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УДК 53.087

“SMART HOME” SYSTEM BASED ON THE ARDUINO MICROCONTROLLER

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Abstract. Today, everyone is striving for home automation. In the apartment many of us have a robot vacuum cleaner, dishwasher, security cameras, etc. But the Smart Home system will expand automation capabilities and ensure safety and comfort. The system will monitor temperature changes, safety systems, gas and water leaks, lighting, and notify of ignition.

Keywords: arduino, sensor, signal, temperature, humidity, transmitter, receiver, security, microcontroller.

СИСТЕМА «УМНЫЙ ДОМ» НА БАЗЕ МИКРОКОНТРОЛЛЕРА ARDUINO

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Аннотация. Сегодня все стремятся к домашней автоматизации. У многих из нас в квартире есть робот-пылесос, посудомоечная машина, камеры наблюдения и т. д. Но система «Умный дом» расширит возможности автоматизации и обеспечит безопасность и комфорт. Система будет следить за изменениями температуры, системами безопасности, утечками газа и воды, освещением и оповещать о возгорании.

Ключевые слова: Ардуино, датчик, сигнал, температура, влажность, передатчик, приемник, безопасность, микроконтроллер.

For the implementation of the Smart Home system in Figure 1, a model of a residential apartment with an area of 31.5 m2 was chosen, consisting of: kitchen, living room, bedroom, bathroom, hallway and loggia.

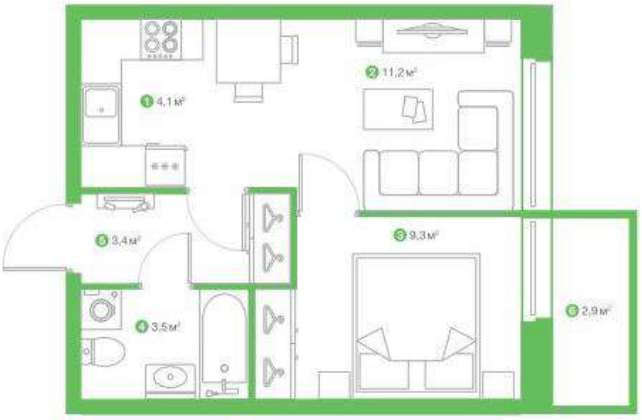

Figure 1. Two-room apartment layout

Each room has a specific sensor to ensure comfort and safety in the apartment.

In the kitchen, it is important to monitor the proper operation of appliances and prevent gas and water leaks, as in most cases it leads to emergencies. Almost everyone has gas stoves installed, so it is important to install a gas sensor to ensure safety. Its principle of operation is that when the rated value of gas in the air (GOST R 54961-2012) increases, it triggers an alarm light signal, signaling a gas leak [1]. It is also necessary to install a fire alarm, which will catch the infrared radiation inherent in the fire. Such sensors can send a signal to a smartphone and the appropriate security services.

The bathroom has the need to monitor humidity and air temperature. With the help of temperature and humidity sensors, you can observe the temperature in the room we need. The principle of operation of the sensors is that when the temperature and humidity rise above or below the nominal value (GOST 30494-2011), the ventilation system is activated [2].

Table 1 – Room temperature and humidity reading rate

Temperature, °C	Humidity, %
18-26	45-60

If the temperature readings do not exceed this value, but the humidity is more than normal, then the ventilation still begins to work.

All sensors work around the clock, but if suddenly one of the sensors works, then an emergency notification comes to the owner's smartphone, and the LCD display also reflects the temperature and humidity indicators in the room.

The security system is implemented in the form of three operating modes. The transition to the first mode of operation is carried out by pressing a button or loud sound, which will catch the sound sensor. If within 5 seconds the landlord disappeared from the field of view of the sensor, then the signal system goes to the second mode of operation, where any movement in the room will be

recorded. If the movement is recorded, then the owner receives a notification of unauthorized entry into the apartment.

The Smart Home system consists of two units: a transmitter and a receiver. Also, the Smart Home system transmits sensor readings via a radio channel. For this, a combination of a microcontroller and a NRF24L01 radio module is used. One is used on the receiver side and the other is used on the transmitter side. The transmitter unit consists of a MEGA microcontroller, a DHT-11 temperature and humidity sensor, a HC-SR501 motion sensor, a liquid sensor, a combustible gas sensor MQ5 and a fire sensor module. All sensors supply data to the Arduino MEGA analog inputs, except for the DHT-11 temperature and humidity sensor, as it transmits data to the digital output. After that, the data is packed into an array and sent to the NRF24L01 radio module via the SPI interface (outputs: SCK, MOSI, MISO and SS) [3].

The receiver unit (Figure 2) consists of Arduino Uno microcontroller, sound sensor, GPRS Shield. Also, an LCD display is connected to the unit for output temperature and humidity values in the room. Arduino Uno receives the sent data array from the radio module NRF24L01, then the microcontroller sorts the data from the array and compares this data with the specified conditions for each sensor. If the value of one of the data exceeds the given condition, then a unit is supplied to a certain LED VD.

