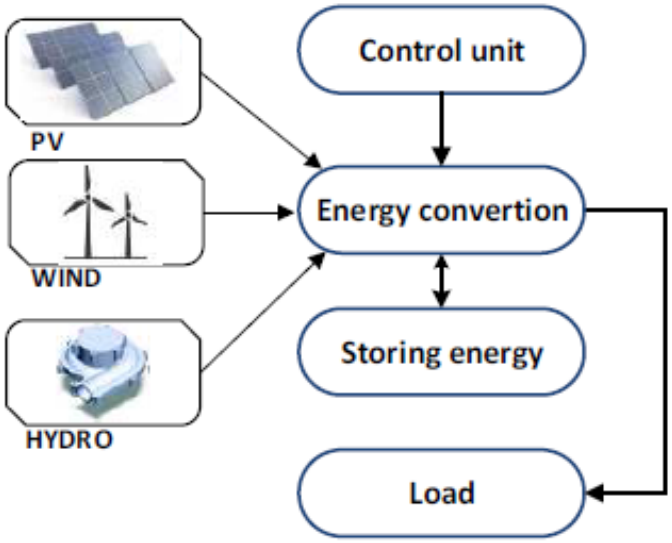

Figure 2. Different conversion levels of energy storage system

Energy storage systems can be categorized into a number of different types according to how a particular type of energy is used. Some of the most popular technologies are discussed.

Mechanical energy storage system (MESS), at its most basic level, has been practiced for a very long time and is one of the simplest solutions. Various mechanical tasks can be accomplished using stored energy.

A thermal energy storage system (TESS) enables the heating and cooling of subsequent use. Anytime there is an imbalance between the production and use of energy, TEST can help with the optimal use and delivery of thermal stored energy.

In electrochemical energy storage systems or battery energy storage systems (BESS) the chemical energy is shifted into electrical energy during the electrochemical reactions. A reaction occurs throughout this conversion process, and the resulting energy is stored as electricity.

BESS is one of the most popular energy storage systems because of its quick reaction to disturbances, scalable size, and autonomy. Battery energy storage systems enhance the integration of renewable energy sources into the distribution grid network, and increase the system's robustness, and flexibility. Some information regarding the characteristics of Li-ion based BESSs are shown in Table.

Table – Main characteristics of Li-ion battaries

Cathode chemistry	Maximum number of cycles	Average specific capacity (mA/h)
LTO	up to 20,000	175
LFP	up to 9000	155
LCO	up to 1000	190
LMO	up to 1500	115
NMC	up to 2500	170

Lithium-ion chemistry-based batteries currently dominate the global mass

market but other types of batteries like lead-acid, and flow battery technologies have also been used to some point.

Optimal operation of ESS can provide additional benefits such as cost reduction, increased reliability and, finally, make these systems more attractive to use.

To ensure reliable and efficient energy management, a distributed small-scale energy storage system is a good option. In a distributed system, the energy storage system is fully connected to renewable energy sources with interfaces consisting of power electronic devices. Maximizing the benefits of shared renewable energy sources with equal coordination, and the distribution of energy flow is the main need for approaches to optimizing energy storage systems. Three common factors – economic, technological, and environmental considerations – can also be used to develop energy storage optimization goals.

The vulnerability of an energy storage system is a problem that occurs when an external disturbance disrupts the operation of the system and creates obstacles to its return to normal after the disturbance occurs. Thus, the reliability of the power system plays an important role during operation. Taking into account factors such as maintaining frequency control, reducing output power fluctuations, voltage regulation and time shift, an autonomous energy storage system can significantly improve the reliability of the system. Thus, the use of energy storage systems helps to increase the overall reliability of the power supply system, including residential complexes and neighborhoods.

The assessment conducted by the CSR Foundation shows that the use of ESS to manage the daily consumption profile of urban residential development facilities, even with current market prices for ESS and current rules of the electricity and capacity market, allows for the construction of a microdistrict with an attached capacity of about 8.5 MW to receive the NPV of an investment project up to 65 million rubles over a 10-year cycle (with a discount rate of 10 %) [1].

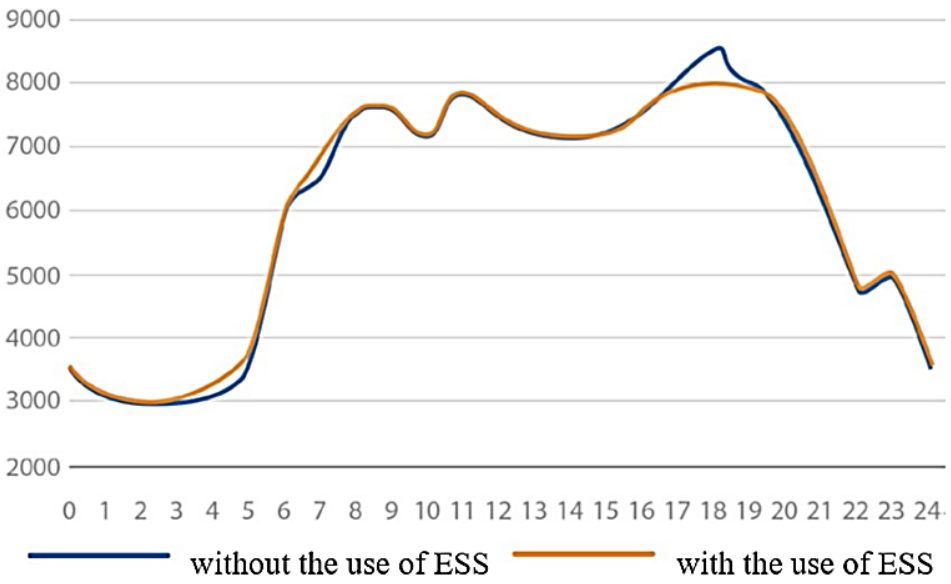

Figure 3. ESS capabilities for managing the hourly electricity consumption profile in a residential neighborhood (kWh)

In this case, the capital cost of the ESS installation with a capacity of about 1 MW and a capacity of 2 MW = h will amount to 80 million rubles. The effects of the use of ESS are achieved by:

- reduction of charges for consumed electricity due to a decrease in consumption during high-price hours and an increase in consumption during low-price hours (price arbitrage);
- reduction of power consumption charges by reducing consumption during estimated (peak) hours;
- reduction of fees for transmitted power due to reduced consumption during estimated (peak) hours;
- reducing the cost of technological connection by reducing the need for connected power to consumers.

The model calculations of the CSR Foundation show that the replacement of peak generation – capacities used only a few dozen hours per year due to the peculiarities of electricity consumption profiles – by ESS allows reducing the cost of construction and operation of such peak capacities by almost 20 %. For example, according to the CSR Foundation, the construction of an electric power plant in the energy system of the Far East would cost 3 billion rubles and provide the NVP of the project (on a 10-year cycle with a 12 % rate) at the level of 156 million rubles [2].

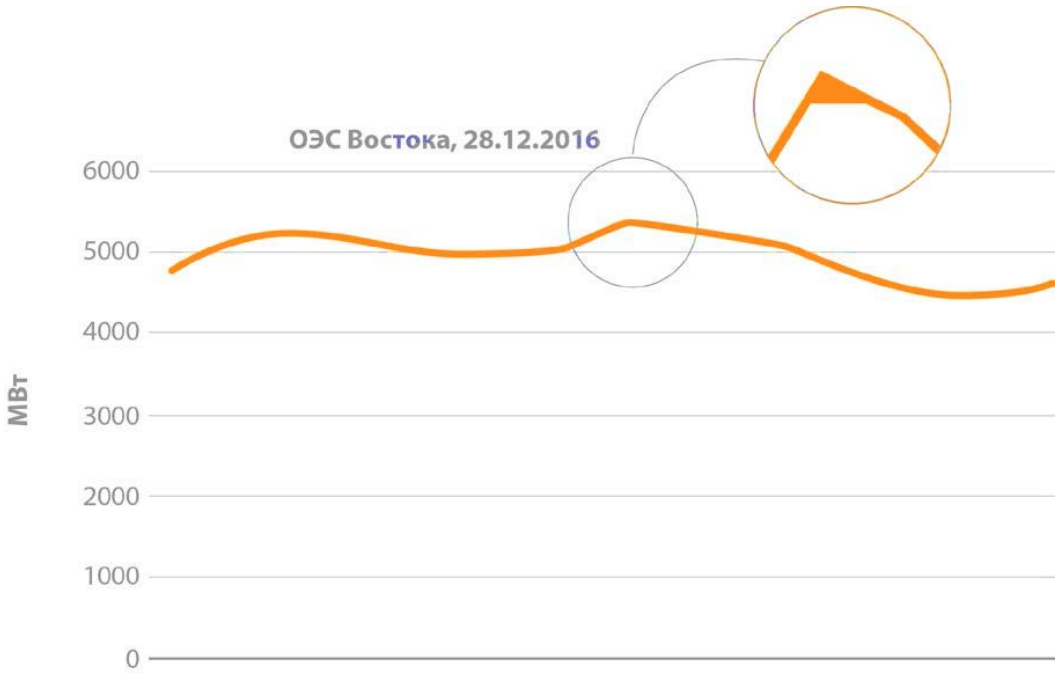

Figure 4. The place of peak generation in the generation profile in the ECO of the East on the example of the power graph of generating facilities for December 28, 2016

Source: CSR Foundation according to JSC "System Integrator"

Energy storage systems can play an extremely important role in the transition to a fundamentally new architecture of power supply systems for residential, commercial real estate and social infrastructure facilities – DC systems. ESS are integrated into direct current systems much easier and cheaper than into alternating current systems, due to the fact that expensive inverters do not need to be used. At the

same time, the role of ESS consists primarily in internal power balancing in power systems and DC networks (the role of a support-balancing storage device), where the integration of distributed generation sources is also simplified. In addition, ESS will optimize the consumption profile, reduce the need for connected power and implement one of the options for wireless charging of devices based on capacitive power transmission.

The transition to the construction of DC power supply systems for residential districts can ensure the achievement of the following beneficial effects [3]:

– due to a more than twofold increase in the voltage in distribution networks (from 380 V for AC networks to 880 V for DC networks), the cross-section of the distribution network lines of the microdistrict decreases and their effective length increases;

– when forming semi-circular lines, substations of 20/0.88 kV can be arranged as single-transformer and at the same time provide the first category of power supply;

– the possibility of implementing a backbone scheme significantly reduces the volume of cable products;

– the size of the alienated territory for the construction of substations and distribution network is reduced;

– problems with the consumer's voltage level and reactive power are eliminated;

– Technical and commercial losses are reduced;

– easy integration of energy storage and renewable energy systems is provided.

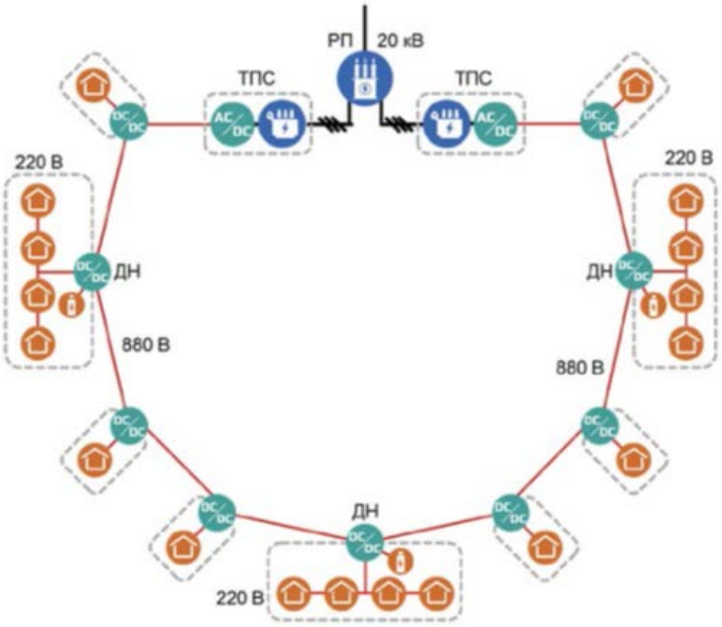

Figure 5. Architecture of the DC power supply system of a residential neighborhood

Source: CSR Foundation

As part of the DC power supply system, it is proposed to reduce the estimated required power of the receivers and thereby reduce the power of the technological connection, taking into account the following factors:

– reduction of technical losses of active power up to 2-3 %;

– reducing the need for connected power by transferring only active power;

– implementation of intelligent load control algorithms implemented through the operation of intelligent interfaces, for example, DC/DC converters in apartments that do not allow simultaneous switching on at full power of more than one receiver.

– The implementation of all these possibilities will reduce the required connected capacity of a residential building (apartment or household) to the nominal capacity of the largest receiver (device) of electricity. In general, we can expect a reduction in the need for connected power up to 3-5 times per room [4].

Due to the variable generation characteristics and stochastic nature, the integration of renewable energy into the network is fraught with serious negative problems. Among these problems are a decrease in the quality of electricity, unstable output voltage, frequency fluctuations and increased complexity of operation and maintenance. The total ESS capacity is expected to increase to 800,000 kWh by 2030. An overview of the most common types of ESS that have been presented in recent scientific publications and literature is presented in this article. This study also evaluated the results of theoretical and experimental studies of the use of ESS in residential areas and neighborhoods carried out by various researchers in this field. The main types of energy storage systems were briefly described.

Despite the fact that this is a fast-growing field of research, there are still some aspects that need to be addressed. More efficient and improved optimization methods are required to ensure stable, efficient and cost-effective operation of energy storage systems. Among the promising areas of research: the development of new modeling and experimental techniques to optimize the size, structure and management strategies that can have a positive impact in terms of reducing costs, increasing productivity, minimizing electricity losses, improving electricity quality and reducing carbon dioxide emissions. In addition, more attention needs to be paid to power outage scenarios and the role of ESS in restoring the system after a failure occurs. Thus, the reliability of the system increases.

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УДК 65.011.56

MACHINE-TO-MACHINE COMMUNICATION IN INDUSTRY 4.0

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Abstract. The paper explores the pivotal role of Machine-to-Machine (M2M) communication within the framework of Industry 4.0. The integration of intelligent machines and devices into plants is considered, as well as the way M2M communication protocols optimize automation, enhance efficiency, and enable real-time data exchange. The article sheds light on emerging trends, challenges, and new opportunities in the field of industrial process automation.

Keywords: CoAP, MQTT, industrial process automation, Industry 4.0, M2M communication.

МЕЖМАШИННАЯ КОММУНИКАЦИЯ В ИНДУСТРИИ 4.0

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Аннотация. В статье рассматривается роль межмашинной коммуникации (M2M) в рамках Индустрии 4.0. Исследуется интеграция интеллектуальных машин и устройств в производства и то, каким образом протоколы коммуникации M2M оптимизируют автоматизацию, повышают эффективность и обеспечивают обмен данными в режиме реального времени. Также анализируются тенденции, проблемы и новые возможности в области автоматизации промышленных процессов.

Ключевые слова: CoAP, MQTT, промышленная автоматизация, Индустрия 4.0, межмашинные коммуникации.

In the era of Industry 4.0, the merger of digital technologies with traditional industrial processes leads to a significant shift in manufacturing and automation. Industry 4.0 represents a paradigm shift in how goods are produced, monitored, and optimized. At the heart of this revolution lies the concept of connectivity – the interlinking of machines, systems, and processes through advanced communication technologies. Among these, Machine-to-Machine (M2M) communication stands out as a base, contributing to the exchange of data and commands across many interconnected

devices. In the context of Industry 4.0, M2M communications play a pivotal role in controlling complex automated processes, enabling machines to communicate, collaborate, and coordinate seamlessly. At present, the aim of automation is to capitalize on the potential of interconnected technologies in order to increase the productivity of the industry.

This article focuses on a comprehensive exploration of M2M communication, revealing their role and potential in driving efficiency, productivity, and innovation across industrial domains.

At the heart of Industry 4.0 lies the integration of intelligent machines, which have the ability to communicate, analyze data and adapt autonomously to changing conditions. M2M communication is the backbone of this interconnected ecosystem, facilitating uninterrupted interaction and collaboration among diverse machinery and equipment, from sensor networks and control systems to robots and automated guided vehicles (AGVs) [1]. The merging of intelligent machines fosters agility, flexibility, and responsiveness in industrial operations.

Automation efficiency depends on the robustness of communication protocols that enable machines to exchange information swiftly and securely. M2M communication protocols, such as MQTT (Message Queuing Telemetry Transport) and CoAP (Constrained Application Protocol), play a pivotal role in organizing the flow of data across disparate devices and platforms. By ensuring compatibility, reliability, and low latency, these protocols allow industrial systems to synchronize processes, coordinate tasks, and adapt in real-time to dynamic production requirements. They also create a network of interconnected devices.

MQTT, or Message Queuing Telemetry Transport protocol, is a lightweight, open-source messaging protocol designed for efficient communication between devices in unreliable networks, especially those with low bandwidth or high latency. It is based on the “publisher-subscriber” model [2]. This model is given in Figure 1, where

- a publisher is a device or application that generates data or events and publishes them to specific topics on the broker;
- a subscriber is a device or application that subscribes to specific topics on the broker to receive messages related to those topics;
- a broker is the intermediary server responsible for receiving messages from publishers and routing them to subscribers based on topic subscriptions [3].

Originally created to monitor oil pipelines, MQTT has evolved into a widely adopted protocol for Internet of Things (IoT) applications, including industrial automation, smart homes, healthcare, transportation, and more.

MQTT is widely used in industrial automation for real-time monitoring, control, and data acquisition. It enables uninterrupted communication between sensors, actuators, PLCs (Programmable Logic Controllers), SCADA (Supervisory Control and Data Acquisition) systems, and other industrial devices, facilitating predictive maintenance, process optimization, and remote management. Furthermore, MQTT is employed for fleet management, vehicle tracking, and supply chain optimization. It allows for seamless communication between vehicles, logistics centers, and back-end

systems. This makes it possible to optimize routes, manage inventory effectively, and track shipments and deliveries in real time.

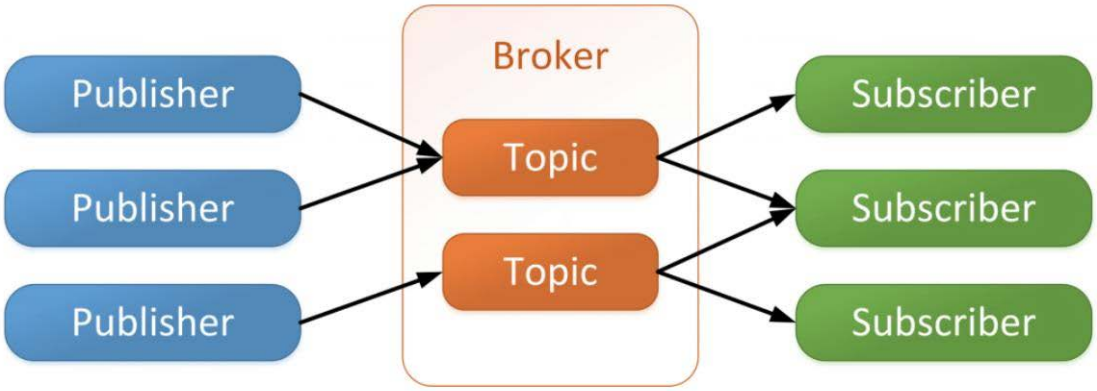

Figure 1. The “publisher-subscriber” model

Constrained Application Protocol (CoAP) is a specialized web transfer protocol designed for use in constrained environments, such as those with limited bandwidth, memory, or processing capabilities. CoAP enables communication between IoT devices and applications using a client-server model, similar to HTTP. However, CoAP is specifically optimized for constrained environments. It provides lightweight messaging, low overhead, and support for unreliable networks. The functioning scheme of this protocol is provided in Figure 2.

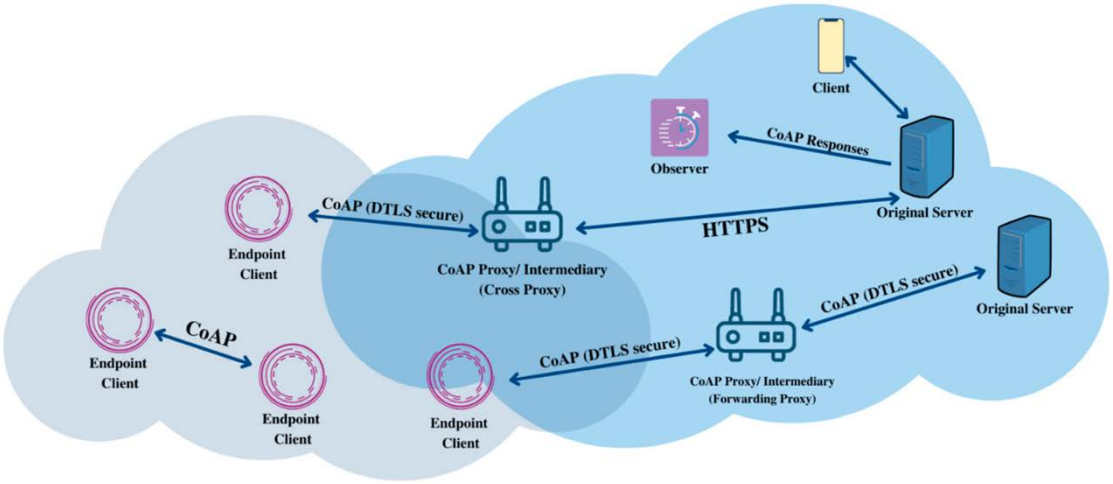

Figure 2. The functioning scheme of CoAP

CoAP is used in industrial automation and controlling systems to enable communication between sensors, actuators, and control devices within manufacturing, warehouses, and industrial buildings. Its lightweight and efficient messaging capabilities make it well-suited for monitoring and controlling industrial processes, optimizing resource usage, and enabling predictive maintenance.

Real-time data exchange is one of the main requirements of manufacturing in Industry 4.0. It enables continuous performance monitoring by providing real-time

control over key performance indicators (KPIs) and production metrics. M2M communication facilitates the uninterrupted transmission of sensor data, performance metrics, and diagnostic information across interconnected devices, enabling quality control and process optimization [4]. Through continuous monitoring and analysis, plants can reduce downtime, minimize waste, and enhance overall operational efficiency. With the help of M2M communications, sensor data from machinery and installations are transmitted in real-time to centralized monitoring systems, where algorithms analyze patterns to predict potential failures or maintenance needs.

By integrating data from production systems, vendor information, and market demand forecasts, it is possible to adjust production schedules and allocate workforce resources in real-time. This flexible approach to resource allocation enhances operational efficiency and reduces inventory holding costs.

One of the striking examples of applying M2M communication is the Russian company KAMAZ. It has designed its own fleet management system called “Fleetly” [5]. Using M2M communication, this system is able to track vehicle routes, control parts wear, and automatically schedule repairs.

Another example from Russian industry is Gazprom Neft. It actively uses M2M communication to ensure remote control of oil pipelines [6]. M2M communication technology is used by a vast list of big companies all over the world, including Amazon, Siemens, General Electric, Bosch, Sberbank, Rosatom, Rostelecom.

While M2M communications offer numerous opportunities in industrial automation, they also have certain challenges and problems. Compatibility issues, cybersecurity threats, and data privacy concerns underscore the need for robust standards, protocols, and specialists. By utilizing advancements in artificial intelligence, machine learning, and edge computing, enterprises can find new ways to apply M2M communication and change the future of industrial automation.