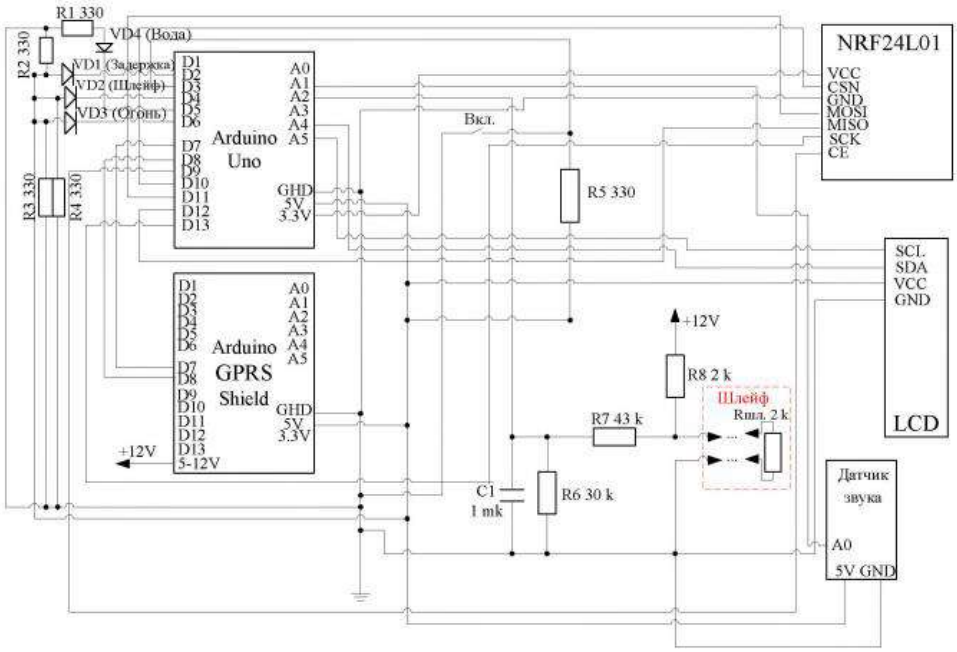

Figure 2. Electrical circuit diagram of the Smart Home receiver

The Arduino Uno sends a command to the GSM module on outputs D6, D7 (COM port) to send an SMS notification to a certain cellular number.

There is an alarm loop in the receiver unit. Alarm loops are a chain of sensors connected in series and in parallel. Multiple sensors can be connected to one.

Several sensors can be connected to one loop, both normally closed (NC) and normally open (NO) [4].

Let's take a look at the scheme of the alarm loop operation. The button “On” is used to turn on the alarm. A short press on the “On” button, while applying a logic zero level to the input D3 of Arduino Uno, the rest of the time there is a logic one level on the input D3 due to the resistor R5, leads to starting the timer for 5 seconds (this is signaled by the blinking of the LED VD1). This time is necessary in order to have time to leave the protected premises without triggering the alarm system. The visual control of the loop is performed by the red LED VD2, the LED VD2 starts blinking for the duration of the timer, but there is no sign for alarm messages. The alarm unit controls the resistance of the loop. If the resistance is less than the lower or more than the upper threshold, the unit alarms.

The resistance of the loop defined by the terminating resistor is considered normal. If the thief closes the wires of the loop or breaks them, then the alarm will go off.

Table 2 – Nominal value of loop resistance

Upper Threshold	Lower Threshold
5900 Ohm	540 Ohm

Loop resistance in the range 540-5900 ohms is considered normal, but if the value exceeds the specified loop resistance limits, an alarm will be triggered.

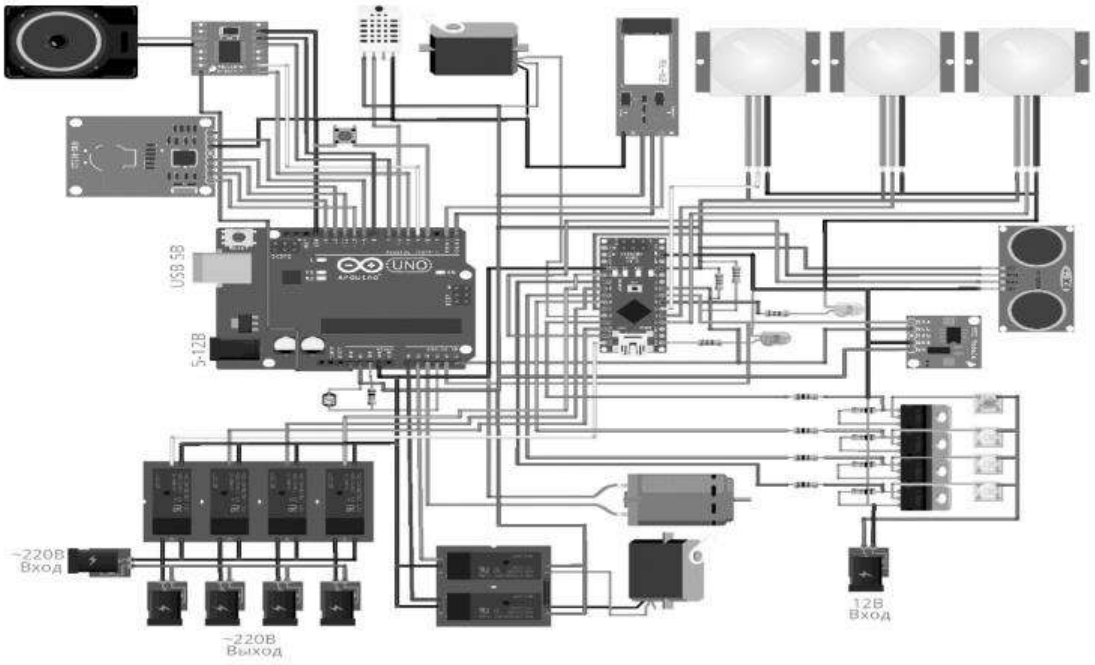

Figure 3. Arduino Module Connection Diagram

The Smart Home system with the help of an Arduino microcontroller (Figure 3) can control all systems by itself, it is only important to program with the help of the C++ program to your liking. All functions of the system will help to make your life comfortable and safe, and most importantly economical.

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УДК 621.316

PROSPECTS FOR ENERGY SAVING METHODS AT INDUSTRIAL ENTERPRISES FROM THE PERSPECTIVE OF AUTOMATED SYSTEM OF COMMERCIAL ELECTRICITY MEASUREMENT

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Abstract. The article discusses the ways of energy saving in industrial enterprises by introducing automated systems of commercial electricity metering (ASCEM) in them. Also, shows the economic efficiency of this method by comparative analysis before the introduction of ASCEM and after.