M2M communication is also used in such fields as building the smart city system, healthcare and telemedicine, farming, energy, home automation, and banking [7].

M2M communication serves as the backbone of the nowadays industry, allowing enterprises to achieve new levels of efficiency, agility, and competitiveness. By integrating up-to-date technologies and solving inherent challenges, we will get the full potential of this technology to shape a smarter future for industrial automation.

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УДК 811.93

INTEGRATION OF METHODOLOGICAL RESOURCES TO OVERCOME LANGUAGE BARRIERS IN IT

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Abstract. Addressing linguistic hurdles in programming instruction, this study proposes the creation of innovative teaching aids aimed at fostering an inclusive educational milieu for a linguistically diverse populace. The research outlines the conception of intuitive, interactive, and culturally-informed pedagogical materials, drawing on feedback from students and educators and the expertise of linguists. The ultimate goal is to enrich the educational experience and ensure that linguistic diversity becomes an asset in learning the universal language of programming.

Keywords: programming training, language barrier, teaching aids, teaching materials, English language, terminology, education.

ИНТЕГРАЦИЯ МЕТОДИЧЕСКИХ РЕСУРСОВ ДЛЯ ПРЕОДОЛЕНИЯ ЯЗЫКОВЫХ БАРЬЕРОВ В IT

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Аннотация. Для устранения лингвистических препятствий при обучении программированию в данном исследовании предлагается создать инновационные учебные пособия, направленные на создание инклюзивной образовательной среды для представителей языкового разнообразия. В исследовании излагается концепция интуитивно понятных, интерактивных и учитывающих культурные особенности педагогических материалов, основанная на отзывах студентов и преподавателей, а также опыте лингвистов. Конечная цель – обогатить образовательный опыт и обеспечить языковое разнообразие при изучении универсального языка программирования.

Ключевые слова: обучение программированию, языковой барьер, методические пособия, учебные материалы, английский язык, терминология, образование.

As global interconnectivity and technological advancements redefine our era, the

imperative of grasping programming know-how escalates to paramount importance within educational curricula. By fostering analytical reasoning and serving as the conduit for spearheading cutting-edge projects, programming is swiftly becoming the quintessential competence for a broad spectrum of professions. Nonetheless, the linguistic divide, primarily the pervasiveness of English in the realm of IT, constitutes a formidable barrier deterring a multitude of students who lack prior exposure to the language.

The exigency for delving into and cultivating methodological tactics and resources, tailored to surmounting programming's linguistic obstacles, is motivated by a burgeoning demand for adept IT professionals and the imperative for assimilating academicians from disparate linguistic and cultural milieus into a cohesive global educational domain.

This scholarly pursuit endeavors to meticulously address the linguistic divide within the programming pedagogical landscape, aspiring to forge efficacious pedagogical tools that accommodate the linguistic tapestry present in contemporary learners. The objective is etched out through a set of delineated investigative tasks [1]:

1. Scrutinize and decode the principal linguistic and cultural impediments impinging upon the programming learning trajectory.

2. Dissect prevailing pedagogical frameworks, gauging their merits and deficiencies from the vantage point of a multicultural scholastic setting.

3. Conceive and sculpt methodical resources attuned to eradicating linguistic and cultural barricades.

4. Undertake diagnostic evaluations of these resources to ascertain their impact and hone their effectiveness.

Substantiating the need to bridge language gaps stands to refine educational practices, while pioneering and propagating specialized methodical resources will enhance programming's pedagogical accessibility and equity.

A linguistic barrier within academia is a phenomenon wherein a scholar grapples with the assimilation and application of a non-native vernacular within communicative or educational contexts. Pedagogical linguistics contemplates this dilemma when a student is confronted with an obstructive learning challenge, diverging from their inherent linguistic framework.

Predominantly, this schism is evident in aspirants whose mother tongue diverges from English, complicating the assimilation of programming dialects deeply rooted in English lexicon. This yields interpretational ambiguities in deciphering programming syntax, keyword functionality, and pertinent literature comprehension, escalating to misinterpretations when engrossed in code commentary and annotation [2].

Notably, cultural prisms influence logical computation and algorithmic thought processes, constituting core tenets of programming virtuosity. These cognitive disparities harbor potential inhibitions within educative contexts.

A plethora of pedagogical stratagems has surfaced to navigate these linguistic mazes, providing support to learners in their quest to master programming. Incorporating pseudocode exemplifies a strategy enabling initial conceptual grasps in one's native idiom prior to code engagement. Other methodologies prioritize refining English proficiency tailored for IT specialists, advocating for dual-language

documentation and instructional mediums.

Despite diligent efforts, transcending linguistic barriers in programming tuition remains a pressing concern, necessitating unrelenting inquiry and the genesis of advanced, impactful pedagogical models.

The following criteria have been identified to evaluate the effectiveness of the methodical aids [3, 4]:

1. Clarity and understanding: The materials must be written in a clear and comprehensible language to facilitate understanding of programming concepts.

2. Compatibility: The aid should easily be incorporated into existing course programs.

3. Feedback mechanism. Establishing a system for gathering feedback from both students and educators is crucial for refining and enhancing methodical materials.

4. Interactive elements. Integrating interactive exercises and hands-on tasks may enhance material retention and practical application.

5. Cross-cultural learning. Enriching materials with cross-cultural elements will enable students to better navigate the international educational landscape.

6. Technical support. Strengthening technical assistance for educational resources, including online platforms and mobile applications, will allow for more accessible learning materials.

7. Collaborative development. Jointly crafting educational content with linguists and intercultural communication experts will fortify the quality of the resources.

The constant application of these recommendations will foster an optimized educational environment, accommodating thorough consideration and dismantling of the language barriers encountered in programming studies.

To facilitate a visual representation of information, a table may be constructed comprising three primary columns [5, 6]:

1. Operator Designation. The first column should list the nomenclature of the operator as encountered within program code.

2. Operator Provenance. Considering the origin of most programming operators stems from English lexicons, it is pertinent to annotate their etymology. That is to elucidate the word or array of words from which the operator's designation has been derived.

3. Operator Functionality. Post familiarization with the nomenclature, it is imperative to cultivate an understanding of the operator’s semantic role within code to ensure its adept utilization in coding practices.

Such a tabular compendium is instrumental in fostering the logical retention in learners. With consistent review of the 'approximate translation' of the operator, over time the student will naturally navigate both the signification and application of the operator within the programming code.

In conclusion, this research has aggregated a series of insights and recommendations that are paramount for advancing programming education in a linguistically diverse learning environment. The significance of integrating interactive exercises, embracing intercultural elements, and ensuring robust technical support is clear in enhancing the educational experience. Moreover, the collaboration with linguists and intercultural experts is invaluable for producing high-quality manuals that

are sensitive to the nuances of language and culture.

Throughout this study, we have navigated through various dimensions of learning challenges and have strived to understand the core elements that constitute effective teaching aids. It is evident that overcoming linguistic barriers in programming is not a one-dimensional issue but a multifaceted challenge that requires continuous attention and a dynamic approach.

As we move towards an increasingly interconnected and technologically advanced future, the need for such tailored educational materials will only continue to grow. Through consistent application and refinement of the proposed methodologies, we are setting a new benchmark for programming education that is inclusive, comprehensive, and capable of equipping students with the necessary tools to succeed in our global digital landscape.

Ultimately, by addressing the language barriers head-on, we reaffirm our commitment to fostering an educational ecosystem where linguistic diversity is no longer a barrier but an asset enriching our collective understanding of the universal language of programming.

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ADVANCEMENTS IN SPACE INDUSTRY FOR SPACE TOURISM AND SPACE STATION EXPANSION

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Abstract. This article presents the analysis of innovations in the space industry with a focus on the prospects for the development of space tourism and the launch of new space stations. It discusses the current and future trends in the space industry: use of new technologies, development of space tourism, and integration of innovative approaches in the creation and servicing of space stations. Special attention is paid to the impact of space tourism on the development of space infrastructure.

Keywords: space tourism, space station, space industry, artificial intelligence, automated systems.

ИННОВАЦИИ В КОСМИЧЕСКОЙ ПРОМЫШЛЕННОСТИ: КОСМИЧЕСКИЙ ТУРИЗМ И РАЗВИТИЕ КОСМИЧЕСКИХ СТАНЦИЙ

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Аннотация. Данная статья посвящена анализу инноваций в космической промышленности с упором на перспективы развития космического туризма и запуска новых космических станций. В статье рассматриваются современные тенденции в космической отрасли, включая использование новых технологий, развитие космического туризма, а также интеграцию инновационных подходов в создание и обслуживание космических станций. Особое внимание уделяется перспективам роста космического туризма и его влиянию на развитие космической инфраструктуры. Научная статья представляет собой аналитический обзор современного состояния и будущих трендов в космической промышленности.

Ключевые слова: космический туризм, космическая станция, космическая промышленность, искусственный интеллект, автоматизированные системы.

The space industry is a sector dedicated to the exploration, development, and exploitation of space. It includes various sectors such as the development and launch of spacecraft, the creation of space stations, conducting scientific research in space, and the development of space tourism. The space industry plays a key role in expanding human understanding of the Universe, providing opportunities for the exploration of new technologies and scientific discoveries beyond our planet.

The importance of innovations in the development of the space industry cannot be overestimated. Innovations drive progress in the space industry, leading to the creation of more efficient and safe space technologies. The latest developments in rocketry, automated systems, artificial intelligence, and materials allow for expanding the boundaries of human presence in space and opening up new opportunities for research, commercial activities, and space tourism. Therefore, innovations play a crucial role in ensuring sustainable development of the space industry and open up new perspectives for humanity in exploring space.

Technological advancements in the space industry are crucial for exploring space. One of the key elements of this industry is rocket engines, which provide the capability to launch spacecraft into orbit, reach other planets, and explore space. Modern research in the field of rocket engines is focused on developing new types of engines, such as ion and nuclear engines, as well as increasing the energy efficiency of traditional engines.

Another equally important direction in the space industry is artificial intelligence, as it enables the processing of large volumes of information obtained from space. The application of artificial intelligence on spacecraft allows for efficient data management and the creation of autonomous system operations. In the future, artificial intelligence could become a key tool for space exploration, accelerating and improving the processes of studying space [1].

A third direction is the development of automated systems in space. The use of such systems leads to increased safety and efficiency of space missions. Furthermore, autonomous systems capable of performing tasks without human involvement help reduce the risk of emergencies and enhance the effectiveness of missions. Integrating artificial intelligence, computer vision, and sensor technology into the development of autonomous systems opens up new possibilities for space exploration and enables the autonomous execution of complex tasks by space vehicles and robots.

Space tourism represents an exciting new sector of tourism that offers ordinary people the opportunity to travel to space and experience the unique sensation of weightlessness, as well as see Earth from the vantage point of a space orbit. With the advancement of technologies and space exploration, space tourism is becoming an increasingly discussed and promising topic.

Companies such as Blue Origin, SpaceX, and Virgin Galactic already offer the possibility of regular flights for private individuals, although the cost of such journeys remains very high, making space tourism inaccessible to most people. However, with the development of modern technologies, the cost of space travel may decrease, making this type of tourism available to a broader audience.

SpaceX is one of the leading companies in the field of space exploration and development. The Starship rocket being developed by SpaceX opens up new

possibilities for space travel and even the colonization of Mars. Despite past unsuccessful orbital flights, the company continues to work on improving technologies and plans new missions in the near future [2].

The idea of space tourism has been around for a long time, but it only became a reality in the early 21st century with the first private spaceflight conducted by Dennis Tito. Since then, space tourism has been gaining popularity. The development of this sector can contribute not only to the advancement of technologies and scientific research in space but also to the creation of new jobs and investment influx into the space industry.

To further reduce the cost of space tourism, it is important to explore and implement new technologies such as rocket engines, autonomous systems, and artificial intelligence. International cooperation and the development of new infrastructural solutions also play a key role in the sustainable development of space tourism.

Overall, space tourism represents a promising direction for the travel industry, which can open up new opportunities for space exploration and inspire future generations of researchers. Space tourism, as a new field in the space industry, has a significant impact on the development of the space industry. Introducing commercial space flights for tourists opens up new possibilities for the industry, stimulating the development of innovative technologies and services in space.

One of the key aspects of the impact of space tourism on the space industry is the increase in demand for space services and technologies. The growth of interest in space tourism leads to an increase in orders for the development of spacecraft, the creation of space stations, and the development of infrastructure for commercial space flights. This contributes to the expansion of the space service market and stimulates competition among companies in this area.

In addition, space tourism attracts investments in the space industry. Interest from private investors and entrepreneurs in the development of space tourism creates a favorable environment for financing innovative projects and research in the space sector. This allows for an acceleration in the development of space technologies and ensures faster implementation of new advancements into practice. Thus, space tourism not only opens up new opportunities for broader access to space but also plays an important role in the development of the space industry, fostering innovation, competition, and investments in this strategically important sector.

Space tourism is a promising direction for the future development of the travel industry. It provides people with a unique opportunity to experience incredible sensations and see Earth from space. However, due to high costs and potential risks, space tourism remains accessible only to a narrow circle of individuals. Additionally, international collaboration in this field, as well as the development of new technologies and infrastructure, are key factors for the sustainable development of space tourism. Therefore, further research and development in this area may contribute to increasing the accessibility of space tourism and opening up new opportunities for exploring space, which, in turn, will allow humanity to reach new horizons and inspire future generations of explorers [3].

Modern space stations, such as the International Space Station (ISS), play an

important role in space exploration and studying human behavior in microgravity conditions (see Figure 1). Launched in 1998, the ISS is a unique research complex that enables long-term habitation of crew in space. The ISS is planned to be utilized until 2024, with the possibility of extending its operation until 2028-2030. The ISS is a joint international project involving many countries, including Russia. The Russian segment of the ISS is controlled from the Mission Control Center in Korolev, while the American segment is operated from the Lyndon B. Johnson Space Center in Houston. The management of the laboratory modules – the European "Columbus" and the Japanese "Kibo" – is overseen by the European Space Agency's Mission Control Center in Oberpfaffenhofen, Germany, and the Japan Aerospace Exploration Agency in Tsukuba, Japan. The main functions of the ISS include studying the effects of the space environment on the human body, conducting scientific experiments in microgravity, and testing new technologies and equipment for space missions. Russia is considering detaching the Russian segment from the ISS in 2024, consisting of three modules ("laboratory module," node module, "science-power module"), and creating a national space station based on them.

Figure 1. The International Space Station

There is another well-known space station called "Tiangong," which is a manned multi-module orbital station of China. The station orbits at a low Earth orbit altitude ranging from 340 to 450 km above the Earth's surface. The core module of the station, "Tianhe," was launched on April 29, 2021, the "Wentian" module on July 24, 2022, and the third module, "Mentian," on October 31, 2022. The launch of the fourth co-orbiting telescope "Xuntian" has been postponed to 2025. With its three modules, the station has a mass of over 60 tons and could potentially be expanded to 100 tons or more in the future. The initial service life of the station is planned for 10 years with the possibility of extension up to 15 years. The station operates a full water recovery system, which contributes to more efficient resource management. "Tiangong" became the world's third multi-module manned orbital station after the "Mir" and ISS stations, but smaller in size. An interesting fact to note is that on November 17, 2022, the first

spacewalk from two orbital stations – ISS and "Tiangong" occurred on the same day.

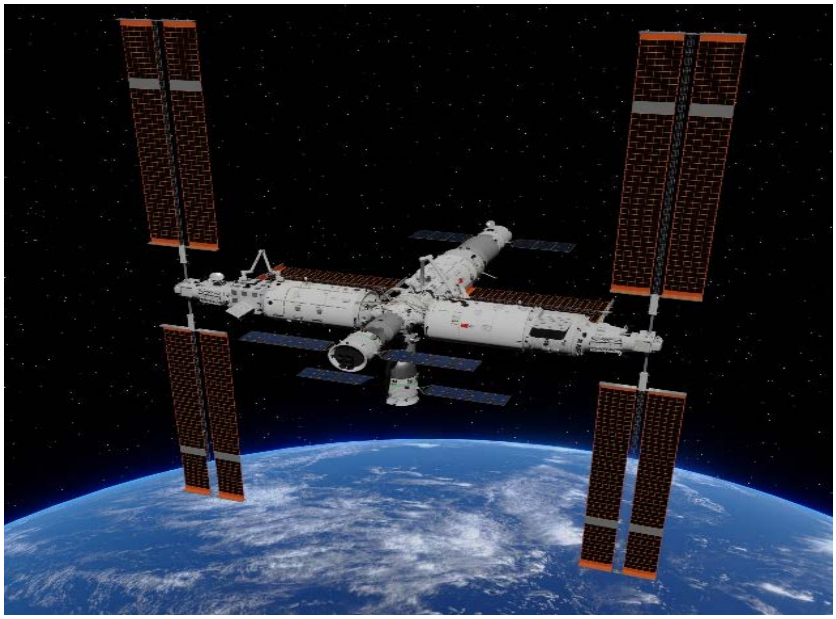

Figure 2. The manned multi-module orbital station «Tiangong»

In Russia, there is also a project for the creation of its own space station, the Russian Orbital Station (National Orbital Space Station) (fig. 3). This project has already passed the stage of technical design, and in 2024, work is planned to begin on creating the orbital complex of ROS, the ground control complex, and the necessary modifications to the Vostochny Cosmodrome.

The ROS is intended to replace Russia's ongoing participation in the ISS. The project is being developed by specialists from RKK Energia. On October 27, 2023, the head of Roscosmos, Yuri Borisov, informed the media that the creation of ROS by 2032 is estimated to cost approximately 609 billion rubles, with 150 billion rubles required in the first three years of station construction (2024-2026). The station will consist of five to seven modules and have a mass of 60 tons. For the first time in the history of Earth's space stations, it is planned to place the station in a high-inclination orbit so that it can operate in Russia's interests with a wide coverage area, including the Arctic. The station's inclination will be 97°.

Figure 3. The layout of the Russian orbital station

The station will be created using new materials and alloys, as well as additive technologies, including the manufacture of complex metal parts for module structures. A 3D printer will be placed on the station for printing necessary parts of instruments and interior from plastic. The ROS modules will be "dressed" in a kind of multilayer armor – anti-meteoroid screens. The creation of robotic systems is planned. The station will work on methods for monitoring ice and environmental conditions, real-time monitoring of the ionosphere, climate and microphysical processes, optical registration of disturbances in the Earth's atmosphere, measurement of Earth's magnetic field characteristics, and other tasks.

As we can see, the development of space stations is being carried out using innovative approaches and technologies. One of the key directions is the use of autonomous control systems, integration of artificial intelligence for optimizing station operations, and the development of robotic systems for servicing and repairing equipment in space. Next-generation rocket engines, capable of providing more efficient maneuvers and transitions between orbits, also play an important role in the modern development of space stations.

The future of space stations is connected with expanding their functionality for scientific and commercial purposes. Currently, two projects are in the planning and implementation stages: the private orbital station "Axiom" (p. 4) of the American company "Axiom Space" and the international inhabited near-moon station "Lunar Orbital Platform-Gateway" (LOP-G, see p. 5), a project within the American lunar exploration mission "Artemis".

For example, the company "Axiom Space" plans to attach its space station to the ISS, connect all the modules, and then detach the station from the ISS. The first module is planned to be attached to the ISS in 2024. By 2026, the Leonardo module, currently located on the ISS, is planned to be relocated to the station. The station is expected to be fully completed by 2028. People will be able to stay on the station, conduct research, and create manufacturing facilities, leading to the development of numerous industrial sectors using technologies only available in microgravity conditions. The station will also support rapidly growing space infrastructure and systems, as well as provide an accessible platform to continue research and development of breakthrough innovations.

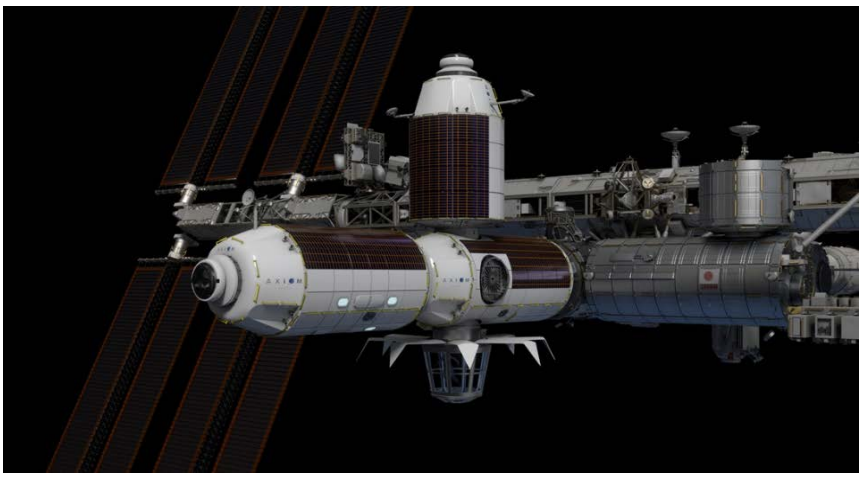

Figure 4. The layout of the private orbital station "Axiom"

The goal of the second station is to bring people back to the Moon for an active presence on the surface. The Artemis mission involves several space agencies, including NASA, the European Space Agency (ESA), the Japan Aerospace Exploration Agency (JAXA), and the Canadian Space Agency (CSA). It is planned that the space station will orbit the Moon and serve as a starting point for both robotic and manned exploration of the lunar South Pole, as well as becoming a springboard for NASA's deep space concept for transportation to Mars [4]. The launch of the RPE electric propulsion module and the HALO small living module is scheduled for 2024, the launch of the SpaceX Starship Lunar lander and the Orion spacecraft with the logistics module, as well as landing on the Moon, are scheduled for 2025, and the launch of Artemis 4 with a crew is scheduled for 2027, with the mission's goal being assembly of the orbital station.

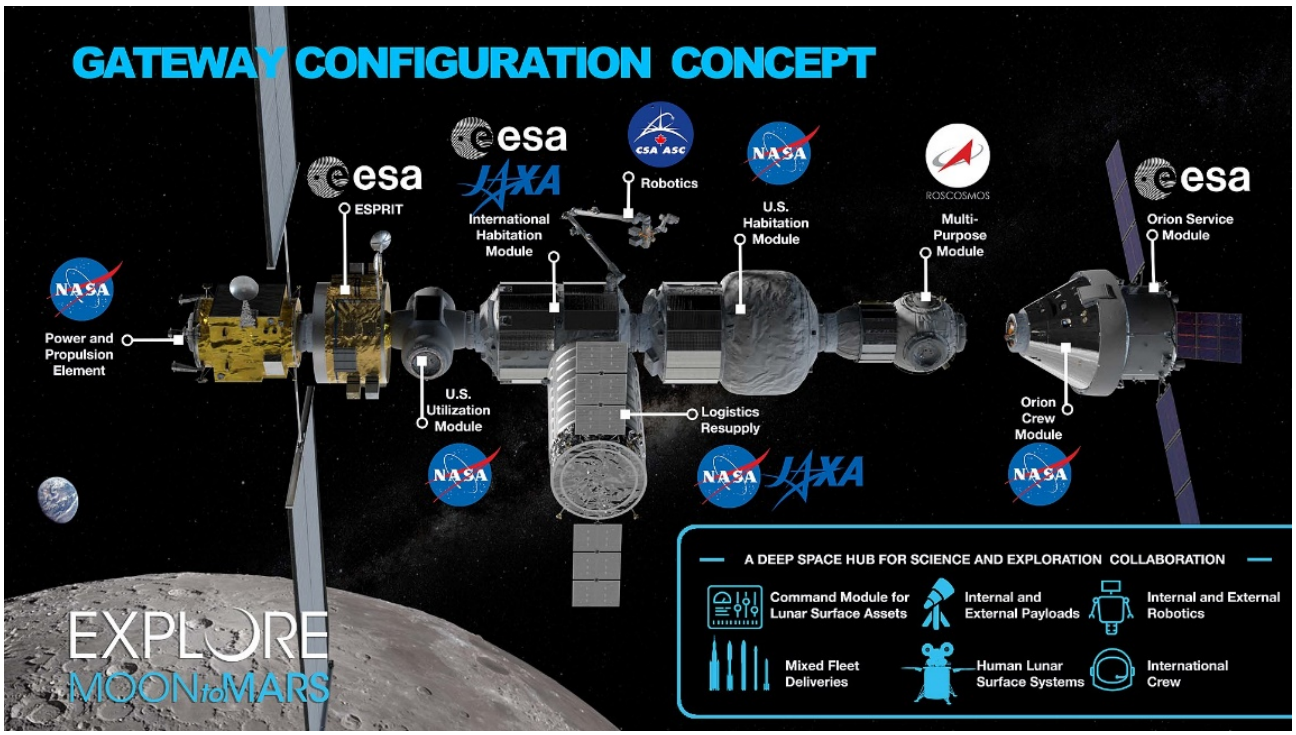

Figure 5. International Manned Circumlunar Station "Lunar Orbital Platform-Gateway"

Another space station under development is called Starlab and is completely managed by private companies (Nanoracks, Voyager Space, and Lockheed Martin). The uniqueness of this project is that the main structure of the station will consist of a large inflatable 340 m^3 habitat. The station will be equipped with a 60 kW power plant, a large robotic arm for handling cargo and external payloads, and a state-of-the-art laboratory system for conducting advanced research and commercial opportunities. This station is planned to be put into operation with a single launch in 2027 and will be able to accommodate a crew of 4 people simultaneously.

Innovations in the space industry play a key role in the development of space tourism and the improvement of space stations. Thanks to new technologies and approaches, space tourism is becoming more accessible and safe for a wide audience. The development of space stations, taking into account modern technological solutions, opens up new perspectives for scientific and commercial research in space. It is important to continue investing in innovation and carry out activities aimed at strengthening cooperation between states and private companies to ensure the sustainable development of the space industry and the realization of the potential of space tourism.

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STRING ENCRYPTION IN C++ UNDER X32 ARCHITECTURE

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Abstract. This article discusses the problem of security in static applications analysis. As a result of the conducted research, one of the possible methods of implementing data protection against intruders was obtained.

Keywords: C++, string encryption, x32 architecture, protection, data.

ШИФРОВАНИЕ СТРОК НА C++ В АРХИТЕКТУРЕ X32

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Аннотация. В данной статье рассматривается проблема безопасности при статическом анализе приложений. В результате проведенного исследования был получен один из возможных методов реализации защиты данных от злоумышленников.

Ключевые слова: C++, шифрование строк, x32 архитектура, защита, данные.

Introduction. In today's digital era, ensuring the security of our data has become more essential than ever. Both personal information and sensitive corporate data require robust protection mechanisms to shield them from unauthorized access. In the domain of C++ programming, the challenge of encrypting strings under the x32 architecture offers both unique challenges and opportunities for innovation. This article introduces a novel encryption method specifically designed for use in C++ on x32 systems. We have developed a technique that significantly enhances the security level of applications by transforming plaintext data into encrypted formats that defy traditional decryption attempts without the correct authentication. Our approach not only secures data but also optimizes performance on x32 platforms, making it a valuable asset for developers aiming to safeguard their applications against modern vulnerabilities.

String encryption. String encryption is the process of converting plain text into a scrambled format, known as ciphertext, using algorithms and keys. This cryptographic technique is crucial for ensuring data confidentiality and integrity,

especially in scenarios where sensitive information is involved. By encrypting strings, even if an unauthorized person gains access to the data, they cannot decipher it without the corresponding decryption key. For instance, consider a scenario where a user's login credentials are stored in a database without encryption. If a hacker manages to breach the system's security, they could easily extract these credentials and gain unauthorized access to the user's account, potentially leading to identity theft or financial loss. However, if the passwords were encrypted using strong encryption algorithms, even if the hacker obtains the encrypted data, it would be nearly impossible for them to retrieve the original passwords without the decryption key. Thus, string encryption acts as a crucial layer of defense against unauthorized access and data breaches, safeguarding sensitive information from exploitation and misuse [1].

Use Cases for String Encryption in C++ on x32 Architecture. String encryption in C++ on x32 architecture is critically important across a variety of applications to ensure data confidentiality and security. This method of data protection is especially relevant in systems where performance and resource constraints are a concern. Here are some detailed scenarios where string encryption on x32 systems is crucial:

Financial Services: In the finance sector, applications often process highly sensitive information such as account numbers, transaction details, and personal identification numbers (PINs). String encryption ensures that this data remains secure both at rest and in transit, protecting against data breaches and unauthorized access.

Healthcare Systems: Healthcare applications store and transmit sensitive information, including patient records, medical histories, and prescription details. Encrypting strings that contain such data helps in complying with legal standards such as HIPAA in the United States, ensuring patient confidentiality and preventing potential leaks of personal health information.

Government and Military Applications: In scenarios involving national security or confidential governmental operations, protecting data integrity and confidentiality is essential. String encryption on x32 systems within these fields ensures that sensitive information remains secure from foreign entities and internal threats.

Educational Software: Systems used in educational institutions handle student records, grades, and other personal information. Encrypting this data protects it against breaches and helps institutions comply with educational privacy laws.

Telecommunications: Telecommunication software deals with massive amounts of data transmission, including SMS, emails, and voice communications. Implementing string encryption is critical to protect the privacy of communications and prevent unauthorized access.

*Protecting User Data in Desktop and Mobile Applications***.** For both desktop and mobile applications developed with C++ on x32 architecture, string encryption is essential for protecting user data. Applications such as personal finance managers, health tracking apps, and personal information managers often handle sensitive data including social security numbers, health records, and personal financial information. Encrypting this data helps prevent unauthorized access, which is particularly vital in scenarios where a device might be lost or stolen.

Ensuring Confidentiality in Corporate Networks. In corporate environments, applications running on x32 systems may be legacy but still critical for daily

operations. These systems handle sensitive business information, including employee data, financial reports, and strategic documents. Encrypting strings in such applications helps ensure that sensitive information remains confidential, protecting it from both internal and external threats. This is crucial for maintaining business integrity and compliance with regulations like GDPR and HIPAA, which require stringent data protection measures.

Securing Information in Cloud Storage. With the increase in cloud storage solutions being used by businesses of all sizes, data security becomes even more essential. Software developed on x32 architecture that interfaces with cloud storage must encrypt data before it leaves the device. This encryption secures sensitive information such as business contracts, client information, and intellectual property from being intercepted or accessed during transmission and while at rest on cloud servers.

IoT Device Communication. In the realm of IoT, many devices operate on minimalistic hardware platforms that support x32 architecture due to cost and power consumption considerations. These devices, ranging from home automation systems to industrial sensors, collect and transmit sensitive data that must be protected. Encryption of this data is essential for preventing man-in-the-middle attacks during data transmission and ensuring that data tampering is not possible, safeguarding the integrity of both the data and the device.

Encryption in Financial Transactions. Encryption plays a pivotal role in the security of financial transactions processed on x32 systems. This includes point-of-sale (POS) systems, ATMs, and mobile payment applications. Encrypting transaction details such as credit card numbers, transaction amounts, and customer information helps protect against fraud and data breaches, ensuring that financial data remains secure from the terminal to the bank server.

As a result, the implementation of string encryption in C++ on x32 architecture is essential across various applications to ensure robust security measures. By encrypting strings, developers can protect sensitive data across diverse platforms and environments, preventing unauthorized access and maintaining data integrity. Whether it is for protecting personal data, securing corporate information, or safeguarding financial transactions, encryption provides a crucial layer of security in an increasingly digital world.

Using constexpr for Improved Performance. In C++, the constexpr keyword allows certain computations to be performed at compile time rather than at runtime. This feature can significantly speed up your application, especially when it comes to encrypting data. By calculating values during the compilation process, constexpr ensures that these computations do not need to be repeated, which can save time when the program is running. How Does constexpr Enhance Encryption? When you declare a function or variable as constexpr, you are telling the compiler that it is possible to evaluate the expression at compile time. This is particularly useful in encryption for creating compile-time constants such as keys, lookup tables, or configuration parameters. For example, if you use a constexpr function to generate a key or configure an encryption algorithm, the compiler can resolve these values when you compile your code. This means that at runtime, the encryption process can proceed more quickly

because it skips the initial setup phase. Using constexpr in encryption routines can lead to more efficient code by minimizing runtime computations. It is a powerful tool in C++ that helps in optimizing performance-sensitive applications like data encryption, making them faster and more reliable [2].

What have we done? We have developed an application in C++ starting from the 14th standard and the minimum supported one is 11. The essence of the application is simple. First, output the encrypted and then the decrypted string and see how it will look during static analysis

Explanation: The constexpr specified declares that it is possible to evaluate the value of the function or variable at compile time. Such variables and functions can then be used where only compile time constant expressions are allowed (provided that appropriate function arguments are given). A constexpr specifier used in an object declaration or non-static member function(until C++14) implies const. A constexpr specifier used in a function or static data member(since C++17) declaration implies inline. If any declaration of a function or function template has a constexpr specifier, then every declaration must contain that specifier.

Conclusion. We have developed a technology that allows us to effectively hide strings during static analysis of applications, thereby ensuring a high level of security and data confidentiality. This technology strengthens protection against potential threats and attacks, making the code inaccessible for analysis and understanding by malicious actors. Such an approach is particularly important in the field of software development, where maintaining data integrity and security is a top priority.

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УДК 54

GREEN CHEMISTRY

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Abstract. One of the biggest environmental problems of our time, with an ever-growing population and limited resources, is environmental pollution. The reasons for this are the irrational use of resources, improper disposal of hazardous substances and the lack of recycling of raw materials. The solution to this problem is Green Chemistry, a science that aims to use less or avoid the use of hazardous substances in chemical processes and to use alternative sources of raw materials.

Keywords: green chemistry, environmental problem, biofuel, bioremediation, ionic liquids.

ЗЕЛЕНАЯ ХИМИЯ

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Аннотация. Одной из крупнейших проблем современности в условиях постоянно растущего населения и ограниченных ресурсов является загрязнение окружающей среды. Причинами этого являются нерациональное использование ресурсов, неправильная утилизация опасных веществ и отсутствие процесса переработки сырья. Решением данной проблемы может стать Зеленая химия – наука, которая направлена на то, чтобы меньше использовать или избегать использования опасных веществ в химических процессах, а также на использование альтернативных источников сырья.

Ключевые слова: зеленая химия, экологическая проблема, биотопливо, биоремедиация, ионные жидкости.

Chemistry has become an important contributor of everyday life during the last century. Due to the features of the chemical industry and related areas, the technology required for the manufacturing of products must be continuously improved.

Towards the end of the 20th century, population growth, depletion of natural resources and developments in the chemical industry has emerged as the most important environmental problems. Especially future concerns have led people to take

precautions. Unfortunately, chemical plants are toxic and they will continue to be so as long as they continue to use mainly flammable and poisonous organic solvents. In addition, the increase in the world population and the rise of life quality standards there are no barriers to sustainable chemical production methods. Production to meet increasing demand is rising day by day with the increasing levels of waste.

As a result, such a direction as green chemistry appeared. Green chemistry is a movement to find alternatives to the use of harmful chemicals such as feedstock, reagents, solvents, products, and byproducts in the production processes [1].

Over the past decade, green chemistry principles have been accepted and incorporated into educational materials, research programs, and manufacturing processes because of the society`s realization of limited resources and a climate crisis the likes of which most of us still fail to fully comprehend.

Implementation of green chemistry techniques has protected human health and brought significant environmental benefits to industry. Green chemistry emerged from pollution prevention programs, environmental divisions within professional societies and government agency programs. The practice has greatly expanded from early academic research efforts and is now a mainstream activity of government industry and nongovernmental organizations worldwide [2, 3]. This article provides some ecological methods for improving chemical processes according to the principles of green chemistry.

The concept of green chemistry is based on twelve principles which were first formulated at the beginning of the 1990s [4].

1. It is better to prevent waste than to treat or clean up waste after it has been created.

2. Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.

3. Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

4. Chemical products should be designed to effect their desired function while minimizing their toxicity.

5. Automated and miniaturized methods should be selected.

6. Unnecessary derivatization (use of blocking groups, protection/deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.

7. Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

8. Catalytic reagents are superior to stoichiometric reagents.

9. The use of energy should be minimized.

10. Reagents obtained from renewable source should be preferred.

11. Toxic reagents should be eliminated or replaced.

12. Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires [5, 6].

Biofuel is a renewable resource that does not emit greenhouse gases when burned. Currently, bioethanol, biodiesel, biohydrogen, and biobutanol are the most widely available forms of biofuel.

In the research to displace fossil fuels, algae have emerged as a suitable candidate due to its renewable and sustainable features coupled with economic credibility to match up with the global demand for transportation fuels. There is potential ground for optimism based on the sustainability of this feedstock and greater likelihood of new applications and products due to its diversity. Moreover biofuels derived from algae have no impact on the environment and the food supply unlike biofuels produced from crops [7, 8].

Microalgae are sunlight-driven cell factories that convert CO_2 to potential biofuels, foods, feeds, and high-value bioactives. They can provide several different kinds of renewable biofuels including methane (produced by anaerobic digestion of algal biomass), biodiesel from microalgal oil and photobiologically produced biohydrogen. The algae cultivation is an eco-friendly process which consumes 1.83g of CO_2 for every 1g generation of algae biomass. Therefore, it helps to develop carbon neutrality. Algal species can grow in a wide range of aquatic environments, whether freshwater or saline. Algae are responsible for almost 40 % of global carbon fixation, and they do it very efficiently. They can produce biomass very quickly, with some species being able to double in almost 6 hours, and some being able to double twice each day. They possess high oil content that can yield 10 to 100 times of oil more than the traditional oil sources. Algae nutrient uptake uses high nitrogen, silicon, phosphate and sulphate nutrients from human and animal wastes. Hence, they can potentially remediate waste streams, as well as municipal wastes. Other application includes wastewater treatment, production of energy co-generation (electricity or heat) even after the extraction of oil, CO2 removal from industrial chimney gases (algae bio-fixation), bio-fertilizer, animal feeds, healthcare and food products. Algae strains have the ability to be engineered, which can be used for improving specific traits and production of valuable co-products [7, 9].

Algae exist in any imaginable environment and can 3 withstand extreme temperature, irradiation, drought, and salinity. However, the environmental condition of a country will definitely influence their cultivation method. For example, marine and freshwater algae could be cultivated naturally in the UK. Also algae biofuel conversion methods such as transesterification, fermentation, and hydrotreatment are more complex and economically expensive, when compared to fossil-derived fuels and even biofuels from other feedstocks. Another challenge that demotivates the use of algae for the conversion into biofuel are its high production cost (5 to 7 times more than lignocellulosic biomass) [9, 10].

Bioremediation of crude-oil contaminated soil is a successful process to a cleanup method for hydrocarbon contaminants from the ecosystem. In this process, up to 99 % of total petroleum hydrocarbons are degraded and the sludges are converted from hazardous to non-hazardous.

Microorganisms have the capacity to degrade the majority of natural hydrocarbon components, especially the dominant saturated and unsaturated alkanes, monoaromatic and low-molecular-weight polycyclic aromatic hydrocarbons (PAHs).

The higher-molecular weight PAHs, resins and asphaltenes are more recalcitrant to biodegradation. Hydrocarbon-degrading microbes must come into contact with their substrate in order for hydrocarbon uptake to occur and the insoluble nature of the majority of petroleum hydrocarbon molecules limits this contact. The most widely recognized modes of hydrocarbon accession are direct microbial adherence to large oil droplets and interaction with emulsified oil [11, 12].

Advantages of bioremediation:

1. Instead of merely transferring contaminants from one environmental medium to another (e.g., from water to the air or to land) bioremediation destroys the target chemicals;
2. Bioremediation is usually less expensive than other technologies that are often used to clean up hazardous waste;
3. Bioremediation can often be accomplished where the problem is located;
4. The residues from the biological treatment are usually harmless products (carbon dioxide, water and fatty acids). Usually less expensive than other technologies that are often used to clean up hazardous waste [13].

Ingredients for successful biodegradation of hydrocarbon:

1. Temperature plays very important roles in biodegradation of petroleum hydrocarbons, firstly by its direct effect on the chemistry of the pollutants, and secondly on its effect on the physiology and diversity of the microbial milieu. Ambient temperature of an environment affects both the properties of spilled oil and the activity or population of microorganisms. At low temperatures, the viscosity of the oil increases, while the volatility of toxic low-molecular weight hydrocarbons is reduced, delaying the beginning of biodegradation. Temperature also variously affects the solubility of hydrocarbons. Although hydrocarbon biodegradation can occur over a wide range of temperatures, the rate of biodegradation generally decreases with decreasing temperature. Highest degradation rates generally occur in the range of 30–40 °C in soil environments, 20–30 °C in some freshwater environments, and 15–20 °C in marine environments;

2. Biodegradability is inherently influenced by the composition of the oil pollutant. For example, kerosene, which consists almost exclusively of medium chain alkanes is, under suitable conditions, totally biodegradable. Similarly, crude oil is biodegradable quantitatively, but for heavy asphaltic-naphthenic crude oils, only about 11 % may be biodegradable within a reasonable time period, even if the conditions are favorable;

3. The additions of nutrients are necessary to enhance the biodegradation of oil pollutants. Depending on the nature of the impacted environment, some of these nutrients could become limiting thus affecting the biodegradation processes. When a major oil spill occurs in marine and freshwater environments, the supply of carbon is dramatically increase and the availability of nitrogen and phosphorus generally becomes the limiting factor for oil degradation. This is more noticeable in marine environments, due to the low background levels of nitrogen and phosphorus in seawater, unlike in freshwater systems that regularly fluctuate in nutrient status as result of perturbations and receipt of industrial and domestic effluents and agricultural runoff. Freshwater wetlands are typically considered to be nutrient limited, due to heavy demand for nutrients by the plants, and they could also be nutrient traps [14].

In the past few years, incorporation of the principles of green chemistry in organic synthesis has gained increasing interest, aiming at the elimination of toxic, volatile organic solvents, and the introduction of greener and safer solvents. Ionic liquids (ILs) have emerged as a solution to this problem and have found application in organic synthesis as alternative green media that can play a dual role, that of the solvent and the catalyst.

These solvents are often fluid at room temperature and consist entirely of ionic species. As they are made up of at least two components which can be varied (the anion and cation), the solvents can be designed with a particular end use in mind or to possess a particular set of properties such as miscibility, hydrophobicity, viscosity, density etc. [15, 16].

Properties of ionic liquids that make it ecologic solvents:

1) The ions in ILs are held together by coulombic forces and thus exerts near-zero vapor pressure above the liquid surface. So ILs do not emit out potentially hazardous volatile organic compounds during their transportation, handling, and use;
2) ILs are non-oxidizing so non-flammable and nonexplosive;
3) The velocity of the reaction increases in ILs due to its ionic character;
4) ILs can be stored without decomposition for a long time;
5) ILs are stable over a wide range of temperature;
6) Large organic cationic part and smaller inorganic anionic part makes them capable for dissolving both organic and inorganic material;
7) IL can be reused again and again due to stability of IL phase towards air and moisture [17].

In 2020, Brzeczek-Szafran synthesized seven new bio-ILs based on glucose and different amino acids and structurally and physicochemically characterized them. The synthesized bio-ILs were examined regarding their biodegradability, revealing that all bio-ILs were readily biodegradable, decomposing within 5–6 days and, thus, revealing the green character of the solvents, while their ability to act as catalysts was examined [16].

The replacement of conventional volatile organic solvents by solvents of new era such as ILs can be proved as stepping stone in making the organic synthesis sustainable and eco-viable. The easily adjustable properties of ILs just by altering the cationic and anionic part make it task specific solvent [18].

Initially, there was little appreciation of the potential benefits of green chemistry. But industrialists have become more interested as it has become clear that green processes can be more profitable than traditional ones. Green chemistry provides economic benefits to be obtained by performing the reaction of the new reality will reduce production costs and saving energy at lower temperatures for the actual design highly efficient reactions. For example, enzymatic reactions have completely displaced conventional catalysis as a low-cost option in the manufacture of several generic pharmaceuticals [19].

Green chemistry aims to develop new practice of chemistry with rules which provides resolutions to problems that human is facing today such as climate changes, sustainable farming, energy need, toxics, consuming of natural sources. It is not a solution to all problems but the most fundamental approach to their prevention. It is

impossible to find the requirements of all twelve principles of the process at the same time. Nevertheless, it attempts to apply as many principles as possible during certain steps of chemical processes [1, 4].

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COMBINATION OF MODERN TECHNOLOGIES TO IMPROVE LIFE ON EARTH AND IN SPACE

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Abstract. This article describes in detail technologies that have found their application in both spheres, investigate their interaction and analyze their impact on the development of society and the field of space research. Special attention is given to technologies such as global positioning system, cushioned shoes, digital photography and a CMOS sensor, a Velcro fastener and a spacesuit. The article discusses the challenges and prospects for the interconnection and interpenetration of technologies to improve life on Earth and space exploration.

Keywords: astronautics, innovative technologies, global positioning system, digital photography, CMOS-matrix.

СИМБИОЗ СОВРЕМЕННЫХ ТЕХНОЛОГИЙ ДЛЯ УЛУЧШЕНИЯ ЖИЗНИ НА ЗЕМЛЕ И В КОСМОСЕ

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Аннотация. Данная статья посвящена исследованию взаимодействия и взаимопроникновения технологий между обществом и космосом. Авторы подробно описывают ряд технологий, которые нашли свое применение в обеих сферах, исследуют их взаимодействие и анализируют их влияние на развитие общества и область космических исследований. Особое внимание уделяется таким технологиям, как глобальная система позиционирования, обувь с эффектом амортизации, цифровая фотография и CMOS-матрица, застежка-липучка Velcro и скафандр. В статье рассматриваются вызовы и перспективы взаимосвязи и взаимопроникновения технологий для улучшения жизни на Земле и исследований космоса.

Ключевые слова: космонавтика, инновационные технологии, глобальная система позиционирования, цифровая фотография, CMOS-матрица.

For a long time, people have dreamed of paving the way to the stars. Space is one of the most mysterious and fascinating phenomena, revealing to us the endless possibilities and mysteries that have attracted humanity for many centuries. Discoveries and research in the field of space have radically changed our understanding of the universe and our place in it. Our desire to understand its depths has led to the development of numerous space programs, scientific expeditions and spacecraft that continue to amaze us every day.