Keywords: ASCEM, AEMS, energy saving, metering, economic efficiency.

ПЕРСПЕКТИВЫ МЕТОДОВ ЭНЕРГОСБЕРЕЖЕНИЯ НА ПРОМЫШЛЕННЫХ ПРЕДПРИЯТИЯХ С ТОЧКИ ЗРЕНИЯ АВТОМАТИЗИРОВАННОЙ СИСТЕМЫ КОММЕРЧЕСКОГО УЧЁТА ЭЛЕКТРОЭНЕРГИИ

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Аннотация. В статье рассматриваются способы энергосбережения на промышленных предприятиях путём внедрения в них средств автоматизированных систем коммерческого учёта электроэнергии (АСКУЭ). Также показана экономическая эффективность данного метода путём сравнительного анализа до внедрения АСКУЭ и после.

Ключевые слова: АСКУЭ, АСУЭ, энергосбережение, учёт, экономическая эффективность.

One of the urgent tasks faced by modern industry is the accurate metering and saving of energy resources. Due to the constant growth of tariffs, the accuracy of energy accounting will enable companies to reduce energy costs or maintain these costs at a constant level. One way to solve this problem is through automated energy management systems (AEMS).

AEMS – automated computer system. It is composed of:

1. Data collection device (DCD);
2. Information-measuring complexes (IMC);
3. Measuring channels (MC)

AEMS allows:

1. Automat data entry, reduce non-productive work of personnel;
2. Reduce, detect, and analyze energy losses and non-productive costs;
3. Accelerate the elimination of pre-emergency or emergency modes;
4. Provide timely and quality information to the staff and managers of the organization about the actual consumption of energy resources, etc.

The structure of AEMS includes the metering systems of electricity and heat supply (AEMS, AMSHS), water supply, sewage treatment facilities (AWSMS, ASTFMS) [1, pp. 78-79]. The functional structure of the AEMS presented in Figure 1.

This system allows you to fully track and control, in automatic mode, the consumption and transmission of energy resources, in real time, which include:

1. Electrical power;
2. Gas;
3. Water and other resources [1, pp. 78-79].

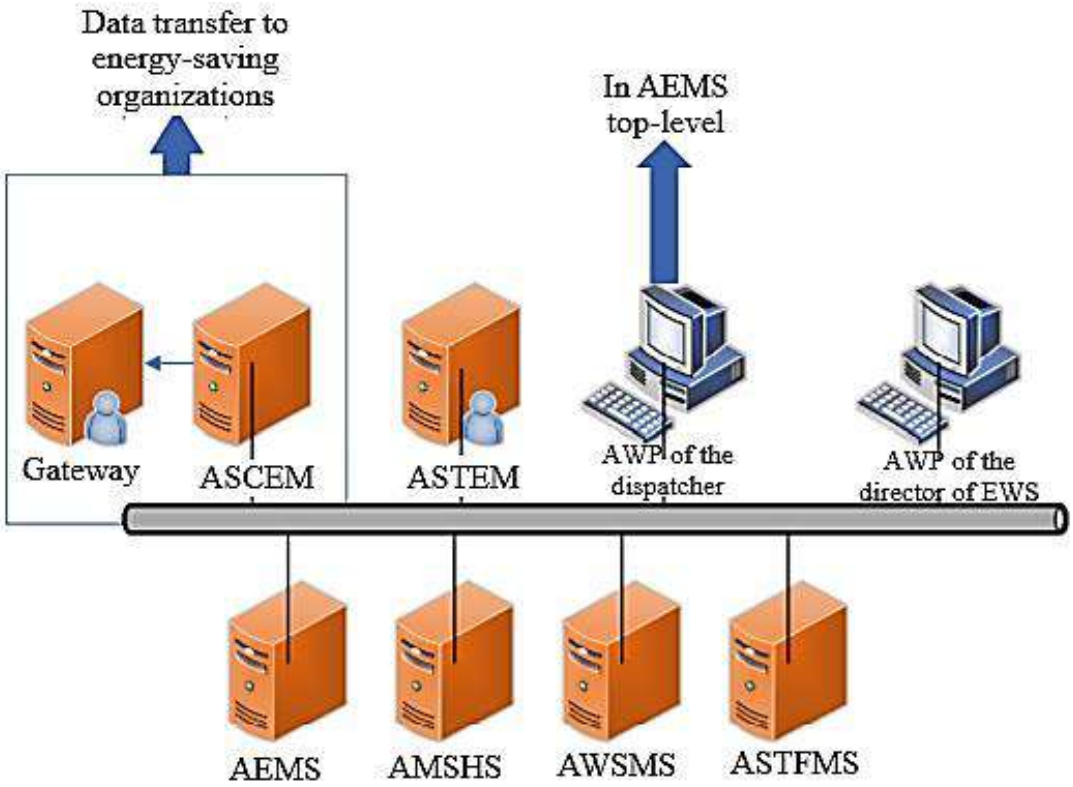

Figure 1. The functional structure of the AEMS

In turn, AEMS is subdivided into ASCEM and ASTEM (automated systems of commercial and technical electricity metering) [2, pp. 28-29]. ASCEM is responsible for accounting for the supply and consumption of energy

by the company for monetary settlements. ASTEM is responsible for recording the process of energy consumption within the company by division and facility. ASCEM and ASTEM can be implement as separate or as a single system. Graphs obtained daily ASCEM and ASTEM allow to analyze the modes of operation of electrical equipment at the enterprise and to optimize the modes of energy consumption [2, pp. 28-29].

ASCEM allows you to constantly save the energy resources of the enterprise at a minimal monetary cost. On average, the economic use of ASCEM ranges from 15 % to 30 % of consumption per year, and the payback of the cost of creation occurs in 2-3 quarters [3, p. 45].