Cosmonautics is a complex of scientific and technical branches aimed at developing rockets and spacecraft, launching them into space, exploring space objects and living on them in order to explore space for scientific purposes and meet the needs of mankind. The history of this field of science has its roots back in the 17th century. The Kepler's story called "Somnium" is the first fictional description of a man's stay on the moon (published in 1634). Trips to other space objects have also been described in the works of Cyrano de Bergerac, Francis Godwin and other authors [1]. Isaac Newton in "Mathematical Beginnings of Natural Philosophy" laid the theoretical foundations of astronautics. L. Euler and J. Lagrange contributed to the calculation of the motion of bodies in space. J. Verne's novels "From the Earth to the Moon" and "Around the Moon" already correctly described the flight to the Moon in terms of the laws of celestial mechanics, although they clearly "lame" technical realization. On March 23, 1881, N. Kibalchich proposed the idea of a flying rocket with an oscillating combustion chamber, capable of space flights. His project was published in 1918 [2]. The beginning of the 20th century was marked by the works of "pioneers of cosmonautics" (F. A. Zander, K. E. Tsiolkovsky, R. H. Goddard, G. Y. Obert, etc.). They substantiated the use of rockets as a means of flight, the use of liquid propulsion (having a higher specific impulse than rocket powder engines), the need to use multi-stage rockets. Scientists actively studied the impact of overloads and weightlessness, considered the issues of life support. Thus, gradually, astronautics has brought to the lives of ordinary people an extremely large number of new technologies, further we will consider some of them.

Everybody knows that space-related technologies have transformed people's daily lives. Such technologies include global positioning system, air-cushioned shoes, digital photography and CMOS-matrixes and others. Each technology should be discussed in more detail.

The Global Positioning System (GPS) is a navigation system that uses satellites to determine location and time anywhere on Earth. The system consists of a network of satellites in orbit around the Earth and GPS receivers that receive signals from these satellites to determine their position. The system is widely used in car navigators, cell phones, tracking devices, and other devices that require precise positioning. GPS can also be used to measure water levels, analyze the atmosphere, probe snow cover, and monitor volcanoes [3].

The global Positioning System (GPS) was created in the United States during the Cold War era in the 1960s and initially served as a navigation tool for the Navy. Initially, the equipment allowed updating information about the coordinates of the vessel only once an hour. Over the following years, the United States actively improved the system, increasing the number of satellites launched. In the 1980s, the

administration of President Ronald Reagan decided to expand access to GPS to the level of civilian needs.

At the moment, the GPS system includes 24 satellites that orbit the planet in high orbit. These satellites move at a speed of approximately 2,500 meters per second, and their orbit is at an altitude of 19,312 kilometers (for comparison, the International Space Station is at an altitude of about 402.34 kilometers). Each satellite has an atomic clock that is accurate to 1 nanosecond [4]. The satellites are positioned in such a way that at least four of them are always visible directly from anywhere on Earth. A GPS receiver on the ground (or on a flying aircraft) receives information about the time and location of these satellites through a radio frequency signal with a frequency of 1.575 Gigahertz (Figure 1).

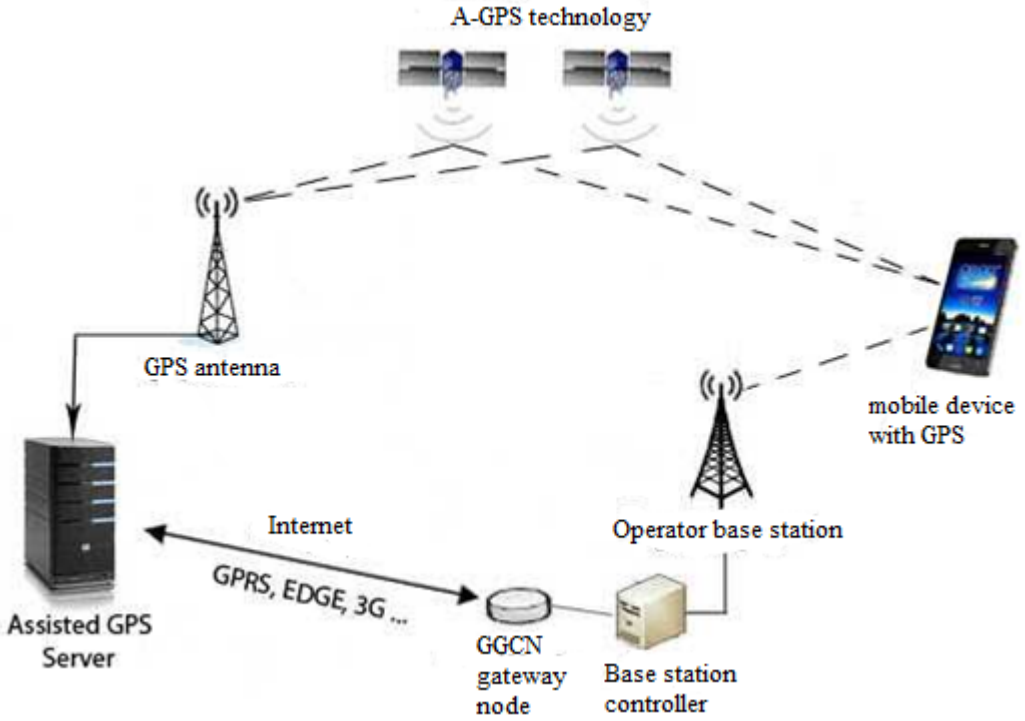

Figure 1. GPS

Modern shoes with the ability to absorb shocks. Another technology borrowed from the space industry is the use of air layers in clothing for astronauts. In the 1970s, NASA engineer Frank Rudy came up with the idea that astronauts' clothes could be made airier with the help of air layers. His invention served as a starting point for the creation of shoes with cavities in the soles, where cushioning reduces the load on the joints while walking. This is achieved thanks to special air cells located under the heel and forefoot [5]. The engineer began to offer his idea to manufacturers of sneakers and boots, but only the American company Nike responded to the space development. Designers decided to flaunt the technology and placed an air capsule in a "window" right under the heel - that's how Nike Air appeared (Figure 2). It is this model that has a huge popularity all over the world and remains relevant at present.

Figure 2. Sneakers with an air gap

Digital photography and CMOS sensors. Modern camera capabilities are the result of the use of technologies developed for space exploration. They include professional optical systems and matrices used in compact devices. CMOS matrix technology has been developed to improve image quality and reduce the size of cameras for space missions [6]. The CMOS matrix (Complementary Metal-Oxide-Semiconductor) is a photosensitive matrix created by the Swedish company Hasselblad using complementary metal-oxide-semiconductor technology (Figure 3). Its advantage is low power consumption, the ability to capture and process the image. This technology was first used by the U.S. manned spacecraft Apollo 11 to film the moon landing. Although CMOS sensors were learned to create in the 1960s, it was not until the 1990s that they began to be massively used in various digital devices.

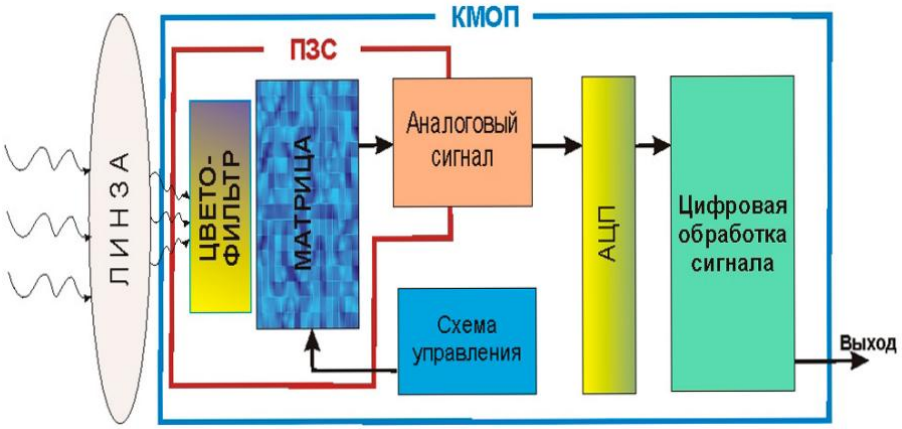

Figure 3. CMOS matrix operation

Public application technologies borrowed by the space industry. Technologies that were created for societal applications but were borrowed by astronautics can include Velcro, spacesuits, and others.

A Velcro fastener. In 1941, Swiss inventor Georges de Mestral invented the Velcro fastener (Figure 4). He borrowed the idea from burdock flowers: his goal was to make more hooks that would catch on any linty surface. He realized that the more hooks per square centimeter the better, as many hooks form a secure grip. The first samples of the product were cotton, then nylon began to be used, and by the mid 50's

the technology of industrial production of Velcro appeared. The technology consists of the following: to make a lot of tiny hooks, loops are pulled out of heated nylon cloth and then cut with a saw with very fine teeth. Velcro subsequently found its way into space in the 1960s. Currently, on board of many space ships and stations are actively used Velcro for fastening various things and devices. Such fasteners are considered to be quite reliable.

Figure 4. A Velcro fastener

The spacesuit. Space suits were not originally intended for use by cosmonauts. At an altitude of six to seven kilometers, a simple oxygen mask and warm clothes are enough, but when overcoming a ten-kilometer barrier, the pressure becomes so low that the lungs cease to function normally. To survive in such conditions, an airtight capsule and a special suit are needed, which, when depressurized, compresses the human body, creating the necessary external pressure. However, with further ascent, the pilot is at risk of dying from oxygen starvation and decompression disorders. The only solution was to create a completely sealed spacesuit that maintains the internal pressure at an acceptable level (usually at least 40 % atmospheric, corresponding to an altitude of seven kilometers). So, scientists have faced a number of problems: the inflated device makes movement difficult and makes precise manipulation almost impossible. In the 1920s, English physiologist John Holden proposed using diving suits to protect pilots and even developed a prototype of such a spacesuit for American pilot Mark Ridge, which was tested in a pressure chamber at a pressure corresponding to an altitude of 25.6 kilometers.

In the Soviet Union, Evgeny Chertovsky, an engineer at the Institute of Aviation Medicine, was involved in the development of spacesuits for high-altitude flights. Between 1931 and 1940, he developed seven models of pressurized suits that solved a problem related to mobility. After supercharging the spacesuit, the pilot needed a great deal of force to simply bend a limb, so the engineer used hinges in the Ch-2 model. The Ch-3, created in 1936, contained virtually all the elements found in a modern space suit, including absorbent underwear. The Ch-3 was tested on the TB-3 heavy bomber on May 19, 1937. The upper and lower parts of the spacesuit were connected by a belt connector, shoulder joints were used to facilitate mobility, and its shell consisted of two layers of rubberized fabric (Figure 5).

Figure 5. A modern spacesuit

The interaction of modern technologies in society and space is an integral and constantly evolving trend. Space technology is becoming increasingly important in everyday life, providing us with communications, navigation, weather forecasts and other amenities. At the same time, the development of technology on Earth opens up new prospects for space exploration, allowing us to plan and implement more complex and ambitious space projects. As technological progress continues, we can expect that the connection between society and space will become even closer. It is important to note that the interaction between modern technologies in society and space brings mutual benefits and has great potential to improve the quality of life of people both on Earth and beyond.

Space technology, as it continues its development, will continue to have a positive impact on the quality of life on Earth through the creation of new innovative solutions and technologies. At the same time, space exploration will increase opportunities for scientific research in astronomy, physics and biology, as well as stimulate economic development through the creation of new industries and technological innovations. As a result of opening new pathways for interplanetary travel, humanity will be able to explore and understand a wider range of space objects, which in turn contributes to expanding our knowledge of the universe and our ability to travel to other planets.

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ELECTRICAL EQUIPMENT IN A CAR: ITS STRUCTURE, PURPOSE AND WORKING PRINCIPLES

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Abstract. The article considers the electrical system of the car and the principles of its operation. The authors describe the device and operation of the lighting system and various elements of the car alarm. The article pays special attention to the importance of diagnostics and maintenance of electrical equipment to ensure the safety and comfort of car owners.

Keywords: accumulator, generator, current sources, current consumers, alarm, electrical system of the car, electrical equipment, electrical appliances and appliances.

ЭЛЕКТРООБОРУДОВАНИЕ АВТОМОБИЛЯ: СТРУКТУРА, НАЗНАЧЕНИЕ, ПРИНЦИП РАБОТЫ

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Аннотация. В статье рассматриваются электрическая система автомобиля и принципы ее работы. Авторы описывают устройство и функционирование системы освещения и различных элементов автосигнализации. Особое внимание в статье уделено важности диагностики и технического обслуживания электрооборудования для обеспечения безопасности и комфорта владельцев автомобилей.

Ключевые слова: аккумулятор, генератор, источники тока, потребители тока, сигнализация, электрическая система автомобиля, электрооборудование, электрические приборы и аппаратура.

In today’s world, technology is developing rapidly. Every year, cars become more electronic and automated, which requires deeper knowledge and skills in the field of electrical equipment. Electrical system failures can lead to serious accidents and accidents on the road, so it is important to constantly improve knowledge and skills in this field. Also, with the development of electric and hybrid cars, understanding the principles of operation and maintenance of electrical equipment becomes even more relevant for professionals and car owners.

The history of the car’s electrical equipment began in the late 19th century, when the first cars with electric ignition and lighting systems appeared. In 1912, Cadillac introduced its first electric startup, which greatly simplified the engine start-up process. Electrical equipment gradually became an integral part of the automotive industry, with the advent of various control and safety systems such as ignition, lighting, alarm systems, etc. [1].

In modern automobiles, electrical energy plays a key role, providing a wide range of functions, including engine start-up, combustion of the working mixture, lighting, alarm, power supply of control devices and other devices. The electrical system of the car consists of various sources and current consumers, which are connected in a single-wire system, where the mass of the car serves as a second wire, connecting the negative poles of electrical appliances. Electric energy consumers in a car operate from 12 or 24 V direct current sources, especially in the case of diesel-powered vehicles.

Current sources. The current sources in the car are the battery and generator. The accumulator battery is designed to supply electric current to consumers when the engine is running at low revs or in idle mode (Fig. 1). The battery is located in the engine compartment of the car and is mounted on a special shelf. The "minus" of the accumulator battery is connected to the "mass" (body) of the car, and the "plus" is connected to the electric circuit of current consumers by means of conductors [2]. The accumulator battery consists of six accumulators connected in series in one housing to form a single electrical circuit with a voltage of 12 V. Each accumulator as a result of its electrochemical processes "emits" 2 V, so in total on pole pins the battery has a voltage of 12 V DC.

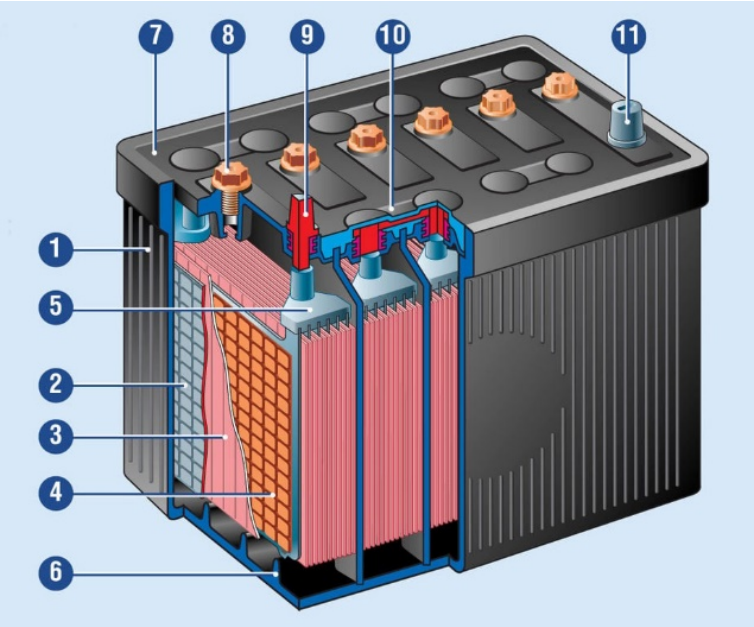

Figure 1. Car battery:
1 – body; *2* – negative electrode (plate); *3* – separator; *4* – positive electrode (plate); *5* – barette; *6* – support prisms; *7* – cover; *8* – filling hole plug; *9* – positive conclusion; *10* – intercell bridge; *11* – negative conclusion

The generator is designed to supply electric current to all consumers, as well as to recharge the battery while the engine is running at medium and large revolutions (Fig. 2). The generator converts the mechanical energy obtained from the rotation of the engine crankshaft into alternating current electrical energy, which is then converted into direct current by means of a rectifier.

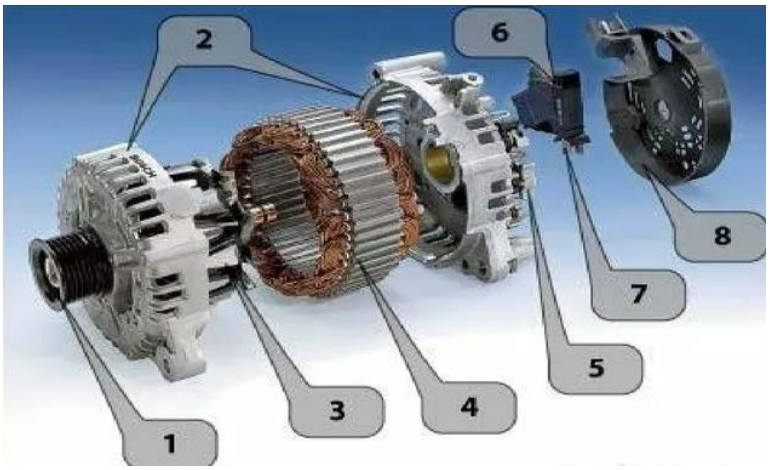

Figure 2. The generator:
1 – pulley; *2* – a body; *3* – a rotor; *4* – a stator; *5* – an assembly with rectifying diodes; *6* – a voltage regulator; *7* – a brush assembly; *8* – a protective cover of the diode module

There are two main types of generators: a direct current generator and an alternator.

DC generator. Up to the 1960s on cars installed generators, which are due to a purely mechanical device, switch, generated direct current required by on-board power

consumers [3]. However, such generators had a low efficiency of conversion of mechanical energy into electrical energy and were cumbersome and heavy, and their service life due to the large number of mechanical parts left much to be desired at high cost.

AC Generator. Today, a common standard is the use of automotive AC generators using compact, lightweight, reliable AC to DC electronic converters. The first production car to include an AC generator was the 1960 Plymouth. The average efficiency of alternators is 60-80 % [4, 5].

Current consumers. The engine start system provides primary crankshaft and engine operation during engine start-up. The electric starter is the most common (Fig. 3). High-speed direct current motors with serial or mixed excitation, structurally combined with a gear drive, are used as starters.

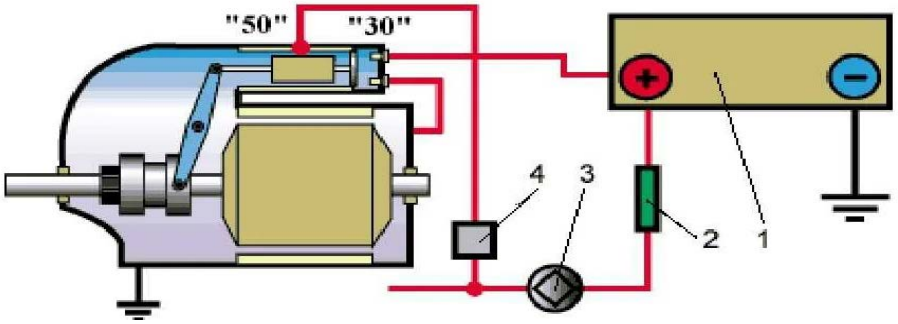

Figure 3. Electric car starter

The ignition system serves to ignite the fuel mixture and is used on petrol engines. Ignition of the fuel mixture occurs as the ignition spark is fed into the cylinders, hence the name spark ignition system [6].

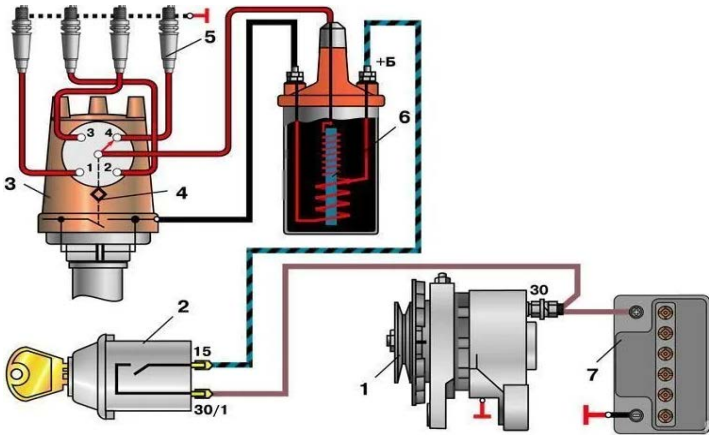

Figure 4. Vehicle ignition system

In other words, the ignition system is used to generate a high voltage current, distribute it through the engine cylinders and ignite the working mixture in the combustion chamber at certain points. Modern cars use contact-transistor and non-contact ignition systems.

Measuring devices in the car play a very important role, as they allow the driver to control the operation of various systems and components of the car. Usually they are on the dashboard in front of the driver in the car (Fig. 5) and provide information on

various parameters such as speed, temperature engine, fuel level and tire pressure.

Figure 5. Vehicle control and measurement devices

With the engine running, it is very important to closely follow the indicators on the instruments. If red light bulbs are lit or the pointers indicate a value in the red area on the scales, this may indicate a possible malfunction in a vehicle system or assembly. In this case, the driver should stop immediately and eliminate the cause of the red signal on the instruments before proceeding.

Ignoring red signals on the instruments can lead to serious consequences and damage to the car, as well as create a dangerous situation on the road. Therefore, drivers should always closely monitor the instruments and respond to any warning signals to ensure safe and reliable movement.

The speedometer is the most important measuring instrument, necessarily present in the construction of any vehicle.

In modern automotive industry two types of devices are used - good old mechanical and more modern electronic, and the speed indicates in km/h or in miles produced [5]. The Fuel Level Sensor (DMT) is designed to control the degree of filling of the tank. The device tracks the amount of gasoline or diesel and sends the information to the indicator. A tachometer is a special device in a car that displays the current speed of the powertrain based on the speed of rotation of the crankshaft.

Lighting. The headlamp device in the car has several basic elements, including the body, light source, reflector and lens. The headlamp body is used for the placement and attachment of other components and is usually made of plastic. The light sources used in headlamps can be of various types, such as tungsten, halogen, gas-discharge (e.g., xenon) or LED lamps.

The reflector in the headlamp is responsible for forming the beam of light. The simplest reflectors have a parabolic shape, but modern reflectors may have a more complex design. The reflector is usually made of plastic, on which a thin aluminium film is applied and lacquered to create a mirror surface.

The lens in the headlamp transmits the luminous flux and can refract it depending on the design. In addition, the lens also serves to protect the headlamp from external influences. Usually, the lens is made of transparent plastic or glass.

The vehicle lighting system includes various lighting devices such as front headlamps, front fog lamps, rear lamps, rear fog lamp, license plate lamp, interior

lighting and control equipment. All these elements play an important role in ensuring safety and comfort during the movement of the car.

Alarm system. The vehicle alarm system consists of three main components: actuators (e.g., engine locks), monitoring devices (sensors) and a control unit (receives data, sends notifications, sends a lock signal) (Fig. 6).

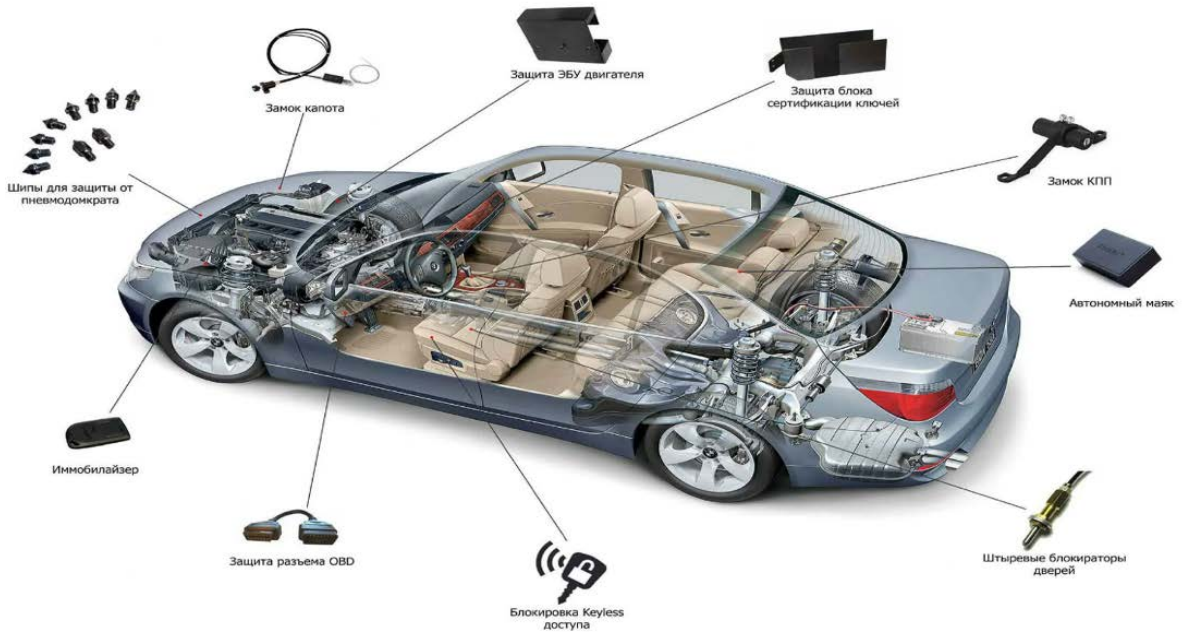

Figure 6. Car alarm elements

The actuators are responsible for performing certain functions such as engine locking. The monitoring devices, in turn, track various parameters and events, such as impacts, inclinations, movements or penetrations into the vehicle, and transmit information about them to the control unit.

In modern car alarms usually present both analog and digital locking. *Analog locking* physically interrupts the electrical circuit required to start the engine, while *digital locking* sends signals to different car units to perform specific commands.

The basic principle of operation of the car alarm is the activation of *electronic sensors* (for example, impact, tilt, motion or penetration) that transmit a signal of possible intervention in the car to the control unit of the security system. *The control unit*, in turn, activates sound (siren) and light (flashing headlights and emergency lights) alarms, and can also send a radio signal to the keychain or make a call to the owner's mobile phone. In an alarming mode, engine locking (which may shut down fuel or ignition) prevents the engine from starting before the alarm is lifted and the alarm is switched off.

Also an important element of the electrical system of the car are electrical wires and connectors that connect all system components together. Wires should be properly laid and protected from external influences to avoid short circuits or breakdowns. The connectors provide convenient connection and disconnection of system components, which facilitates maintenance and repair.

In addition, modern vehicles are increasingly equipped with various electronic systems, such as parking assistance, security, navigation and multimedia systems. All

of them consume energy and are integrated into the overall electrical system of the car.

Thus, the electrical system of the car is an important and complex component, providing reliable operation of all electrical devices and systems of the car. Faultless operation of electrical equipment devices is achieved by comprehensive diagnostics and a complex of adjustment and maintenance works at maintenance of the car. From the serviceable state of the battery, generator, starter, control and measuring devices, lighting and alarm devices, depends on the performance of the entire system of electrical equipment. Virtually all systems are electronically related, and any malfunctions can lead to engine disruption or car startup blockage.

Diagnostics and regular maintenance of electrical equipment help ensure reliable operation of the car every year the electrical equipment of the car improves, creating a great level of comfort and safety for car owners. On the one hand, a number of requirements, including the training of highly qualified specialists, must be met in order to maintain the safety of the vehicle. On the other hand, the understanding of the principles of operation and maintenance of modern electrical equipment is becoming more relevant and in demand among specialists in this field of knowledge.

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DEVELOPMENT OF THE “MEDCOS-M2” SPACE SUIT FOR COSMONAUT HEALTH MONITORING AND ASSISTANCE IN WEIGHTLESSNESS

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Abstract. The article presents the development of the space suit "Medcos-M2", which is a comprehensive solution to the problems associated with space travel, including weightlessness. The importance of the idea of the suit creation, the purpose of the project, the analysis of analogues, technical and software parts are discussed in detail. The scientific and practical significance of the project is explained, highlighting its potential commercial prospects and its relevance to space programmes at various levels.

Keywords: space suit, health, physical loads, voice assistant, medical device.

СОЗДАНИЕ МЕДИЦИНСКОГО УСТРОЙСТВА «МЕДКОС-М2» ДЛЯ МОНИТОРИНГА ЗДОРОВЬЯ КОСМОНАВТОВ И ПОМОЩИ ПРИ НЕВЕСОМОСТИ

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Аннотация. В статье представлена разработка космического костюма «Medcos-M2», который представляет собой комплексное решение проблем, связанных с космическими путешествиями, включая невесомость. Подробно рассматривается важность идеи создания костюма, цель проекта, анализ аналогов, техническая и программная части. Объясняется научное и практическое значение проекта, освещаются его потенциальные коммерческие перспективы и его актуальность для космических программ на различных уровнях.

Ключевые слова: космический костюм, здоровье, физические нагрузки, голосовой помощник, медицинское устройство.

The absence of gravity leads to muscle and cardiovascular system atrophy, particularly the heart, which no longer needs to work intensively to pump blood to the brain. This "relaxation" can result in serious consequences upon landing when the load increases due to the need to overcome the force of Earth's gravity. The only solution to this problem is maintaining physical fitness and regular strength exercises on board a spacecraft (station). In the 21st century, this issue is addressed on the International Space Station through the presence of a gym area, but astronauts typically have such a demanding work schedule that time for physical training may come at the expense of sleep and rest. The development of space suits plays a crucial role in ensuring the health and safety of astronauts during space missions. This article will describe how *to create the "Medcos-M2" suit,* which is a continuation of the "Medcos-M1" project.

During space flights, cosmonauts undergo a series of changes in their bodies: muscle atrophy due to the absence of gravity, calcium depletion, and alterations resulting from increased radiation exposure. Unfortunately, space medicine cannot yet predict and prevent all potential negative consequences of prolonged stays in space [1]. Astronauts spend up to 2 hours of their working time on regular medical check-ups, and in the best-case scenario, only 2.5 hours are allocated for workouts on exercise machines. Our device will autonomously conduct medical check-ups and counteract the negative effects of weightlessness on the human body, reducing the need for constant training and freeing up astronauts' schedules.

The main goal of our project was to develop a comprehensive device capable of influencing the human body through electrical impulses and recording, storing, and updating the obtained data on the individual's physical condition in digital format. The device should maintain physical parameters within normal ranges and enable monitoring of the individual's body condition in space.

Table 1 – The project roadmap

Stage number	*Brief description of the stage*	*Period of execution*
Stage 1	The preparatory stage	1 month
Stage 2	The stage of selecting components and software	1 month

Stage 3	Creating a 3D layout	1 month
Stage 4	Creating a test sample of a suit	1 month
Stage 5	Testing the layout and correcting flaws	2 month
Stage 6	Creation of the first serial sample	1 month
Total		*7 months*

The development of the suit is made possible by the increasing availability of mobile high-tech devices, the need for their continuous improvement, and the popularization of space flights, where astronaut health and safety take precedence and significantly impact the successful execution of planned missions in space.

In the process of implementation of this project, the idea of creating an add-on to existing cosmonaut suits led to the development of a full-fledged suit with a wide range of capabilities, based on the existing "Penguin" suit (Figure 1). The operational principle of the "Penguin" suit involves creating resistance, an alternative to Earth's gravity, which forces muscles to work with every movement of the limbs or the entire body [2]. As a result, the cardiovascular system is stressed, and heart function improves. The "Penguin" suit consists of a complex system of tension devices located on the legs and torso in a way that resistance from the tension device must be overcome with every movement. The key difference in our suit (Figure 2) is that it will keep the body toned through electrical impulses transmitted to the astronauts' bodies, and built-in medical sensors will allow tracking changes in the astronaut's health status [3, 4].

Figure 1. The "Penguin" suit

Figure 2. The "Medcos-M2" suit

The "Medcos" model M2 offers several advantages over the "Medcos" model M1:

– a voice assistant helps astronauts solve everyday and emergency tasks;

– improved ergonomics after identifying and correcting ergonomic shortcomings in the first-generation model;

– enhanced quality of suit components after a series of tests to evaluate reliability and durability;

– the presence of detachable connectors and fasteners allows the suit to be partially reusable (only the wiring inside the suit is non-removable), reducing operational costs.

The technical part of the suit consists of 4 blood oxygen level sensors, 6 ECG sensors, 4 arterial blood pressure sensors (sphygmomanometer), and 20 muscle stimulators that can work simultaneously and stimulate specific body parts when necessary. The structure also includes a device for detailed recording, storage, and processing of information (e.g., in .xlsx (Excel) format on a MicroSD card for data structuring and analysis) and a microcomputer for implementing the voice assistant. The operation principle of such a suit resembles the functioning of a synapse in the nervous system. The entire device is made of high-strength, radiation-shielding, chemically neutral materials suitable for the astronaut's stay on the station. Materials such as composites, kevlar, rubber, aluminum, magnesium, zirconium, and their alloys can be used. The result is a comfortable compression suit resembling thermal underwear that can be worn under a spacesuit.

The project's software part consists of the open-source Arduino UNO R3 platform based on the ATmega328 microcontroller [5, 6]. The choice of this platform is due to its acceptable dimensions and decent computing power. In addition to the main board, an Ethernet W5100 R3 expansion board is used to connect the Arduino microcontroller to the Ethernet network via TCP/IP cable and internet connection. The platform features a slot for a MicroSD card, allowing data on the system's operation, including the Ethernet Shield W5100, to be recorded on the MicroSD card and read from it via the SPI protocol. The main advantages of this software are high speed and the ability to connect multiple devices on a single data bus. The free Arduino IDE programming environment is used to write the software. The software is presented in Figures 3-4.

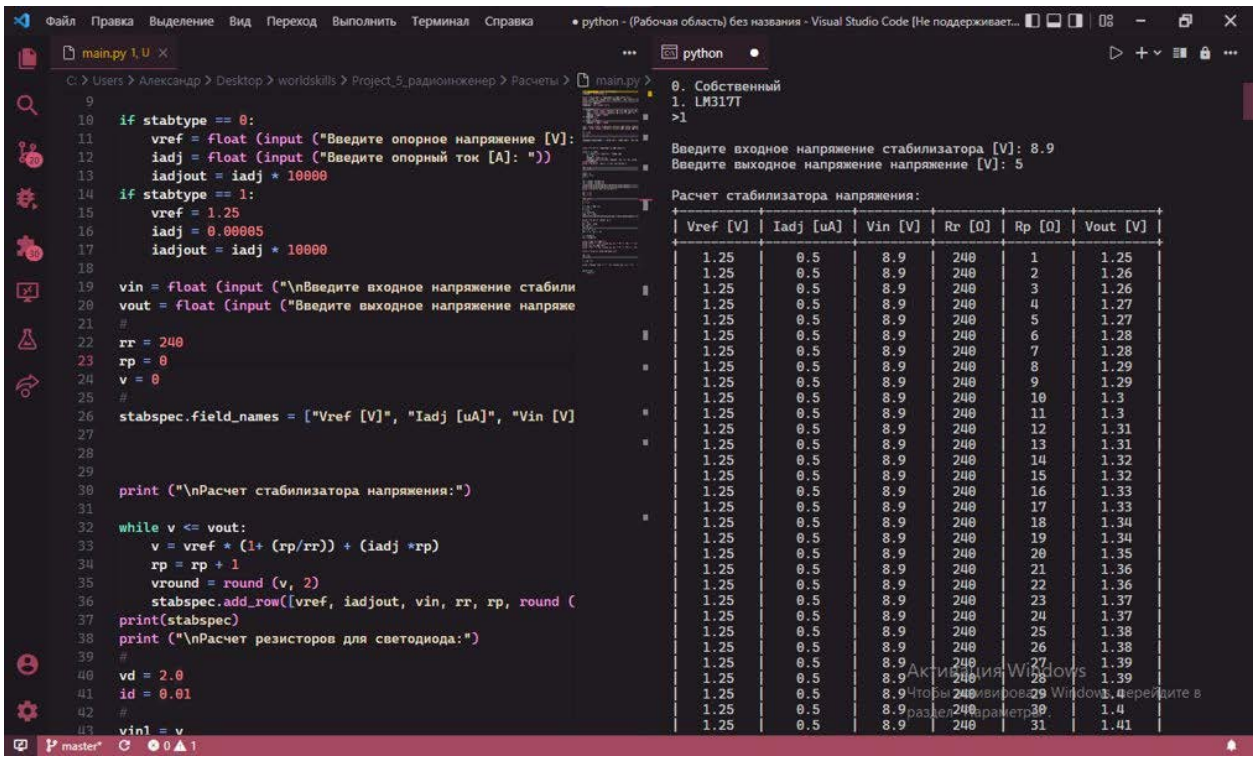

Figure 3. The project's software

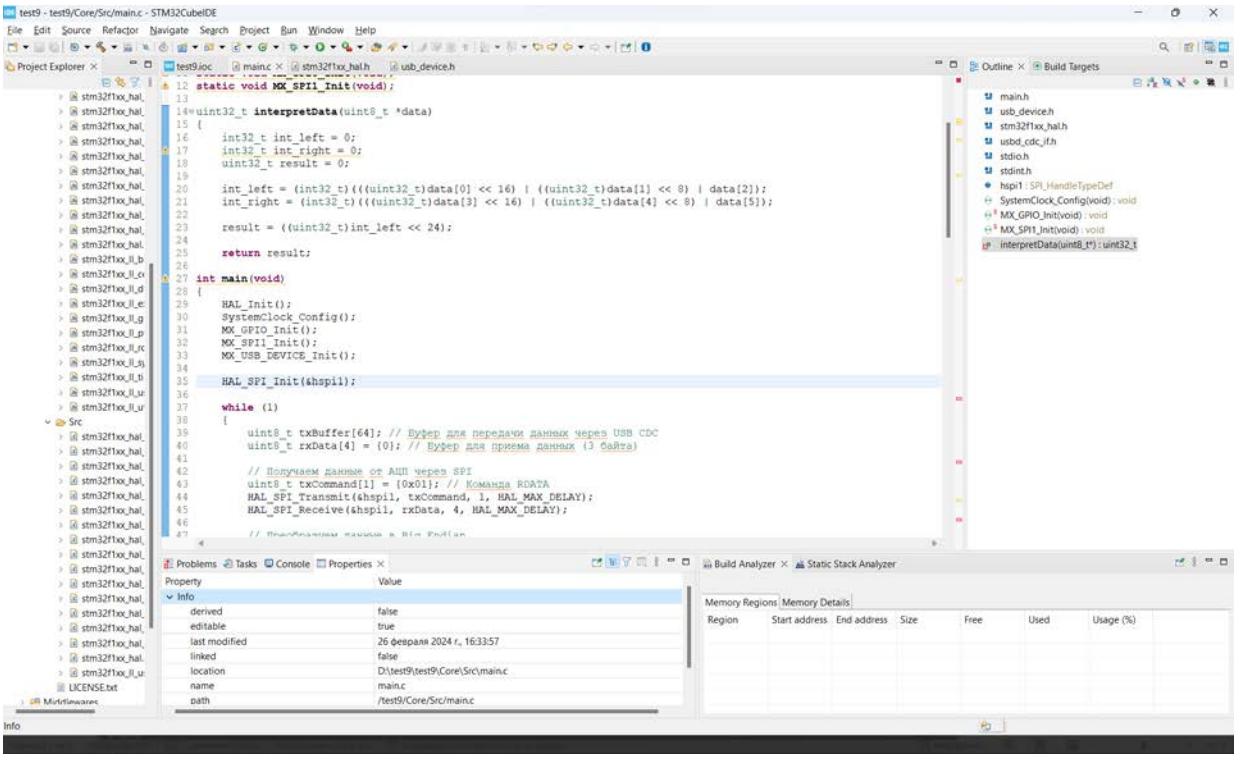

Figure 4. The project's software

This project is promising in terms of its *commercialization potential* due to its uniqueness, comprehensive solution to weightlessness-related issues, and the use of advanced technologies in space medicine. Therefore, it may find wide application in the implementation of space programs at various levels, appealing to both Russian and international space companies.

From a scientific and practical standpoint, our project offers the following

solutions: simplifying health monitoring for the wearer of the suit, providing flexibility for astronauts' freedom of movement within the station, saving time on physical training, increasing astronauts' work time without compromising health, enabling continuous monitoring of astronauts' health status, conducting additional research on the impact of weightlessness on the human body, and the possibility of continuous wearing of a multifunctional voice assistant on the head.

Analysis of existing solutions and their comparison with the proposed solution in the project [7]:

– The orbital module of the Russian segment is equipped with the multifunctional complex "Gamma-1M," which allows for the registration of astronauts' electrocardiograms in various positions, as well as sphygmograms, pulsegrams, venous-arterial pulsegrams, kinecardiograms, arterial pressure, and rheograms.

– The "Orlan" spacesuit, designed for spacewalks, is equipped with the "Beta-08" unit, allowing for the registration of astronauts' electrocardiograms, pneumograms, and body temperature upon exiting the spacecraft.

– The medical monitoring tools also include the "Reflotron-4" blood biochemical analyzer with 15 parameters and the "Urolux" urine biochemical analyzer with 10 parameters.

– For 24-hour electrocardiogram measurements of astronauts in 2 leads onboard, a wearable device "Cardioregistrator-90205" is provided for continuous operation.

– A separate device "Hematocrit" is included in the ISS RS equipment, necessitated by the need to measure the hematocrit number of astronauts' blood.

– Among the monitoring tools for astronauts is a mass meter – a special device for measuring body mass in weightlessness ranging from 50 to 100 kg, as well as for measuring small masses within the range of 0.02 to 2.00 kg.

The "Medcos-M2" suit combines all these devices in terms of functionality. Currently, the suit is in the design and technical improvement stage.

Table 2 – The list of resources used in the work

№	*Item of expenditure*	*Unit of measurement*	*Cost per unit in rubles*	*Number of units*	*Amount in rubles*
1	Arduino UNO R3	piece	1500	1	1500
2	Ethernet W5100 R3 SHIELD	piece	1500	1	1500
3	Battery	piece	1000	2	2000
4	Omron Electrodes Plates	packaging	2800	5	14000
5	OMRON M2 Basic	packaging	2500	1	2500

	Blood Pressure Monitor				
6	Polar OH1 Heart Rate Monitor	piece	6500	1	6500
7	Compression suit	piece	3000	1	3000
8	Wiring	packaging	1000	1	1000
9	Unforeseen expenses				2000
	Total				*34000*

The project has participated in numerous conferences and competitions, achieving prize-winning positions and being nominated for a grant at the Space Research Institute of the Russian Academy of Sciences.

The "Medcos-M2" space suit project represents a significant advancement in space medicine technology, offering a comprehensive solution for astronaut health monitoring and assistance in weightlessness. By consolidating various health monitoring devices into a single suit, the project aims to enhance astronaut safety, efficiency, and overall well-being during space missions. The ongoing design and technical refinement of the suit demonstrate its potential for future implementation in space exploration endeavors. The project's recognition in conferences, competitions, and grant nominations underscores its innovative approach and contributions to the field of space medicine.

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CURRENT STATE AND PROBLEMS OF ALTERNATIVE ENERGY DEVELOPMENT IN THE WORLD

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Abstract. The article presents the current state and analysis of factors, affecting the use of alternative energy sources on a global scale. The rate of growth of renewable energy sources is insufficient and the authors identify factors affecting the efficiency of their use and barriers to accelerating the rate of substitution of traditional energy sources. Special attention is paid to the state support measures and relevant legislative acts aimed at stimulating and attracting the necessary investments in this sector of the economy for ensuring energy security.

Keywords: CO2 emissions, alternative energy, renewable energy, incentives, barriers, energy security.

СОВРЕМЕННОЕ СОСТОЯНИЕ И ПРОБЛЕМЫ РАЗВИТИЯ АЛЬТЕРНАТИВНОЙ ЭНЕРГЕТИКИ В МИРЕ

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Аннотация. Статья посвящена современному состоянию и анализу факторов, влияющих на использование альтернативных источников энергии в глобальном масштабе. Темпы роста возобновляемых источников энергии (ВИЭ) недостаточны, и авторы определяют барьеры, препятствующие ускорению темпов замещения традиционных источников энергии ВИЭ. Особое внимание в статье уделяется мерам государственной поддержки и соответствующим законодательным актам, которые направлены на стимулирование и привлечение необходимых инвестиций в данную отрасль экономики для обеспечения энергетической безопасности.

Ключевые слова: CO2 выбросы, альтернативная энергетика, возобновляемые источники энергии, меры стимулирования, барьеры, энергетическая безопасность.

Achieving an acceptable level of energy security was an important factor in the development of the country and a key national priority for virtually all States of the world, Energy security is a multidimensional concept with a definite definition of energy security, since the level of the State's energy endowment is a major determinant of stability and socio-economic development. The interdependent and independent dimensions of its measurement. Improving energy security was becoming a priority objective of society as it was necessary to meet basic human needs. Many scientists consider the term «energy security» as «abstract, elusive, vague, complex and blurred» [1]. With rising and volatile energy prices, rising consumption and dependence of developed countries on energy and energy supplies, recurrent energy and oil crises, climate change, political competition, the interest in energy security was increasing every year.

In the post-war period, owing to the lack of sufficient oil reserves for most industrialized countries to meet their needs, as well as to the concentration of most of the world's oil reserves in one region (Middle East) and the decolonization process. The structure of the international market had been altered as a result of which industrialized States had lost much of their energy sources of raw materials. In the view of G. Morgenthau, this led to an epoch-making coup, as the political and economic power of the State ceased to depend directly on its military potential, as it was earlier, since the most important factor was the control of energy supplies [2].

According to G. Morgenthau, this led to an epoch-making coup, as the political and economic power of any State ceased to depend directly on its military potential, as it was earlier, since the most important factor was the control of energy supplies [3]. Whether a country is an energy exporter or an energy importer, *energy security* is an important element of the national security of any of them. Energy-importing countries face the problem of their high cost, dependence on the external market, while for exporting countries, investment in extractive industries and energy is a serious problem, which support them in ensuring both a stable supply of energy to the economy and the population, as well as an appropriate level of energy exports, revenues for which are the most important components of the budget.

The importance of energy security for countries lies in the fact that it:

- ensures the independent development of the economy through the most efficient use of energy resources;
- reduces the risk of dependence on the external market;
- serves the national security interests of the country.

Because of the risks of oil price volatility, the capital intensity of the process of creating new energy technologies, the high cost of energy infrastructure, the depletability of traditional energy sources and a number of other reasons, many countries are switching to «green energy», i.e. an important reason for the integration of renewable energy sources (RES), is also ensured.

The transition to renewable energy sources has become a pressing issue in the global energy sector, driven by concerns over climate change, rising fossil fuel prices, and the need for energy security. While nuclear power has been a significant source of electricity in many countries, accidents such as Chernobyl and Fukushima have highlighted the risks associated with this technology. As a result, there is a growing consensus on the importance of shifting towards renewable energy sources to meet energy demands sustainably. This paper aims to analyze the efficiency of alternative energy sources and provide recommendations for supporting electricity producers based on renewables, drawing on international experiences and case studies.