Consider the difference between the cost of electricity before and after the introduction of ASCEM on the example of the metallurgical factory in the city of Kerch. The cost of electricity and cost differences presented in Tables 1-3 [4, p. 62].

Table 1 – Cost of electricity before ASCEM implementation

Month	Max. power during peak hours, kW	Cost of consumed electricity rub., excluding VAT	Cost of max. power, rub., excluding VAT	Grand total, rub.
January	15 588,24	8 002 524,42	12 954 285,47	20 956 809,89
February	19 227,49	8 974 996,10	17 135 485,62	26 110 481,72
March	14 347,43	8 222 829,97	13 089 885,35	21 312 715,32
April	24 787,89	4 875 442,12	24 519 621,96	29 395 064,08
May	7 279,79	1 873 657,03	7 151 013,32	9 024 670,35

Table 2 – The cost of electricity after the implementation of ASCEM

Month	Max. power during peak hours, kW	Cost of consumed electricity rub. without VAT	Cost of max. power, rub., excluding VAT	Grand total, rub.
January	4 485,00	6 761 364,97	2 429 456,54	9 190 821,51
February	4 027,00	8 232 720,90	3 588 851,57	11 821 572,47
March	2 862,00	7 471 424,35	2 611 147,47	10 082 571,82
April	1 878,00	4 743 301,19	1 857 675,35	6 600 976,54
May	771,00	1 814 548,51	757 360,88	2 571 909,39

Table 3 – Difference in cost after and before the implementation of ASCEM

Month	Cost of electricity with ASCEM	Cost of electricity without ASCEM	Cost differential
January	9 190 821,51	20 956 809,89	11 765 988,38
February	11 821 572,47	26 110 481,72	14 288 909,25
March	10 082 571,82	21 312 715,32	11 230 143,50
April	6 600 976,54	29 395 064,08	22 794 087,54
May	2 571 909,39	9 024 670,35	6 452 760,96

Comparing the difference in the cost for the given period, we can see that the total savings are 66 531 889.63 million rubles. Thus, the introduction of ASCEM allows to improve not only the indicators of the economic component of the enterprise, but also to reduce the level of energy consumption, which ultimately boils down to energy saving.

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PRINCIPLES OF RADIO COMMUNICATION ON THE EXAMPLE OF AMPLITUDE MODULATION

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Abstract. The article briefly discusses the main branch of discoveries and experiments that contributed to the study of electromagnetic waves and the development of radio communication. An installation based on amplitude modulation is also presented, which allows transmitting and then receiving a radio signal. The considered installation is the simplest of its kind, but not the last in importance in history, because it paved the way for the development of information transmission.

Keywords: amplitude modulation, sound transmission, radio communication, carrier frequency generator, Hertz vibrator, electromagnetic waves, radiogram.

ПРИНЦИПЫ РАДИОСВЯЗИ НА ПРИМЕРЕ АМПЛИТУДНОЙ МОДУЛЯЦИИ

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Аннотация. В статье кратко рассмотрена основная ветвь открытий и опытов, способствовавших изучению электромагнитных волн и развитию радиосвязи. Также представлена базирующаяся на амплитудной модуляции установка, позволяющая передать и затем получить радиосигнал. Рассмотренная установка является простейшей в своем роде, но не последней по значимости в истории, ведь она проложила путь развитию передачи информации.

Ключевые слова: амплитудная модуляция, передача звука, радиосвязь, генератор несущей частоты, вибратор Герца, электромагнитные волны, радиограмма.

T. A. Edison endeavored to establish radio communication at the end of the 19th century, when electromagnetic waves were not yet discovered by H. R. Hertz. This was not successful, but it was beneficial because it was followed by other researchers with the same task – establishing communication at a distance. W. Crookes described the principles of radio communication in 1892, but their implementation occurred later.

H. R. Hertz in 1886 – 1888 proved the existence of electromagnetic waves, and then successfully transmitted an electromagnetic signal using a device called the dipole antenna. The vibrator consisted of two copper bars with brass balls at the ends. There was a gap between them - a spark gap. To receive the radio signal, Hertz used a resonator – an unclosed ring with brass balls at the ends and an adjustable discharge gap.

In 1894, O. J. Lodge introduced a radio communication device. During the demonstration, he sent a signal that was received at a distance of 40 meters. The device consisted of a radio conductor, a galvanometer, and a current source. The radio conductor needed to be shaken from time to time to restore its sensitivity to Hertzian waves.

Also, one of the founders of radio communication is considered to be A. S. Popov, who in 1895 introduced a device capable of transmitting information at a distance of up to sixty meters. He improved the Lodge device – now it was shaken with a hammer and worked from the received radio pulse. Popov also connected the receiver to the telegraph and received a recording of the transmitted radio signal.

Using a dipole antenna and his own receiver, A. S. Popov transmitted a radiogram in 1897.

A huge contribution to the development of radio communication was made by the Italian radio technician, Guglielmo Marconi. By connecting Popov's advanced receiver to a telegraph and the transmitter to a Morse key, he made radiotelegraphic communication possible. Further work, in particular the construction of the first radio station, led Marconi to the Nobel Prize for his contribution to the development of wireless telegraphy [1].

In order to successfully transmit information, it must be at a certain frequency. This frequency is called the carrier frequency. The same frequency is used, because if it is variable, other communication channels will receive other people's information that they should not have received. To create it, a generator of undamped oscillations is used.

The device that transmits audio data starts with a microphone. It is connected to an amplifier that increases the weak electromagnetic oscillations

transmitted by the microphone. The amplified vibrations are then transmitted to the transformer [2].

The generator of electrical oscillations must have a current source. In our system, its negative output is connected to the current source, and the positive outputs of the current source and the generator of electrical oscillations are connected to the winding of the transformer (Figure 1).