The development of the energy sector in modern conditions is characterized by an increasing share of alternative energy sources, especially solar and wind energy. According to *the International Renewable Energy Agency* (IRENA), the use of renewable energy sources is accompanied by a multiplicative effect: doubling the share of renewable energy in the global energy balance by 2030 will lead to a GDP growth of 0.6–1.1 % ($1.3 trillion), as well as an increase in well-being by 3.7 %, with employment in the renewable energy sector increasing by 6 % annually [4].

In 2022, the share of alternative energy in the global energy sector, including nuclear energy, reached 39 %. At the same time, the high share of coal in electricity production leads to significant CO2 emissions, which reached a historical maximum in 2022 (224 Mt) [5]. This process contributes to global warming and climate change, manifested in rising sea levels and natural disasters. Therefore, studying issues related to global trends in the use of alternative energy sources, analyzing factors influencing their development, and overcoming obstacles to their wider dissemination is relevant for the modern scientific community.

In the modern world, regions and countries are interdependent in terms of sustainable economic development, energy security, and effective measures to combat climate change. *Global energy consumption* from 1980 to 2022 has more than tripled, driven by the sustainable development of the global economy and increasing heating and cooling needs in some parts of the world. Figure 1 shows data on CO2 emissions from fossil fuels.

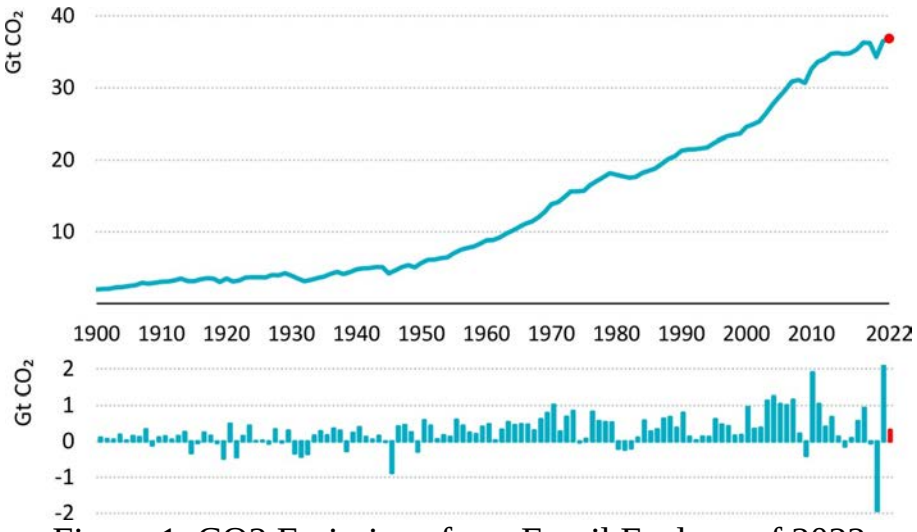

Figure 1. CO2 Emissions from Fossil Fuels as of 2022

It is expected that by 2030, global energy demand and CO2 emissions will increase by approximately 60 %, and by 2050, more than double. By 2050, coal consumption will be almost three times higher than in the early 2000s, gas consumption will increase by 138 %, and oil consumption by 65 % [6].

The foundation of the world's energy currently relies on hydrocarbon reserves (coal, oil, gas), constituting approximately 70 % of global energy production. However, the world is approaching a pivotal moment where reevaluating the traditional energy structure based on hydrocarbon sources is imperative. Besides the depletion of these finite energy reservoirs, the ecological crisis also plays a significant role. Annual carbon dioxide emissions are on the rise at an average rate of 100 tons. Scientists warn that if this critical situation persists, humanity could face a global catastrophe.

Countries like India and China heavily rely on coal for 70-80 % of their energy mix, while the USA, Japan, and Germany use 30-40 %. In contrast, countries like England, Canada, Spain, Italy, and Ireland have a lower coal share ranging from 5-15 %. Hence, the global community is emphasizing the expansion of renewable and alternative energy sources such as wind, solar, hydro, nuclear, and hydrogen technologies. It is widely acknowledged that each energy-consuming entity must make a choice between traditional and non-traditional renewable energy sources to tailor an individual solution for their heating and energy supply systems, primarily focusing on alternative (AlE) or innovative energy (InE).

Alternative Energy (AlE) or Innovative Energy (InE) concepts involve devices that generate electrical and thermal energy from sources other than hydrocarbons, including wind, solar, geothermal, among others. Alternative energy is categorized into various types based on the energy source, including wind, small-scale energy, solar, energy from waste, biomass, hydrogen, nuclear, and more.

There are approximately 15 different types of *alternative energy sources*. Globally, significant experience has been gained in developing and implementing energy-efficient, renewable, and environmentally friendly technologies. Programs aimed at fostering alternative energy sources began emerging in some advanced countries in the 1980s, but it was not until the 1990s that most countries started taking substantial steps in this direction. Currently, 66 countries have political programs dedicated to the advancement of alternative energy, including all 27 EU countries, 29 American states, and 9 provinces in Canada [7].

The energy strategies of developed countries, such as the US, Canada, Germany, Japan, and England, are aimed at constantly increasing the share of alternative energy sources in the total energy balance in order to reduce the dependence of these economies on oil and gas imports, and minimize the use of traditional energy sources due to the risks of their extraction and use, adverse effects on the environment, human health and the climate of the entire planet. Among the developing countries with the most successful policy approaches to improving energy security and efficiency are Morocco, India, the Philippines and South Africa (South Africa). According to the World Energy Council and other international organizations, these countries are demonstrating the example of the formation of a sustainable energy sector, the minimization of threats to national energy security and the dynamic development of renewable energy.

One of the most important measures in this regard is *the development of alternative energy standards*, which require retail electricity suppliers to use a certain percentage of electricity generated from renewable energy sources. These standards are currently enforced in 44 nations, such as the USA, the Netherlands, the UK, Belgium, Denmark, France, and others. A pivotal action has been the implementation of regulations within the realm of alternative energy, compelling retail electricity suppliers to integrate a specific portion of renewable energy-generated electricity. These initiatives collectively contributed to raising the renewable energy share to 30 % in 2022, reaching up to 39.2 % when factoring in nuclear energy (refer to fig. 2).

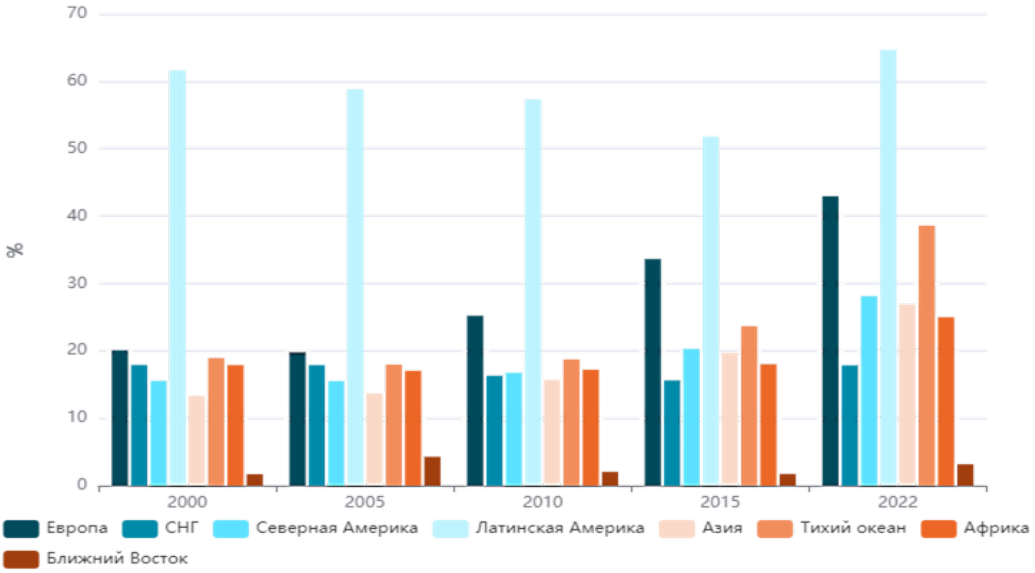

Figure 2. Share of Renewable Energy Sources in Electricity Consumption in 2022, %

In China, renewable energy capacity saw an 8.1 % increase in 2022 compared to 2021, despite power challenges and mounting subsidy debts. The total capacity, encompassing hydroelectric, biomass, solar, and wind energy, stood at 2799 GWt-h by the close of 2020, marking a 261 GWt or 10.3 % rise from 2019.

China stands out globally for its renewable energy production and utilization, particularly in hydroelectric, wind, solar, and biomass sectors, with notable progress in geothermal and marine energy. These sources contributed to over 70 % of China's total electricity generation in 2022. The National Energy Board projects that renewable sources like wind, biomass, geothermal, and solar power will make up 12 % of the country's electricity production by 2035.

Nuclear power, another form of alternative energy, accounts for 10.2 % of global energy production, with about 450 nuclear reactors operating across roughly 30 nations. In 2022, Russia's nuclear power plants achieved a new milestone by producing over 223 billion kilowatt-hours of electricity.

Table 1 – Electricity production in Russia in 2021-2022.

Энергосистема	Потребление электроэнергии, млрд кВт·ч			Динамика потребления, %	
	2022 год	2021 год	Отклонение (+/–) от 2021	Фактическая	Приведенная к температурным условиям 2021 года
ЕЭС РОССИИ	**1 106,3**	**1 090,4**	**15,9**	**1,5**	**1,8**
ОЭС Центра	257,3	256,3	1,0	0,4	0,9
ОЭС Средней Волги	110,9	111,4	-0,6	-0,5	0,2
ОЭС Урала	260,8	256,7	4,2	1,6	1,9
ОЭС Северо-Запада	97,1	97,6	-0,4	-0,4	0,1
ОЭС Юга	111,0	108,3	2,8	2,6	3,1
ОЭС Сибири	224,7	217,3	7,3	3,4	3,4
ОЭС Востока	44,5	42,9	1,6	3,8	3,9

The primary challenges associated with this form of renewable energy include the high costs of future nuclear power plants and safety issues at nuclear facilities. Incidents such as those at Chernobyl and Fukushima have underscored the risks of radioactive contamination following environmental releases. For instance, Ukraine faces additional financial burdens from programs like the State Agency of Ukraine's management of the exclusion zone and contributions to nuclear safety funds. Nuclear power units typically have a service life of 30 years, and in Ukraine, some reactors have surpassed this limit, necessitating substantial investments for upgrades and replacements.

Japan has also suffered significant financial losses from nuclear accidents, exceeding 100 billion US dollars. Even after the final shutdown of reactors, annual expenses for maintenance and safety measures amount to millions of dollars. The storage and monitoring of high-level reactor waste for hundreds of years require substantial financial resources. Therefore, we believe it is crucial to hold referendums on critical safety issues that impact not only specific regions but the entire country. Germany, for example, has opted to phase out nuclear power gradually and transition to renewable energy sources. Following the Fukushima incident, Japan aims to triple its electricity production from renewables by 2030 compared to 2010, reflecting a prudent strategy [8].

When making decisions about electricity supply, it is essential to weigh the pros and cons of various energy sources. We conducted a study that organized factors influencing the efficacy of alternative energy sources and developed recommendations to assist electricity producers utilizing renewables, drawing on international best practices.

Table 2 – Classification of factors influencing the effectiveness of using alternative energy sources

Climatic conditions	Technical and economic conditions	Environmental conditions	Geographical conditions
- wind speed, m/ s; - the degree of openness of the area; - insolation, W / m2; - the presence of natural or artificial watercourses; - geothermal sources, etc.	- equipment price; - cost of transportation and installation of equipment; - the life of the equipment; - payment for environmental pollution; - the state of the power equipment; - efficiency coefficient; - electricity tariffs from traditional sources, etc.	- impact on animals and birds from rotating blades of wind generator; - effects of electromagnetic fields on marine animals; - the amount of harmful emissions and the greenhouse effect of conventional energy sources, etc.	- distance from the centralized power supply system; - distance from fossil fuel suppliers; - minimum distance from installation to built-up areas, etc.

Despite advancements in the use of renewable energy sources, India and China continue to rely on coal for 70-80 % of their energy balance, despite having significant renewable energy potential [9]. According to experts, to achieve a balance between the demand for electricity and its production, India should pay special attention to nuclear energy. Currently, nuclear energy accounts for only 2 % of the total electricity generated by 7 nuclear power plants. To accelerate the transition from traditional energy sources to renewables, it is necessary to identify barriers hindering this process:

- *Political and regulatory barriers:* Countries lacking government support often lack legislative acts supporting the use of renewable energy sources, leading to a lack of investor interest due to the absence of incentives and associated high risks.

- *Technical barriers:* In certain developing nations, the lack of technology and infrastructure hinders the progress of alternative energy initiatives. Limited educational opportunities and a scarcity of skilled labor, particularly in countries located south of the Sahara in Africa, pose challenges in importing equipment and technologies for renewable energy projects. The high costs associated with importing equipment can drive up electricity prices, rendering it unaffordable for impoverished populations. Furthermore, the absence of spare parts and qualified technicians for maintenance and repairs exacerbates the problem when equipment malfunctions. The transmission of renewable energy sources through grids, especially wind energy, presents significant challenges, resulting in energy losses that deter investors due to elevated risks [10].

On the other hand, the 2019 BloombergNEF (NEO) energy forecast highlights the swift advancement of renewable energy sources, indicating a potential to restrict

the global temperature increase to 2°C by 2030. Projections suggest that by 2030, newly established wind and solar power facilities, often integrated with storage solutions, will generate electricity more affordably than existing coal and gas power plants across most regions worldwide. Consequently, coal's role in the global energy mix is anticipated to diminish from 37 % to a mere 12 % by 2050, while oil's significance as an energy source is expected to dwindle significantly as wind and solar energy's share rises from 7 % to 48 % by 2050. In contrast, hydroelectric power, natural gas, and nuclear energy are predicted to maintain relatively stable contributions in terms of percentage distribution.

According to forecasts, global electricity consumption is expected to continue to rise over the next two decades. At the same time, the global community is concerned about climate change, rising fossil fuel prices, and political instability in major supplier countries. Therefore, renewable energy sources have become a key focus of research aimed at increasing their share in the overall energy consumption.

Persistent subsidies and other forms of government support for the oil extraction and refining industry also hinder the widespread use of renewable energy sources and the improvement of competitiveness. Hence, it is necessary to consider factors influencing the efficiency of renewable energy integration, as well as barriers that impede the acceleration of the process of replacing traditional energy sources with renewables (such as political and regulatory barriers, technical, socio-cultural, financial-economic, market, geographic, and environmental barriers).

In conclusion, the shift towards renewable energy sources is crucial for achieving sustainable and secure energy systems for state energy security. While challenges such as political, technical, and financial barriers exist, the rapid deployment of renewables offers a promising pathway towards reducing greenhouse gas emissions and mitigating climate change. By investing in renewable energy technologies and overcoming barriers to their integration, countries can ensure a cleaner, more resilient energy future for generations to come. It is imperative for policymakers, industry stakeholders, and the global community to work together to accelerate the transition to a renewable energy-based economy and achieve a more sustainable energy landscape.

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УДК 621.3

A METHOD FOR DIAGNOSING AND SUPERVISING THE INSULATION CONDITION OF CABLE LINES

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Abstract. This article provides an overview of methods for diagnosing and monitoring the insulation condition of cable lines. It discusses the different types of cables, the main causes of cable line faults, and how to detect faults on cable lines. The article describes the main techniques and devices used to diagnose the insulation of cable lines, enabling effective monitoring and detection of potential problems, as well as ensuring the reliable operation of cable networks.

Keywords: cable lines, damages, insulating material, electric power.

МЕТОД ДИАГНОСТИКИ И КОНТРОЛЯ СОСТОЯНИЯ ИЗОЛЯЦИИ КАБЕЛЬНЫХ ЛИНИЙ

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Аннотация. Данная статья представляет обзор методов диагностики и контроля состояния изоляции кабельных линий. В ней рассматриваются различные виды кабелей, основные причины повреждения кабельных линий, а также способы обнаружения поломок на кабельных линиях. В статье описаны основные техники и приборы, используемые для диагностики изоляции кабельных линий, позволяющие эффективно контролировать и обнаруживать потенциальные проблемы, а также обеспечивать надежную работу кабельных сетей.

Ключевые слова: кабельные линии, повреждения, изолирующий материал, электроэнергия.

The main goal of energy companies involved in the transmission of electric energy from producers to consumers is not only to preserve energy resources and the environment, but also to ensure the quality and reliability of electricity supply. While high-voltage transmission lines are used to transport electricity from generating companies to load centers (large cities or industrial areas), AC cable lines (from 0.4 kV and higher, depending on local conditions) are used to distribute electricity within cities and large industrial enterprises. Since cable lines make up the majority of distribution networks, they require more attention and maintenance.

The main types of cables for electrical circuits are:
Symmetrical cable: it consists of two insulated conductors with the same structural and electrical properties (Fig. *a*)
Coaxial cable: The inner conductor is concentrically located inside the outer conductor, which is shaped like a hollow cylinder. The inner conductor is isolated from the outer one by various insulating layers (gaskets, balloons, cords, etc.) (Fig. *b*).
Power cable: It consists of a central core and protective layers. The core consists of twisted insulated conductors that form electrical circuits. The protective layers are a waterproof shell (metal, etc.) (Fig. *c*).
Fire-resistant cables: they are designed to ensure continuity of power supply and prevent the spread of fire in the event of a fire (Fig. *d*).
Aluminum cables: They are lighter in weight and cost compared to copper cables, but have lower electrical conductivity. They are often used in overhead power lines and in underground power distribution systems (Fig. *e*).

a) *b)* *c)* *d)* *e)*

Figure. Types of cables:
a) Symmetrical cable *b)* Coaxial cable *c)* Power cable
d) Fire-resistant cables *e)* Aluminum cables

The following basic materials are used for the manufacture of cable lines:
Copper – is the most high-quality and widespread material for conductive cable cores, suitable for use in all classes of cable products.
Aluminum – is also widely used for cable cores, especially in industry (welding, metallurgical), but is inferior to copper in conductivity.
Steel and bimetallic cores (steel with copper or aluminum coating) – are rarely used due to poor electrical conductivity.

The main advantages of using copper for the manufacture of cable cores are:

- Better electrical conductivity compared to aluminum, which makes it possible to transmit more current with the same cross-sectional area
- High mechanical strength and resistance to deformation
- Chemical inertia, lack of reaction with most substances
- The possibility of application in all classes of cable products, including flexible cables
- Advantages of aluminum:
- Low cost and low weight, which simplifies and reduces the cost of installation
- Oxidation resistance, formation of a protective film on the surface
- High plasticity, the ability to give the cable any shape
- No expansion when heated with sufficient cross-section
- The main disadvantages of aluminum:
- Lower electrical conductivity compared to copper, requires a larger cross-section to transmit the same current

- Tendency to electrochemical corrosion, galvanic effect
- The need to replace connecting fittings and sockets when replacing copper cables with aluminum ones
- Increased diameter of aluminum cables with the same conductivity, which does not always correspond to existing designs.

To plan, organize and perform the operation and maintenance of each cable line (CL), a design technician is required. documentation and passports, as well as address lists of cable structures [1].

The KL passport is drawn up on the basis of acceptance documents and includes the following information: 1) the brand and length of the cable; 2) the layout of the reiper marks; 3) data on the connecting and end fittings; 4) information on protection against corrosion, vibration and mechanical damage; 5) information on preventive tests; 6) information on damage and repairs of the CL; 7) information on the loading of the CL.

Cable transmission lines have a number of advantages and disadvantages compared to other methods of electricity transmission:

A more compact and inconspicuous gasket that does not clutter up urban areas, high reliability and protection from external atmospheric influences, such as thunderstorm overvoltage's, wind loads, icy conditions, high throughput, full protection from unauthorized access, no need for maintenance of rotating parts, low loss of active power.

But unfortunately, cable lines can be subject to various damages. All this information should be stored in a data bank. A properly compiled passport should help in assessing the condition of the CL and making timely decisions about the repair of the line. The passport usually indicates the name of the facility, its dispatch number and the address of the nearest city building.

The main causes of damage to cable lines are: mechanical damage (43 %), direct mechanical damage caused by construction and other organizations (16 %), defects in couplings and end connections during installation (10 %), damage to cables and joints as a result of subsidence of the earth (8 %), corrosion of the metal shell cables (7 %), cable manufacturing defects at the manufacturer (5 %), cable laying violations (3 %), aging of insulation due to prolonged operation or overloads (1 %), and other and unidentified causes (7 %). Single-phase earth faults (14.2 %), multiphase earth faults (75.7 %), mechanical damage (5 %) and malfunctions in cable connections and branches (5.1 %).

The frequency of damage to CL requiring repair is more than 30 per 100 km per year, which is more than four times higher than the norm of 7.5 per 100 km per year [2].

Heating the cable can lead to a decrease in its performance and even damage. If the cable heats up completely, this may be a sign that the current exceeds the conductor cross-section and it cannot cope with the load. In such cases, it is necessary to reduce the power or replace the wire with a model with a suitable cross section. If only a certain area heats up, it may be caused by substandard connections that need to be fixed. It is for this purpose that thermal calculations of cable lines are performed. It is based on the solution of the heat balance equation, which takes into account the active power released in the cable, which turns into heat, which heats the cable and the

surrounding soil. This equation does not depend on the length of the cable line and can be given per 1 meter of its length. After all, due to an increase in temperature in the cable line, it can lead to a deterioration in the quality of data transmission due to several factors. Firstly, heating the cable can cause changes in its electrical properties, which can lead to signal distortion and data loss. Secondly, at elevated temperatures, the likelihood of interference and interference increases, which can also negatively affect data transmission.

Let's take a closer look at the factors that lead to cell damage. The main factors affecting the damage to the CL are: the duration of operation of the CL at operating voltages and currents, leading to physical wear of the insulation during prolonged use. Poor manufacturing quality of the terminal and connecting couplings of the CL, mechanical damage to power cables during construction and other works at the facility. The CL zone and geological factors in the territory through which it passes, corrosion of protective shells of power cables under the influence of geochemical and hydrological factors. Systematic and prolonged overload of the CL, the number of short circuits in the electrical network, is accompanied by the flow of high currents through the CL, causing overheating and accelerated wear of insulation, the presence of increased levels of switching overvoltages in the electrical network created by switches and causing an electrical breakdown of the insulation of the CL elements, the discrepancy between the test voltage and the actual insulation level of the CL elements and possible overvoltages in the electrical network, failures in the frequency of preventive tests of CL insulation, violation of cable manufacturing technology, including insulation, violation of cable laying technology (mechanical loads, unacceptable bends, mechanical damage during laying, etc.) [3].

The traditional detection of damage in cable lines is carried out in three stages. At the first stage, when a damaged cable is detected, the CL is disconnected and the insulation burns out. At the second stage, the distance to the damage site is determined using appropriate devices. At the third stage, the place of damage is determined, after which repair and restoration work is carried out using complex technology.

To search for damage on cable lines, it is more expedient and economically profitable to use mobile mobile electrical measuring laboratories. This is usually a car with a van equipped with test equipment mounted on the chassis. Inside there is a private generator set that ensures operation in the field. The machine is also equipped with devices to determine the distance to the damage site.