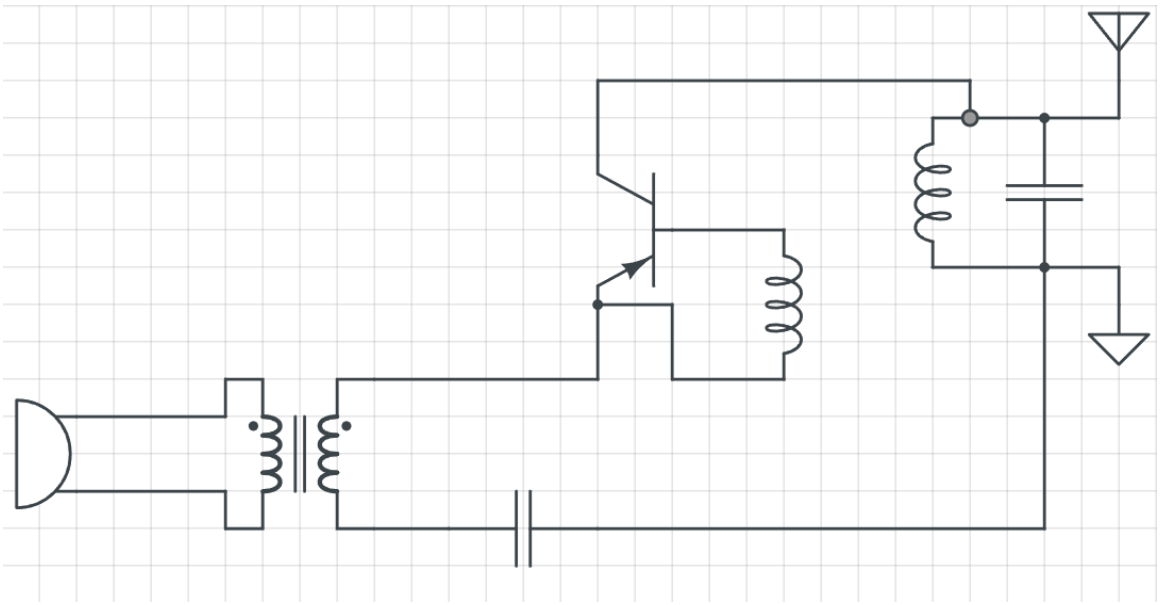

Figure 1. Broadcaster diagram

Thus, if the microphone does not detect sounds, the voltage difference between the windings will be zero. As a result, the generator of electrical oscillations will be directly connected to the power source through the winding of the transformer. At the same time, the amplitude of oscillations is constant, and at the output we have non-extinguishing self-oscillations.

If the microphone begins to detect sound, there will be electrical vibrations of low frequency, which will be amplified and transmitted to the modulation transformer. As a result, the amplitude entering the carrier frequency generator will change. It is worth noting that the frequency will remain unchanged. That is why several transmitters can work in parallel without interfering with each other.

To obtain information, you will only need to adjust the receiver to the frequency we need. When we tune into the frequency of the radio station, a voltage resonance will arise, as a result of which the amplitude will increase dramatically, which will allow us to distinguish a certain wave among hundreds of others.

As a receiver, we use the simplest circuit – a detector receiver. It consists of a variable capacitance capacitor, an oscillatory circuit, an antenna and a grounding. The receiver is connected to a diode and a speaker, in parallel to which a capacitor is connected. The role of the capacitor is to bypass the speaker with a high-frequency current since the frequency received by the receiver is ideal for transmission but absolutely unsuitable for playback (Figure 2).

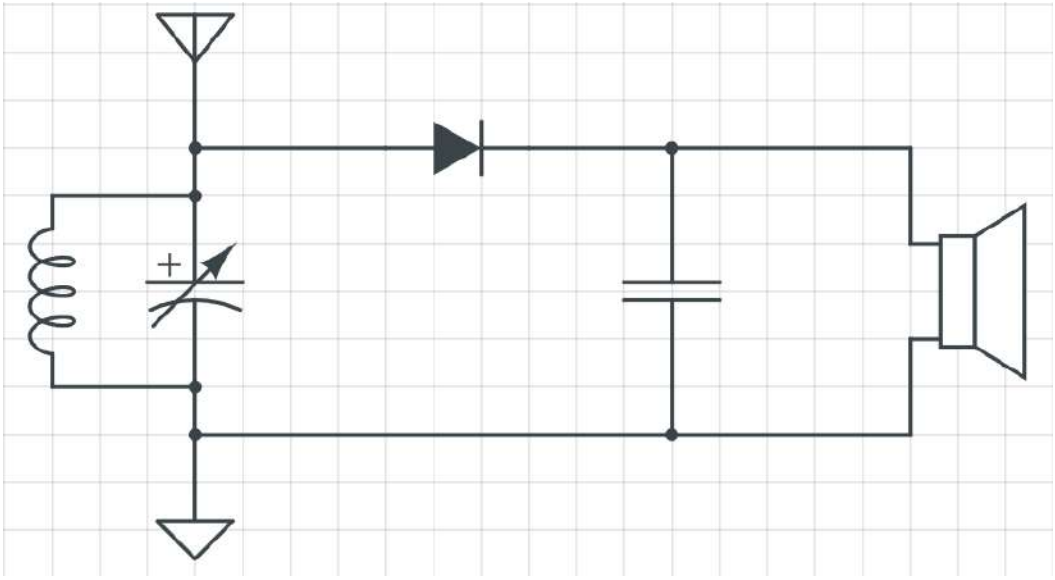

Figure 2. Radio receiver circuit

In order to tune the receiver to a certain frequency, we used Thomson's formula. By changing the inductance of the coil or the capacitance of the capacitor, we alter the frequency to the one we need [3].

Although amplitude modulation has begun to give way to frequency modulation over time, it has a number of advantages. First, the devices based on it are relatively simple in terms of design. Secondly, the wavelength in amplitude modulation is noticeably bigger than in frequency modulation. Thus, even in the age of high technology, amplitude modulation has its place.

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CARBON REGULATION IN RUSSIA AND ABROAD

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Abstract. The paper studies the carbon regulation strategies of Russia, the USA, China and the EU. As a result, the goals of climate regulation, instruments and mechanisms of these countries are overviewed and compared.

Keywords: carbon regulation, climate, greenhouse gas emissions.

УГЛЕРОДНОЕ РЕГУЛИРОВАНИЕ В РОССИИ И ЗА РУБЕЖОМ

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Аннотация. В статье исследуются стратегии углеродного регулирования России, США, Китая и ЕС. В результате рассматриваются и сравниваются цели регулирования климата, инструменты и механизмы этих стран.

Ключевые слова: углеродное регулирование, климат, выбросы парниковых газов.

The climate crisis is one of the most important problems of recent years. Now every region of the planet is feeling the effects of climate change. According to the sixth assessment report of the Intergovernmental Panel on Climate Change (IPCC), greenhouse gas emissions from human activities have been responsible for a 1.1°C change in temperature since the second half of the 19th century [1].

Reducing greenhouse gas emissions through carbon regulation is one of the most urgent tasks at the moment.

The first national greenhouse gas strategy adopted in Russia on October 20, 2021 describes two development paths: inertial and intensive [2].

The inertial path does not provide for the introduction of significant changes. According to it, a planned replacement and modernization of obsolete equipment will be carried out.

The intensive path ensures the fulfillment of the goals of reducing GHG emissions, the transition to technologies with low GHG emissions. The implementation of this path will lead to an 80 % reduction in greenhouse gas emissions by 2050 compared to 1990 levels.

Instruments for reducing anthropogenic GHG emissions, which are described in the strategy:

– greenhouse gas emissions trading system (ETS),
– introduction of technologies with low GHG emissions and high energy and resource efficiency,
– carbon tax system,
– certificates for energy production using low-carbohydrate technology.

The main document regulating GHG emissions is the Federal Law "On Limiting Greenhouse Gas Emissions", published on July 2, 2021 [3].

The goals of the document are consistent with the Decree of the President "On the Reduction of Greenhouse Gas Emissions", which requires reducing greenhouse gas emissions by 70 % by 2030 compared to 1990 levels, considering the maximum possible absorption capacity of forests and other ecosystems.

The law establishes the maintenance of state accounting for GHG emissions, the establishment of emission reduction indicators, support for activities to reduce GHG emissions.

The document also introduces new terms such as "greenhouse gases", "absorption of greenhouse gases", "carbon credit", "carbon footprint" etc.

Thus, the document consolidates the introduction of state accounting for GHG emissions, forming an emissions inventory, and also obliges to submit an annual report on emissions. This approach will allow tracking most of the GHG in the country. At the same time, the document does not specify the size of the emission reduction target and does not imply the possibility of bringing the system for determining the volume of GHG emissions and their removal to international standards.

As for the ETS, at the moment it has been implemented as an experiment in Sakhalin.

Also, to stimulate GHG reduction, the Ministry of Economic Development of the Russian Federation prepared a draft tax incentive for participants in climate projects [4].

Consequently, at the moment in Russia such tools are used as:

– ETS as an experiment on Sakhalin),
– system of climate projects and carbon credits,
– system for maintaining a register of greenhouse gas emissions and setting targets for their reduction.

Climate regulation in the European Union (EU) differs significantly.

At the beginning of the 21st century, the EU set a goal to gradually reduce greenhouse gas emissions by 2050. To achieve these goals, the Climate and Energy Package 2020 was adopted.

This document has three key goals:

- 20 % diminution in GHG emissions compared to 1990 levels;
- generation of 20 % of EU electricity from renewable sources;
- 20 % increase in energy efficiency.

The main areas of activity to achieve the goals set are the ETS, national emission diminution targets, national targets for renewable energy, innovation and financing, and energy efficiency [5].

The legal framework for the European carbon market is formulated in the ETS Directive [6].

To achieve the EU's targets, it is important to invest in sustainable projects and activities. Sustainable Growth Financing Action Plan called for a common classification system for sustainable economic activity or an "EU taxonomy" in 2018 [7].

The EU taxonomy is a classification system that sets out a list of environmentally sustainable economic activities.

The EU has announced a Green Deal in 2019 with a target of decreasing emissions by 55 % by 2030. The targets are contained in the "Fit for 55" package published in July 2021 [8].

As for China, at the moment there is no single document that would deal exclusively with the problems of climate change. The national strategy is formulated in a number of political and state planning documents.

The main law in the PRC, which also sets out climate regulations, is the Environmental Protection Law, under which national and local governments develop national and local environmental protection plans to promote clean energy.

Now in China, the ETS, launched in February 2021, is actively working and developing. In the future, the government plans to expand the system to more sectors of the economy. In addition to the energy sector, the system will also work in the chemical industry, the oil industry and the production of building materials.

Another tool for carbon regulation in China is the setting of limits. There are national environmental quality standards, which are set by the Ministry of Ecology and Environment, and on their basis, national GHG emission standards are developed.

As for the US, due to its federal structure, power is shared between the federal government and the states.

Consider California's climate regulation. California sets out the following goals:

- achieving carbon neutrality by 2045 or earlier,
- decrease emissions by up to 40 % below 1990 levels by 2030,
- elimination of emissions from all vehicles by 2045.

The state's most important climate regulation law is The Global Warming Solutions Act (Assembly Bill (AB) 32). One of the key tools for carbon regulation described in this law is the cap-and-trade system [9].

In the US, this system is based on the gradual reduction of the overall limit and the reduction of units intended for trading. Some units are allocated based on emissions from previous periods, and some are allocated through auctions. The State uses auction proceeds for a variety of purposes, including improving the environmental conditions of low-income communities and providing grants for other GHG reduction activities.

California has also introduced several tax incentives for activities that benefit the climate, such as sales tax exemptions for certain renewable energy products.