The search for damage begins with burning the cable line. This method is used in cases where high transient resistances can make accurate diagnosis difficult. The essence of the procedure is to use special devices and devices to supply high-voltage voltage to the damaged section of the cable, which allows you to create conditions for the formation of a breakdown and accurately locate the damage site. After that, remote methods are used to determine the location of the damage, such as the pulse or capacitive method. A high-voltage pulse is supplied to the cable line, which returns after interacting with the damage. The distance to the defect is calculated based on the pulse return time. If the cable line is broken, you can determine the distance to the breakage by measuring the capacity of the core. However, it is impossible to accurately indicate the location of the damage on the map or diagram, therefore, a visit to the site is required to clarify the location of the cable. If the route of the cable is unknown, it

can be determined by sending a signal from a special generator to the damaged or adjacent cable [4].

In Russia and other countries of the former USSR, a system of scheduled preventive tests is used to ensure reliable operation of power cable lines. It provides for periodic testing of cables with a constant voltage 4-6 times higher than the rated voltage, while simultaneously measuring leakage currents. This is done to prevent possible cable breaks. Cables of 6-10 kV are tested with a voltage five times higher than the rated voltage for five minutes for each phase, at least once every three years. The leakage current characteristics are monitored during the test. The cable line is considered to have passed the test if, after establishing a constant current, there is no rupture or increase in leakage current. However, even successful completion of these scheduled preventive tests does not guarantee uninterrupted subsequent operation of cable lines and may even shorten their service life. This is especially true for cable lines with a long service life or with significantly degraded insulation. High direct current voltage tests are practically useless for cables with cross-linked polyethylene insulation, which has high electrical strength and low leakage currents, and can even negatively affect the condition of polyethylene insulation [5].

The methods of supervising the condition of cable lines discussed above indicate a constant and intensive search for solutions by researchers. However, their abundance suggests that the problem remains relevant and requires solutions based on fundamentally new approaches based on the principles of non-destructive technologies. To implement non-destructive technology of technical diagnostics, information obtained from the electromagnetic field around the cable can be used, and the characteristics of the spatial structure of the field can be evaluated on the element being diagnosed.

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BAIKONUR COSMODROME: A HISTORICAL OVERVIEW AND FUTURE DEVELOPMENT PROSPECTS

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Abstract. The article provides an overview of the Baikonur Cosmodrome, a historic space launch site located in Kazakhstan. It discusses the infrastructure, launch statistics, and operational history of the cosmodrome, highlighting its role in space exploration over the past 65 years. The article delves into the significance of Baikonur as the launching site for key space missions, including the first artificial satellite and manned spaceflights. Additionally, it explores the future prospects and continued importance of Baikonur in advancing space exploration endeavors.

Keywords: Baikonur, cosmodrome, space industry, space launch.

КОСМОДРОМ БАЙКОНУР: ИСТОРИЧЕСКИЙ ОБЗОР И ПЕРСПЕКТИВЫ РАЗВИТИЯ

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Аннотация. В статье рассматривается создание и развитие космодрома Байконур: его инфраструктура, статистика запусков и история эксплуатации космодрома, а также его роль в исследовании космоса за последние 65 лет. Особое внимание уделяется значению космодрома как стартовой площадки для ключевых космических миссий, включая первый искусственный спутник и пилотируемые космические полеты. Автор подчеркивает, что в будущем космодром сохранит свою позицию в продвижении космических исследований.

Ключевые слова: Байконур, космодром, космическая промышленность, запуск.

The Baikonur Cosmodrome stands as a testament to human ingenuity and exploration, serving as a pivotal launch site for numerous space missions since its inception in 1955. Nestled in the vast expanse of the Kazakh desert, Baikonur's history is intertwined with the evolution of space exploration, witnessing milestones such as

the launch of the first artificial Earth satellite and the historic flight of Yuri Gagarin, the first human in space. Over the years, Baikonur has evolved into a sophisticated spaceport with modern infrastructure and a rich legacy of successful launches.

The Baikonur Cosmodrome is the first, as well as the largest operating cosmodrome in the world (Figure 1). Once all-Union, and today located in the Kyzylorda region of Kazakhstan, between the village of Dzhusaly and the city of Kazalinsk, near the village of Toretam, Baikonur is leading in the number of space launches.

Figure 1. The Baikonur Cosmodrome

Cosmodrome history. On February 12, 1955, a joint resolution of the Central Committee of the CPSU and the Council of Ministers of the USSR was issued on the creation of a new military training ground for the flight testing of the first domestic intercontinental ballistic missile (ICBM) R-7. A special commission was assembled, which decided: an extensive (at least 7 thousand km long) and sparsely populated area was needed, next to which there are sources of fresh water and a railway for the delivery of rocket blocks.

They considered the Mari ASSR, Dagestan, Astrakhan and Kyzylorda regions of the Kazakh SSR (now the Kyzylorda region. Of the Republic of Kazakhstan). But only the last of the options allowed for a convenient location of ground-based radio control points of the missile. Sergei Korolev, the designer of space rockets, also insisted on building there: he believed that the closer the launch pad was to the equator, the more convenient it would be to use the Earth's rotation speed.

Therefore, the desert of Kazakhstan was chosen for the construction of the 5th Research and Test Site (NIIP) of the USSR Ministry of Defense, the future Baikonur cosmodrome. The first groups of builders arrived at the place of work – in January 1955.

The construction of the landfill has become a competition with nature. The sand froze by one and a half meters, so we had to blow it up. The first dugouts appeared only in spring, and in early May the first wooden building of a residential town was laid. In summer, the wind there becomes withering – the temperature rises to 50 degrees (Figure 2).

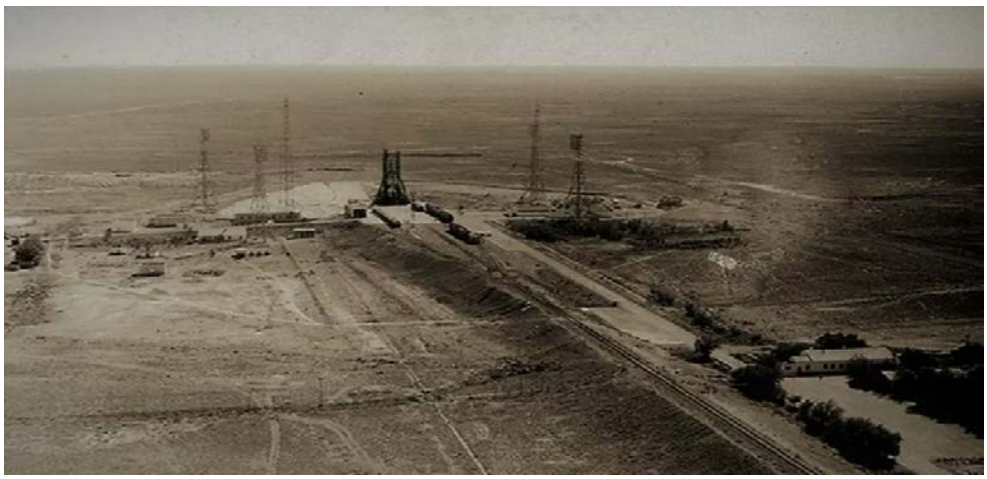

Figure 2. The construction of the Baikonur Cosmodrome

The founding day of Baikonur is considered to be June 2, 1955, when the directive of the General Staff of the Armed Forces of the USSR approved the organizational and staff structure of the 5th NIIP and created the headquarters of the polygon – military unit 11284. In the first half of 1955, the area of formation of the polygon had the conditional name "Taiga". Back then, there was no word "cosmodrome" in the Russian language.

The construction was carried out from scratch, in the bare steppe, the only existing infrastructure element at that time was the railway. By the beginning of the flight tests of the R-7 in May 1957, the launch complex, assembly and testing and assembly buildings were erected, a concrete road and railway access roads were laid to the launch pad. Simultaneously with the construction of the landfill near the «Tyuratam» railway station, the construction of a residential settlement for testers was carried out. The landfill and the settlement received the unofficial name "Zarya". [1]

Launch history. Baikonur started functioning in 1957. The first launch, carried out on May 15, failed. The R-7 ICBM left the starting position, but due to an explosion in one of its side blocks, an emergency shutdown of the engines occurred at the 98th second of the flight. The wreckage of the rocket fell 400 m from the launch, but in general the complex was not damaged. The successful launch of the R-7 took place three months later – on August 21.

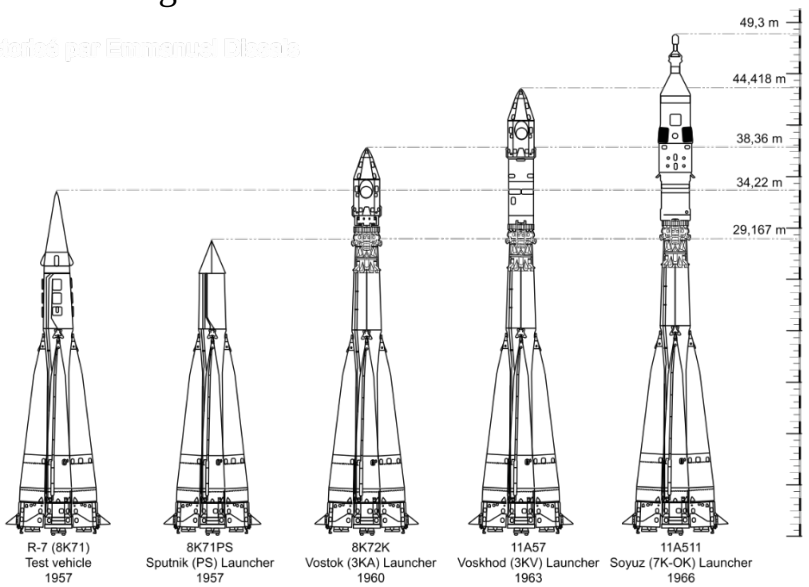

Figure 3. The R-7 rocket and its modification

On October 4 of the same year, the first artificial Earth satellite was launched into near-Earth orbit with the help of the R-7 rocket converted for space launches (Figure 3). It was in orbit for 92 days (until January 4, 1958), having completed 1,440 revolutions around the Earth (about 60 million km). Its radio transmitters worked for two weeks after launch.

On April 12, 1961, the Vostok spacecraft was launched from the cosmodrome with the first cosmonaut of the planet Yuri Gagarin on board. In the documents and press about this launch, the classified military training ground was first named Baikonur (from Kazakh – "rich valley"). In fact, such a name was borne by a village in the Karaganda region, 325 km northeast of the launch site. It was decided to call the 5th NIIP Baikonur to disorient foreign intelligence services, for this purpose, dummy launch pads were built in the village of the same name. However, later this name was assigned to the polygon. The same name has been given to the administrative center of the cosmodrome since 1995 (in 1958-1969 – the village of Leninsk, in 1969 it received the status of a city).

Various generations of ICBMs (R-9, R-36, UR-200, UR-100, etc.), launch vehicles and their modifications based on the R-7 were tested at the Baikonur cosmodrome: Vostok, Molniya, Voskhod, Soyuz, as well asCyclone", "Proton", H-1, "Zenith", "Energy" and others.

The first Soviet manned spacecraft Vostok (1961-1963) and Voskhod (1964-1966) were launched from it. Since 1967, manned spacecraft of the Soyuz family have been launched (the first test launch took place in 1966), and since 1978 – cargo Progresses.

Automatic interplanetary stations "Luna" (1959-1976), "Mars" (1960-1973), "Venus" (1961-1978), "Vega-1" and "Vega-2" (1984), various satellites ("Cosmos", "Meteor", "Screen", "Rainbow", "Horizon", "Molnya", etc.).

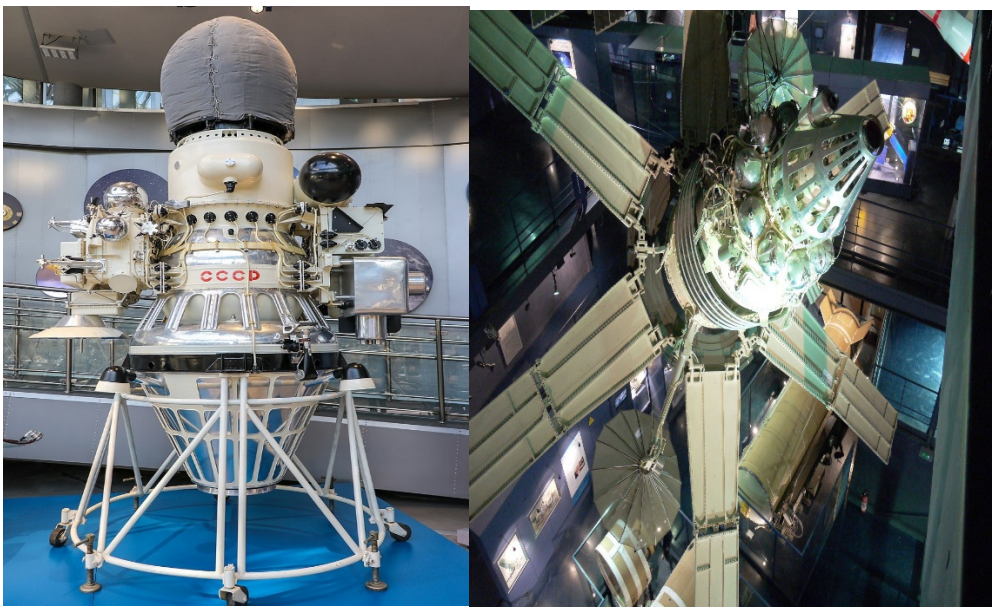

Figure 4. The station "Venus-9" and the satellite "Molnya-1"

In 1988, a reusable Buran spacecraft was launched from the cosmodrome using the Energia rocket, this launch became the only one for it, then the program was closed. It made two orbits around the Earth and landed on the territory of the cosmodrome.

The flight took place without a crew, its duration was 205 minutes. Buran became the first spacecraft in history to land in automatic mode [2].

Table – Chronology of the cosmodrome history

January 12, 1955	The arrival of the first unit of military builders at the Tyura-Tam crossing to prepare locations and deploy construction and installation infrastructure. The beginning of the construction of the village.
February 12, 1955	Resolution of the Council of Ministers of the USSR on the establishment of a test site for intercontinental ballistic missiles.
July 20, 1955	The start of construction of the first launch pad.
May 15, 1957	The launch of the first R-7 rocket from the cosmodrome. The next one, also unsuccessful, is in a month.
August 21, 1957	The first successful launch, the rocket delivered conditional ammunition to Kamchatka.
October 4, 1957	The beginning of the space age, the launch of the world's first artificial Earth satellite PS-1 using P-7.
January 29, 1958	The settlement (the administrative center of the landfill, which bore the unofficial name Zarya) received the official name Leninsky.
May 9, 1959	The launch of a new design by engineer-inventor Ya. I. Koltunov (from the scientific group under the hands) was assembled at one of the launch pads of Baikonur. M. K. Tikhonravova), which made it possible, when performing the same tasks, to reduce the size of newly constructed similar structures many times and thereby reduce their cost.
July 29, 1960	The polygon was awarded the Order of the Red Star for the successful test of the R-7 rocket and in connection with the 5th anniversary of the decree of the Presidium of the Supreme Soviet of the USSR,
August 3, 1960	By order of the Minister of Defense of the USSR, June 2 is defined as the day of the foundation of the landfill.
October 24, 1960	During the test of the R-16 ICBM, a fire occurred, as a result of which 76 servicemen and representatives of industry were killed (including the commander-in-chief of the Strategic Missile Forces, Chief Marshal of Artillery M. I. Nedelin, the test leaders from the range, Colonels A. I. Nosov and E. I. Ostashev).
April 12, 1961	The date of the first human space flight – Yuri Gagarin.
May 9, 1962	The Presidium of the Supreme Soviet of the USSR established Cosmonautics Day.
June 16, 1963	The launch of the Vostok-6 rocket, on which the world's first flight of a female cosmonaut V. V. Tereshkova was carried out.
November 1, 1963	The launch of the first space combat satellite Polet-1.
March 18,	The launch of the Voskhod-2 rocket, which carried out the world's

1965	first human spacewalk – A. A. Leonov.
May 8, 1965	By decree of the Presidium of the Supreme Soviet of the USSR, the polygon was awarded the Order of Lenin.
June 16, 1965	The first launch of the Proton launch vehicle (RN).
June 21, 1966	By decree of the Supreme Soviet of the Kazakh SSR, the village of Leninsky was renamed the city of Leninsk.
October 27, 1967	The first launch of the Cyclone launch vehicle.
February 21, 1969	The first launch of the RN "N-1".
January 15, 1971	By decree of the Presidium of the Supreme Soviet of the USSR, the landfill was awarded the Order of the October Revolution.
1980	A mock—up of the Soyuz rocket launcher was installed in the city center.
February 20, 1986,	The base unit of the Mir orbital station was put into orbit.
May 15, 1987	The launch of the RN Energia.
November 15, 1988	The launch of the RN Energia with the Buran orbiter.
May 25, 1992	An agreement was signed in Moscow between Russia and Kazakhstan on the procedure for using the Baikonur cosmodrome.
July 1993	The Office of the National Aerospace Agency of Kazakhstan was established at Baikonur.
December 10, 1994	An agreement was signed between Russia and Kazakhstan on the lease of the Baikonur cosmodrome (entered into force on September 25, 1995).
December 20, 1995	By decree of the President of the Republic of Kazakhstan, the city of Leninsk was renamed the city of Baikonur.
February 1, 1999.	The construction of the International space station began with the launch of the Zarya functional cargo unit into near-Earth orbit.
1999-2015	Launches of the "Dnepr" rocket, a joint Russian-Ukrainian production
2000-2019	Launches of the "Rokot" rocket
2001-2009	Launches of the "Soyuz-FG" rockets
2016-present	Launches of the piloted spacecraft "Soyuz MS" delivering crew members to the International Space Station (ISS).
2020-present	Four space launches have been conducted from the cosmodrome, one of which was crewed.

Lease and operation of the cosmodrome by Russia. Since its foundation, the Baikonur cosmodrome was a part of the structure of the USSR Ministry of Defense (later it was under the jurisdiction of the Russian Ministry of Defense). After the collapse of the Soviet Union in 1991, it became the property of Kazakhstan. In accordance with the agreement signed on March 28, 1994 by the Presidents of Russia

Boris Yeltsin and Kazakhstan Nursultan Nazarbayev, and the lease agreement dated December 10, 1994, the cosmodrome was leased to Russia for a period of 20 years. In 2004, the lease was extended until 2050. The annual rent is $115 million.

In 1994, in order to implement the Russian-Kazakh agreement, the Government of the Russian Federation decided to transfer Baikonur (officially called the 5th State Test Cosmodrome, GIK-5) from the Ministry of Defense to the jurisdiction of the Russian Space Agency (now Roscosmos State Corporation), under which the Center for the Operation of Ground-based Space Infrastructure Facilities (CENKI) was formed. In 1995-2011, a phased transfer of the cosmodrome facilities from the military to the civilian department was carried out.

Currently, the maintenance of the spaceport's operability and its operation is carried out by the TsENKI branch – the Yuzhny Space Center (Yuzhny KC). He coordinates the work of organizations and industrial enterprises in Baikonur, interacts with the territorial bodies of the federal executive authorities of Russia and Kazakhstan. In addition to the Yuzhny Space Center, the Rocket and Space Corporation Energia, the State Space Research and Production Center named after M.V. Khrunichev, the Military Industrial Complex NPO Mashinostroeniya and others participate in the operation of the cosmodrome [3].

Infrastructure and launch statistics. Over the 65-year history of Baikonur has changed significantly. It has nine launch complexes (including 15 launchers, including five operating ones) for launching launch vehicles, four launchers for testing ICBMs, 13 assembly and test buildings, which house 34 technical complexes for pre-launch preparation of launch vehicles, upper stages and spacecraft, as well as refueling-neutralization and refueling stations.

The cosmodrome has a measuring complex with a computing center, an oxygen-nitrogen plant. Its infrastructure includes two airfields ("Extreme" 1st class and "Jubilee"), 470 km of railway tracks (including 40 km of special tracks), 1281 km of highways, 600 transformer substations, 6610 km of power transmission lines, 2784 km of communication lines. In total, more than 10 thousand people work at the cosmodrome [4].

Launches of Proton-M launch vehicles (since 2001), Soyuz-2 are being carried out from the Baikonur cosmodrome ("Soyuz-2.1a" and "Soyuz-2.1b" since 2006). Until recently, Rokot (2000-2019), Soyuz-FG (2001-2009), as well as Russian-Ukrainian Dnepr (1999-2015) and Zenit-3SLB (2008-2013) missiles were launched.

Russia can carry out manned launches only from Baikonur. Soyuz MS ships (since 2016), delivering expedition members to the ISS, and Progress MS cargo ships (since 2015), serving the space station, are being withdrawn from it [5].

In total, over the 65-year history of the cosmodrome, almost 5 thousand launches of various rockets, including 3 thousand for space purposes, were made from its sites. Approximately 150 cosmonauts and astronauts (USSR and Russia, as well as other countries) started from Baikonur.

In 1957-1991, the USSR conducted about 2.5 thousand space launches. In 1992-2019, 530 launch vehicles were launched.

The Baikonur Cosmodrome is unique in that it was and remains the first and largest platform in the world from which spacecrafts are launched. The launch of the

first artificial satellite of the Earth, the flight of the first man into space and subsequently other manned spacecraft – Vostok, Soyuz and Voskhod, the Mir and Salyut orbital stations – all this took place here at the Baikonur cosmodrome. From here, the reusable Energy system – Buran, artificial satellites of our planet and spacecraft that plow the expanses of the Solar System to this day were sent into near-Earth orbit [6].

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УДК 629.127

VLADIMIR TARADONOV'S UNDERWATER BICYCLE

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Abstract. The article discusses a dry multi-role underwater vehicle with a muscular drive. The characteristics of the invention and the areas of its application are studied. Similar vehicles are analysed and the underwater bicycle is compared with them. The authors conclude that the application of a new solution for the movement of the vehicle based on the use of the Coanda effect can be reasonable.

Keywords: underwater bicycle, underwater vehicle, Coanda effect, muscular drive, innovative project.

ПОДВОДНЫЙ ВЕЛОСИПЕД ВЛАДИМИРА ТАРАДОНОВА

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Аннотация. В статье рассматривается сухой многоцелевой подводный аппарат с мускульным приводом. Изучаются характеристики изобретения и возможности для его использования. Анализируются аналогичные аппараты, производится сравнение подводного велосипеда с ними. Авторы приходят к выводу о том, что применение нового решения для движения аппарата, основанного на использовании эффекта Коанда, может быть целесообразно.

Ключевые слова: подводный велосипед, подводный аппарат, эффект Коанда, мускульная тяга, инновационный проект.

Humanity attains new heights but forgets about the depths. People persistently aim for space, stubbornly ignoring the fact that the major part of the underwater world remains a mystery to them. Moreover, even already discovered and explored things turn out to be hidden from ordinary people. The enjoyment of seeing an enchanting show of the underwater world becomes the privilege of those who have expensive equipment and special training.

However, it is an open secret that the underwater world still attracts people. Everyone sees their own in it: one is interested in the wonderful inhabitants of the water depths, another dreams of finding treasures lost in the sea... Fortunately, thanks to inventors, more and more new ways of making the underwater world open to everyone are appearing.

Vladimir Taradonov set himself such a goal. As the head of a laboratory in Saint

Petersburg State Marine Technical University, he worked on the vehicle with his colleagues for many years in order to present the underwater bicycle to the public.