A comparison of the carbon regulation system in these countries is shown in Table 1.

Table 1 – Carbon regulation in Russia, China, USA and European Union

	Russia	China	USA, California	European Union
Founding document	Federal Law "On the Limitation of Greenhouse Gas Emissions"	Law "On Environmental Protection"	Law AB 32	Climate and Energy Package 2020
Goals of the national strategy	Diminution of greenhouse gas emissions by up to 30 % by 2030 compared to 1990 levels	Achieve carbon neutrality by 2060	Reduction of greenhouse gas emissions by up to 20 % by 2050 compared to 1990 levels	Reduction of greenhouse gas emissions by up to 20 % by 2030 compared to 1990 levels
Emission trading system (ETS)	Implemented as an experiment	Yes	Yes	Yes
Other regulation mechanisms	System of climate projects and carbon credits, emission register, reduction targets	The system of standards	Tax incentives	Classification systems for sustainable economic activity

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УДК 69.05

TECHNOLOGIES OF AUTOMATION AND ROBOTICS IN CONSTRUCTION PRODUCTION

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Abstract. The article substantiates the use of automation and the introduction of mechanized robotics within the framework of technological and production processes in the construction industry. The norms and properties of robotic technology in the construction of buildings and structures with a height of more than 100 m are studied. Indicators that prevent the use of automation and robotics in Russia are determined. Conclusions are formulated, solutions and technologies for the modernization of the construction industry of unique buildings and structures are proposed.

Keywords: automation, robotics, construction, robotic equipment.

ТЕХНОЛОГИИ АВТОМАТИЗАЦИИ И РОБОТИЗАЦИИ В СТРОИТЕЛЬНОМ ПРОИЗВОДСТВЕ

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Аннотация. В статье обосновано применение автоматизации и внедрение механизированной робототехники в рамках технологических и производственных процессов в строительной отрасли. Исследованы нормы и свойства роботизированной техники при возведении зданий и сооружений с высотой более 100 м. Определены показатели, которые препятствуют использованию автоматизации и роботизации в России. Сформулированы выводы, предложены решения и технологии по модернизированию строительного производства уникальных зданий и сооружений.

Ключевые слова: автоматизация, роботизация, строительство, роботизированная техника.

Introduction

The construction of buildings and structures is considered one of the main branches of human activity. In the modern world, the complexity of building construction technologies is increasing, as well as the variety of designed construction projects. The construction processes of erecting a building are of high complexity and danger in comparison with other professions. The success of each project under construction depends on three indicators: quality, project cost and completion time.

To improve the quality of the characteristics of a construction site, it is necessary to modernize the technologies for erecting and manufacturing buildings and structures using advanced and innovative automation and robotics technologies. Robotics helps to reduce construction time, increases the safety and nature of the tasks performed on the construction site, and also contains the prerequisites for reducing the number of people in the hazardous construction area.

Analysis of the methods of using robotics in the construction industry

The relevant task of the study consists of analyzing and evaluating the performance of the use of specialized equipment and robotics and automation processes in the construction of buildings and structures, as well as its implementation in Russia. Since the mid-80s of the 20th century, the most important tasks of automation and robotics of construction processes and works have been of great interest to specialists and researchers from engineering research institutions of the construction profile. The level of application of automated robots in various construction processes is not increasing, despite a large number of scientific and design prototypes in the field of construction robotics [1]. When developing robotic equipment for the construction industry, the design documentation of buildings or structures where mechanized robots will be used, as well as the design features of the object being built, is studied. Taking into account the study of mechanization and automation, it is possible to classify the structural elements of a building or structure, as well as improve the technology of certain building processes using robotic technology. It is also necessary to correctly choose mechanized robots for construction, since after calculating the payback of robots and cost analysis, a construction company can afford the introduction of mechanization and robotics technologies for the studied organizational and technological processes in the conditions of construction production. Also, automation and robotics technologies should provide a positive economic effect.

Research and analysis of technological factors, causes of automation and robotics of construction production

Various problems arise in the processes of construction production, during transitional phases and stages of construction, which are caused by inaccurate calculations in the design of a building or structure, imperfect communication with contractors, as well as the complication of obtaining high-quality engineering and communication communications between all participants in construction production. There is a system of main priority tasks when using technologies for automation and robotics of construction production, during the construction of construction objects, which can both provoke negative phenomena and correct them, as well as speed up the process of erecting buildings and structures: products and resources, the implementation on their basis of studying and testing the company's plant and the formation of standard complex proven and based on the principles of science programs for the commissioning of robots and special types of technological processes in the construction of buildings and structures; b) installation of new advanced and technological operations and their improvement due to the mechanized robots produced with the help of the engineering industry and a special innovative manipulator [2]; c) creation of a special purpose of manipulators, robots for narrowly focused branches of the construction industry; d) standardization and creation of classifications for manipulators and robotic equipment, which is used at construction sites or enterprises; e) development and creation of technical equipment for robotics of production operations in the construction industry, as well as equipment for mechanized robots; f) increasing the productivity of a construction company and reducing the time for erecting buildings and structures by improving technological processes and individual operations at a construction site or production, which will include the conditions and requirements of automation and robotics; g) commissioning of associations of robots in individual sections and production lines or a construction site, as well as the development of standard kits and schemes for certain construction and production works; h) preparation of construction sites and industries for the introduction of mobile mechanized robots into operation, as well as the creation of lines, sections and other sites on their basis; i) solution of technical and organizational issues of operation of mechanized equipment at factories and project sites in the construction industry [3].