Of course, the exact scientific name of this invention is different: “dry multi-role underwater vehicle with a muscular drive”. The underwater vehicle (UV) of Vladimir Taradonov and his colleagues is not a bicycle on which a scuba diver would go under water, as one might conclude from the unofficial name. It represents something much more unusual and looks like an orange UFO. Initially, Taradonov's invention brings to mind such an association since it is a large transparent glass ellipsoid of rotation slightly smaller than a human height, surrounded by an orange disk. Even its name - BlueSpace, to some extent, suggests traveling to distant planets.

Inside the vehicle, everything looks almost like inside a car: seats for two pilots, opposite each seat is a steering wheel, similar to a computer joystick. There are pedals at the bottom, just like on a real bicycle, and by pedaling pilots set the vehicle in motion. One can get into the cabin through the hatch from the above (Figure) [1].

Figure. The model of the underwater bicycle

Of course, Vladimir Taradonov's invention attracts people not only by its extraordinary appearance. Such underwater bicycle is an interesting technical solution as well!

A fundamentally new solution was used to set this vehicle in motion. It reduces the power required for setting underwater vehicles in motion. However, it's not about the selection of movement modes or improving the geometric shape – more than 100 years ago, optimal contours and profiles for a moving body were found. The point is to create an environment with different characteristics in front of a moving vehicle. Here lies the secret of the energy efficiency of the invention. The essence of the technical solution is to use the Coanda effect to create thrust directly on the vehicle hull [2].

Coanda effect assumes that if an air or water jet is blown out through a flat slot in tangential direction, this jet adheres to the surface on a comparatively large spacing from the slot. At the same time, rarefaction or thrust is generated on the surface. That is, passengers pedal, and the pedals actuate rotary thrusters. With the help of these thrusters, water is sucked into the nasal slits and pushed through other slits onto the body. As a result, low pressure occurs on the front part of the hull. According to the laws of physics, the vehicle moves towards low pressure, that is, forward [1].

If so, then what is the reason why no underwater tourist vehicle with a muscular drive, similar to a surface bicycle, has ever been created in the world? The answer is simple. According to the laws of hydrodynamics and peculiarities of geometry of traditional underwater vehicles, maintaining its motion under water at a speed of 2-3 knots (1 - 1.5 m/s) with the help of usual propulsion screws, and also maneuvering in vertical and horizontal planes with the help of additional propulsors would require a propulsion capacity of about 2.5-5 kW.

Due to the well-known experimental facts, an average person, while riding a bicycle, is capable of developing a propulsion capacity not exceeding 0.2 - 0.4 kW within a period of 1-3 hours. Hence, the muscular force of two tourists-underwater voyagers – would not be enough for the provision of a movement of a traditional underwater bicycle with the necessary speed and maneuvering.

Moreover, with the traditionally mounted screw propulsors fixed on the underwater vehicle, it would not be possible to ensure the necessary requirements for the speed of surface and underwater motion, because the capacity developed by one or two people would be limited. At the same time, the use of the new rotor propulsors, in conjunction with the realization of the Coanda effect, with the UV's housing having a special geometry, would allow a normal person to provide the motion of an underwater vehicle with the necessary underwater speed for a period of time from 2 to 4 hours [3].

This is the main difference between the underwater bicycle and its analogues. Their shortcomings include the need for expensive and oversized batteries to ensure movement and control, the complexity of management, the necessity for an escort vessel and the relatively high cost of the underwater vehicle and its maintenance.

The advantages of an underwater bicycle in comparison with analogues are relatively low power costs for movement and control, and therefore a significant reduction in the number, volume and weight of batteries. Also, another advantage is that the UV design simplification and the absence of necessity for an escort vessel decrease the cost of the vehicle and its maintenance [4].

According to the scientist, the orange color of the underwater bicycle, was not a random choice either. The reason is that in case of an emergency, rescuers will best see this color. However, such a situation should not happen, because the main requirement for an underwater vehicle is to ensure the safety of the people in it, since the depth does not excuse mistakes. For this purpose, the underwater bicycle must be equipped with:

1) an automatic (with the help of the depth transducer) and a mechanical drive to release emergency ballast of the emergency surfacing system;
2) individual means of emergency surfacing;
3) automatic, electronic and visual positioning aids, communication aids and emergency signal aids [1].

As one could already guess from the design, there should be two people in the crew. The pilots will see the information on the screens in front of them. The number of controls is minimal: pedals and a steering wheel, buttons and indicators. The number of onboard systems and the equipment is minimal and works both in automatic and in manual modes.

The vehicle can dive to a depth of up to 35 meters and has a high maneuverability. The hull of the vehicle design is as transparent as possible to ensure maximum visibility. Being capable to operate in seawater, the vehicle might be used to explore not only freshwater reservoirs. The vehicle must be of such weight that it could be transported on a car trailer, so it should not be difficult to deliver the underwater bicycle to the reservoir.

Various modifications allow the application of the UV in different areas:

1) cognitive (the use of an UV for study of the underwater world);
2) sporting (organization and realization of entertainment sporting competitions in races with the use of the UV's);
3) tourist (short-term trips on the UV's in a surface or in an underwater position, the use of UV's for overcoming water barriers);
4) scientific-research (research of the underwater world, long stay under water under comfortable conditions with the purposes of observation);
5) underwater-archeological (realization of research on the sea bottom, with the purpose of finding the subjects of archeology, supervision over the course of archeological works);
6) observation with video-shooting (cinema-, photo-, and video-shooting of the underwater world by private persons for personal collections, and by organizations, for the issuing of entertaining and scientific-cognitive programs);
7) commercial (the use of the UV as a prospecting and auxiliary means at production of fish, sea products, pearls);
8) show-entertaining (the use of the UV at realization of mass entertainment functions);
9) production (investigations of the treasures of the soil);
10) rescuing (the use of the UV with the prospecting purposes at rescue on waters);
11) guarding (the use of the UV for the maximal control over the condition of water borders);
12) for the purpose of technical survey of underwater structures and mains, sea-bottom strings of oil and gas pipelines, dams and other structures, requiring constant inspections and monitoring;
13) for underwater farmers on sea water areas;
14) search of the sunk explosive and poisoning chemical substances;
15) other areas of application, requiring an operative and safe penetration under water, down to a depth of 30 meters, even for those not capable of swimming [4].

For this invention, Vladimir Taradonov received several patents:

1. Patent of the Russian Federation No. 2127692 dated 03/20/1999 “Method of creating thrust of any direction on transport facility” [5].

2. Patent of the Russian Federation No. 2133209 dated 07/20/1999 “Water craft

propeller” [6].

3. Patent of the Russian Federation No. 2148525 dated 03/10/2000 “Rotary-plate water jet propulsion” [7].

4. Patent of the Russian Federation No. 2219098 dated 12/20/2003 “Rotor-type water-jet propeller” [8].

5. Patent of the Russian Federation for invention No. 2457146 dated 07/27/2012 “Vehicle body” [9].

6. Patent of the Russian Federation for invention No. 2467916 dated 11/27/2012 “Ship propulsor” [10].

Theoretical and experimental research accomplished by the developers of the UV, as well as the awarded patents for their inventions in the field under consideration, have confirmed the possibility of creating of such an UV, as well as the world novelty of the elaborated technological solutions. The tests of the prototype of the underwater bicycle were carried out. Unfortunately, the mass production of the vehicle was never started. It's a pity, because the creator noted that his invention could be used in different fields.

Vladimir Taradonov's underwater bicycle can be considered unique, since currently there are no underwater vehicles with a muscular or combined electric drive produced in the world. Unfortunately, no one is working on this invention right now. However, we want to believe that there will be people who will continue the work of Vladimir Taradonov, and one day it will be possible to use underwater bicycles for exploring the underwater world and admiring its beauties!

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УДК 004.51

MODERN TRENDS IN MOBILE APPLICATIONS UX/UI DESIGN

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Abstract. The study explores the user interface (UI) and user experience (UX) design of mobile applications, along with the findings of user surveys regarding their preferences. The analysis delves into different aspects: the distribution between UI design and UX design, users' preferences in color scheme and style, and the examination of the ratings of popular applications. Additionally, trends in UI/UX design of applications are identified.

Keywords: UI design, UX design, mobile application, style, color scheme.

СОВРЕМЕННЫЕ ТРЕНДЫ В ОБЛАСТИ UX/UI ДИЗАЙНА МОБИЛЬНЫХ ПРИЛОЖЕНИЙ

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Аннотация. Статья посвящена анализу важности UI/UX дизайна при создании мобильных приложений в настоящее время и выявлению предпочтений пользователей. На основании данных составленного и проведенного опроса сделаны выводы о доле UX и доле UI дизайна в успехе приложений, выявлены актуальные предпочтения в стилистике и цветовой гамме, используемые в них, также определены тренды в UI/UX дизайне.

Ключевые слова: UI дизайн, UX дизайн, мобильное приложение, стилистика, цветовая гамма.

Mobile applications have become one of the most sought-after software products of our time. Whether it is for communication, shopping, health tracking, gaming, reading, or entertainment, there is an app for virtually every need on your smartphone or tablet. With a great variety of apps in the modern market, competition is fierce. As such, any application under development must not only boast essential functionality and seamless performance but also offer an appealing visual design and intuitive navigation. It is UI/UX design that is responsible for the qualities (visual and navigation).

UI and UX design. UI/UX designers are people who create the layout of an

application in accordance with the idea and tasks set, sometimes also engaged in frontend development.

The UI (User Interface) design is responsible for how the application appearance will look. UI designers are responsible for choosing color schemes, button shapes, line widths, and text fonts in the application. They need to make sure that the interface is attractive and meets the goals of the application.

The UX (User Experience) of an application is determined by how easy or difficult users interact with the application: is the user experience intuitive or confusing? Is the navigation in the app logical? Does interacting with the application create the feeling that tasks are being performed efficiently? UX designers define the interface structure and functionality and how all parts of the application are organized and connected to each other – that is, they design its operation.

Analyzing user preferences. When creating a UI/UX application layout, the designer needs to consider the trends and preferences of the target audience. We conducted a survey (survey No. 1) [1] to find out which design is attractive to people today and identify promising areas in application design. The survey consisted of 7 questions:

1. How old are you?
2. How important is the design in an application?
3. What do you consider the most important in the design of the application?
4. What color combination in the apps do you like?
5. What design style do you like?
6. Evaluate the design and usability of markets.
7. Evaluate the design and usability of messengers.

The majority of respondents were young people: 18–29 years old (Diagram 1). Users rate design as a crucial factor, with an average score of 9.6 out of 10 (Diagram 2).

How old are you?	How important is the design in an apps?
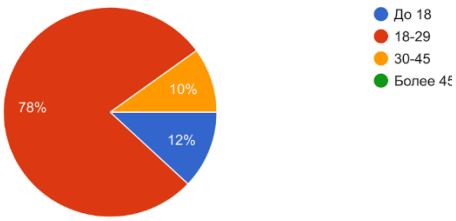	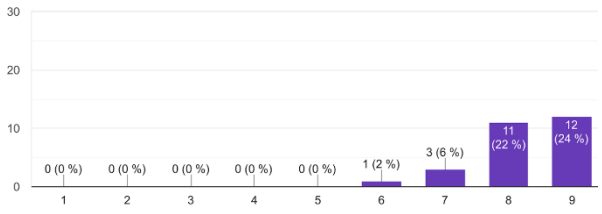
Diagram 1. Respondents	Diagram 2. Rating of the design

According to survey No. 2, half of the respondents (49 percent) noted that they are willing to discontinue using the application if they do not like the design update, and 11 % of them will do so even in the absence of alternatives [2].

In application design, respondents consider the following points important (Diagram 3):

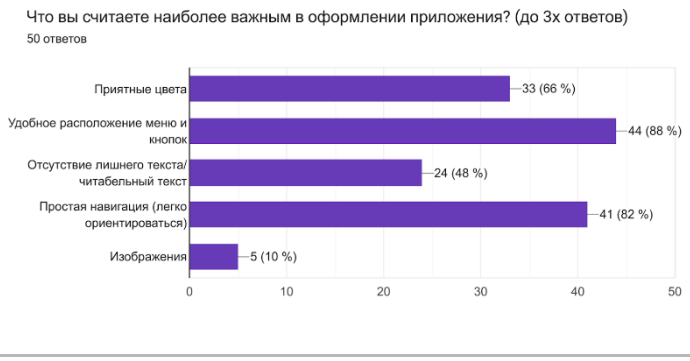

Diagram 3. Important points in app

– Convenient placement of menus and buttons (88 %, 44 respondents). One of the biggest considerations is the size of touchscreen targets. While a mouse or trackpad can click with pinpoint accuracy, fingertips are much less accurate. Ideally, targets should be 7–10mm on a mobile device screen and put in a “thumb zone” (Figure 2) – the area of a phone screen that can be easily accessed with the thumb when a person is holding their phone with one hand. This allows for a fingertip to tap the target without having to aim too carefully [3].

– Simple navigation (82 %, 41 respondents). This quality can be achieved through recognizable design patterns, such as hamburger menus (Figure 1), as well as recognizable icons (a “home” icon for the home screen, a chat bubble for messaging, etc). The application should also provide some small instructions at the first login, in case the developers have made any changes to the traditional functions or added any new, atypical ones [3].

Figure 1. Hamburger menu

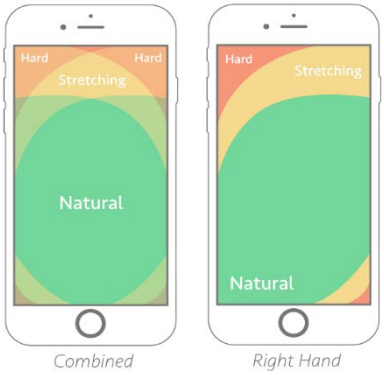

Figure 2. Thumb zone

– Pleasant colors (66 %, 33 respondents). The absence of unnecessary text was chosen by 48 % (24 respondents) and the least popular response was "images" (10 %, 5 respondents).

Thus, UX design, which includes simple navigation and convenient placement of menus and buttons, has 85 replies – 58 % and UI design, which includes pleasant

colors, text and images, has 62 replies – 42 %.

For comparison, for example, we can cite survey data No. 2: in the design of applications, Russian users most appreciate an intuitive interface (73 %), simplicity (58 %) and beautiful design (51 %) [2].

From the survey results, it can be said that users are primarily interested in UX design, and secondly, in UI, also it can be concluded that an application will be successful only if it has a convenient, understandable, and beautiful interface.

Color schemes. According to the results of the survey No. 1, the following user preferences regarding color schemes were revealed: users prefer pastel combinations more (warm – 62.5 % and cold – 65 %), and less bright cold ones (22.5 %).

The preference for pastel shades can be explained by color theory. Obviously, a pure spectral color (bright) will always be harsh, unpleasant to the eye… compared to less saturated, softer, that is, pastel colors [4].

The choice of cold combinations is related to the psychology of color: “Associative perception of color arises from the accumulation of habitual experience, which has formed stable associative chains. For example, red – fire – hot, yellow – sun – warm, blue – water – coolness [3, p. 50]. Any cold color has an admixture of blue, as it is a primary color in the palette along with red and green, and it is the only cool shade among them. Blue is associated with constancy, reliability, and loyalty, and it has a calming effect: it reduces blood pressure and slows the pulse [5]. Navy blue – is a "deep," "feminine" color that creates a calm atmosphere. We also contemplate blue without being able to stop. This color attracts us.” [5].

Thus, we can conclude that, in the vast flow of information, people find moments of peace and want to enjoy them behind their devices.

Dark mode. This mode is one of the best app UI trends worldwide. It is a user interface (UI) design where the screen has a dark or black background showcasing text in light colors. The black mode is particularly useful for reducing strain on the eyes and for improving battery performance.

Stylistics. The result of the survey No. 1:

The 3D style turned out to be the most popular (Figure 3) – it was chosen by 42.5 %. The second place was taken by the “Frosted glass effect” or “Glass morphism” (Figure 4) – 25 % consider it the most beautiful. For example, it is used by widgets located on the main screen of the device (Figure 5).

Figure 3. 3D style

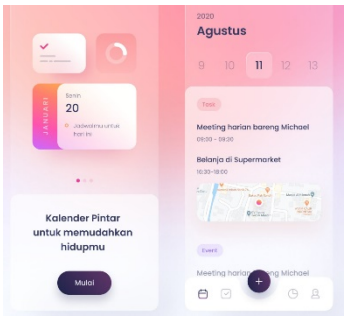

Figure 4. Glass Morphism

Figure 5. Widgets in style Glass Morphism

Together, such design styles accounted for 67.5 %, therefore, the applications will be successful with users.

These styles have shadows, according to the theory of color science, “the alternation of zones of light and shadow has an optical significance – it eases overall perception” [3], while “a light shadow ... gives softness and lightness to the entire image. The deep shadow highlights the shape of the object more sharply, emphasizes its heaviness” [3].

In the third place is the standard flat style (Figure 6): 17.5 % and only 15 % of the respondents chose a detailed design or a “heavy composition” (Figure 7).

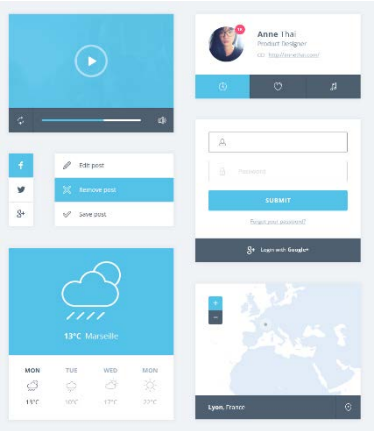

Figure 6. Flat style

Figure 7. Detailed design

User rating of apps. The survey offered to evaluate the applications of popular online stores and messengers, below are descriptions, characteristics and survey results of the average design and usability ratings.

Megamarket app

The design (we are considering the white theme as it is independent of what is set on the phone). Cool color scheme: a white background, purple buttons with white text, images in the shape of rounded squares or with transparent backgrounds, and price tag colors

The number of steps required to make a purchase: 12–15.

The least popular application.

Yandex market app

The design (we are considering the white theme as it is independent of the phone settings). Warm color scheme: a white background, bright yellow buttons, square images, price tag colors in dark green and burgundy, with relatively large text. It is simple, minimalist, and 'calm.' Loading has an animation (for a generic content template) and a moderate duration.

The number of steps required to make a purchase: 12–14.

The most minimalistic application (borders, product description and quantity in the basket are gray), while it has pleasant price colors – noticeable, but not provocative.

OZON app

The design (we are considering the dark theme as it mirrors the theme set on the

device). Cold color scheme: dark background, blue buttons, rounded square pictures, price colors: bright red and bright green (neon for both current and old prices), white text (for product names and descriptions), rather large text. The loading is fast—the content template appears immediately without any animations.

The number of steps required to make a purchase: 9–11.

Flashy prices. The minimum number of steps to purchase among analogues. The most popular application.

Wildberries app

The design (we are considering the dark theme as it mirrors the theme set on the device). Cold color scheme: dark background, gray buttons with purple inscriptions, pictures in the form of a rounded square, price colors: purple and gray (old prices), descriptions and names in white, white text (names and descriptions of goods), rather large text. The loading has an animation (for a generic content template) and a moderate duration.

The number of steps required to make a purchase: 10–12.

The second most popular application.

Table 1 – User rating of market apps

	Wildberries	Yandex	Ozon	Mega Market
Average ratings	3,56	3,39	3,60	3,04
Percentage of users	0,88	0,75	0,94	0,53
Most popular rating	4	4	4	2
Percentage of the most popular rating	24,22	23,38	36,91	10,38

The respondents consider Ozon to be the most convenient and attractive. It can be sad that young people like bright accents and fast task completion.

User rating of messengers. In all apps except VK, the home screen contains a list of chats. In all apps, tapping on a row with the chat name opens that chat. All apps duplicate the theme installed on the device, so next there will be a description of dark themes.

Viber

Colors and shapes. Cold color scheme: dark background, user's messages are gray, the interlocutor/other participants are darker gray, messages in the form of a rounded square, types of buttons: 1 – round with a purple gradient and a white image (icon), 2 – on a transparent background with a purple icon.

Typography. White text is used for contact names and messages, gray for the last message in a conversation that is visible on the chat list screen, with text fonts in “Arial” and “Times New Roman”.

Organization. Dialogues and communities are on the same screen. You can pin a conversation on the main screen. Calls are in a separate tab. There is an 'interesting' section where you can find masks, stickers, and media. You cannot create folders for specific chats/communities. Messages can be edited and deleted, but not entirely: a

placeholder remains in the dialogue with the text “message deleted”.

The number of steps required to change the language: 5.

Whatsapp

Colors and shapes. Warm color scheme: dark background, user's messages are dark green, the interlocutor/other participants are gray, rounded shapes of buttons and messages, buttons are bright green and dark green pastel colors.

Typography. White text (contact names and messages), gray (the last message in the dialog located on the main screen), font “Helvetica Neue”.

Organization. Dialogues and communities are on separate screens. You can pin a conversation on the main screen. You cannot create folders for specific chats/communities. Messages can be edited and deleted, but not entirely: a placeholder remains in the dialogue with the text “message deleted”.

The number of steps required to change the language: 4.

VK

Colors and shapes. Cool color scheme: the background is dark, the user's messages are gray, the interlocutor/other participants are darker gray, the messages are in the form of a rounded square, the buttons are dark gray oval or with a transparent background.

Typography. White text (contact names and messages), gray (the last message in the dialog, which is visible on the chat list screen), “Tahoma” font, if the previous one is not supported – “Arial” is used.

Organization. VK is a social network and has many functions: viewing the news feed (main screen) and the ability to create posts/stories, watching videos, listening to music, using mini-applications, participating in communities. Chats are located on a separate tab, they can be pinned, and you can access them by clicking on the “messenger” button in the lower panel (menu).

The number of steps required to change the language: you cannot change the language; it defaults to the system language set in the device settings.

Telegram

Colors and shapes. Cold color scheme (default): dark background, user's messages are bright blue or purple, the interlocutor/other participants are dark gray, messages are in the form of a rounded square, buttons have a transparent background and gray icons.

Typography. Contact names and messages are white, and the last message in the dialog, which is visible on the chat list screen, is gray. The device system font is used (by default in androids it is “Roboto”, in iPhones it is “SF Pro Display”).

Organization. There is an option to pin chats to the main screen and create folders for specific chats (you can switch between folders using the top bar). Messages can be edited and deleted without leaving a trace; these functions are in the same menu that appears when you press and hold on a message.

The number of steps required to change the language: 4.

Table 2 – User rating of messengers

	Telegram	VK	Whatsapp	Viber
Average ratings	4,45	3,43	2,92	1,72
Percentage of users	0,96	0,96	0,96	0,71
Most popular rating	5	4	3	1
Percentage of the most popular rating	54,63	41,45	28,26	29,07

The respondents consider Telegram to be the most convenient and attractive. Thus, important aspects of the messenger are the presence of a small number of functions that will be at hand, the presence of folders, the ability to pin the chat and conveniently edit and delete messages [6].

The presented research results demonstrate that UI/UX has a significant impact on the success of a mobile application, with UX design exerting more influence than UI design, as people primarily require a convenient structure and navigation.

Currently, design in cozy pastel tones or bright warm hues, uncluttered with elements, text, and unnecessary information, remains relevant for use in applications. A cold pastel design with readable yet not overly contrasting and flashy inscriptions is suitable for sales and messengers. However, during development, attention should be paid to the fact that a simple flat design looks dull, but with bright elements is good. Moreover, applications with voluminous elements and layers will be successful.

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