Research into the main branches of construction operations indicates that certain processes on the construction site can be improved by the use of mechanized robots. In the study of labor costs at a construction site, it was revealed that installation work is the most complex and time-consuming construction operations. When erecting buildings and structures made of reinforced concrete, the main task is to automate and robotize the processes of

connecting, fixing, separating, dismantling, supplying and installing various elements in a given position with high accuracy [4]. In the conditions of the modern economic space of Russia, construction companies solve these problems with the help of loader cranes, special mounting equipment, as well as positioning robots. Another type of work – painting work is the most prepared for robotics, since at the moment there are many different robotic and automatic robots that have a remote control for supplying paints, as well as applying a primer [5]. The painting type of work needs robotics, because when analyzing the technological operations of preparing and painting walls in the working area, a finely dispersed aerosol air environment is formed, which harms the surrounding workers of the construction site. Also, the use of paints and varnishes is dangerous, as they can cause an explosion.

Automation technology and the use of robotic technology helps to reduce the workload on builders who are engaged in physical labor in the construction of unique buildings and structures, as well as to reduce the number of workers in production and construction sites. An increase in labor productivity allows you to improve the quality of work performed for the construction of the project and reduce the number of defective building materials and products in their production at factories, due to the exclusion of human and other factors. Due to the high demand and scale of the construction industry, as well as its dependence on the labor of workers, the technology of mechanization, automation and the use of robots in various construction processes has great economic potential.

It is also important to emphasize that the cost of housing in Russia is largely dependent on the prices of building materials, products and equipment. The cost of labor force does not have a big impact. Therefore, the use of automation and robotics technologies does not affect the reduction in prices for apartments and houses. Despite this, at present, some construction companies and manufacturing enterprises are analyzing, researching and finding positive prerequisites for the introduction of robotic equipment into operation.

The main reasons that limit and hinder the use of mechanized robots in the construction of buildings and structures in Russia are: a) lack of experience in the use of mechanized robots, methodological materials for the technical and economic complex of robotic technologies among Russian companies; b) lack of research and methods of the technical and economic complex on technologies for the use of robots; c) a small number of qualified workers and specialists who can ensure the operation and improvement of robotic equipment; d) lack of specialists and engineers who can create a project of a mechanized robot, as well as ensure its implementation and technological preparation during the construction of buildings and structures.

Automation technology and the use of robotic technology helps to reduce the workload on builders who are engaged in physical labor in the construction of unique buildings and structures, as well as to reduce the number of workers in production and construction sites. An increase in labor productivity allows you to improve the quality of work performed for the construction of the project and reduce the number of defective building materials and products in their production at factories, due to the exclusion of human and other factors. Due to the high demand and scale of the construction industry, as well as its dependence on the labor of workers, the technology of mechanization, automation and the use of robots in various construction processes has great economic potential.

Special parameters and characteristics of mechanized robots in the construction of buildings and structures

Currently, the production of robots and mechanized equipment is developing. Software control was installed on industrial robots of the first generation. Touch panels with the function of technical vision were installed on the second generation of robotic technology. The third generation of robots has been refined and improved, these models used intelligent control.

The small size and good technical characteristics of robotic equipment give an advantage when moving around the construction site, and also optimize construction costs. Only one professional operator can operate robotic equipment. The use of robots is required to reduce injuries to workers in potentially hazardous construction sites. Exploring the market of construction manipulators and robotic technicians that companies offer, they can be divided into several groups.

1) Industrial robots. Industrial robotic technology is mainly used in factories. Articulated robots are very similar to the human hand, which allows them to be used in a variety of jobs from simple automated assembly to complex welding jobs.

2) Drones. Drones have already become an integral part of the construction industry around the world. Drones are controlled remotely, so they can observe the process of building an object at a construction site.

3) Self-propelled construction vehicles. Autonomous machines have been used in the construction industry for a long time. Autonomous track loaders (ATL) from Built Robotics are equipped with a LiDAR system that measures the distance to an object using light pulses and a powerful GPS complex. As a result, the loader can work completely without an operator. With it, you can quickly carry out earthworks on the adjacent plot.

4) Humanoid robots. Nowadays, many companies offer a wide range of robot models that can perform various operations on a construction site. By systematizing the organization of robotic equipment, which contains information

about its purpose, the nature of production operations, the type of mobility at the construction site, as well as the conditions and requirements for load capacity and coordination accuracy, construction and industrial robotic equipment actively interacts with the external environment.

The level of injury as one of the main and fundamental aspects of the use of mechanized robotics

In the modern world, construction is still the most traumatic profession. During construction, many dangerous and harmful factors arise at the work site, such as working at heights, poor climatic conditions depending on the region, and being near the facility under construction of an operating enterprise or plant. The above factors pose a potential threat to the life and health of workers and people who live near the construction site or pass by. Therefore, the construction site must comply with the regulations so as not to harm the surrounding people, as well as workers.

During the construction process of the facility, being on the site itself, workers may encounter various hazards: the presence of moving mechanisms and machines on the site, high noise levels, increased vibration levels, the risk of injury from electrical appliances or machines, the possibility of burns when working with hot mastics or a blowtorch, falls from a height, physical overload, the presence of gas hazardous and flammable substances, increased or decreased air temperature of the working area depending on the season, the danger of falling on slippery floors, moving parts of production equipment, the location of the workplace at a considerable height relative to the surface floors and much more, depending on the climatic features of the city and the relief.

There are several prerequisites for injury at a construction site: a) lack of supervision and control over the correct and safe conduct of work; b) the use of faulty equipment that can cause great damage to workers, as well as to the construction site; c) non-compliance by workers with safety regulations at the construction site; d) violation of technological standards, lack of projects for a company that builds a building or structure, as well as a shortage of high-quality equipment and project documentation; e) work in bad climatic conditions; f) work with an increased content of hazardous and harmful substances in the air of working areas; g) insufficient or excessive lighting at the construction site, increased noise, vibration, precipitation, as well as the presence of various radiations that exceed the permissible limits); h) physical and overload of the worker.

The main reason for reducing injuries depends on the correct implementation of labor safety requirements at a construction site or production. Neglect of the norms is the cause of injuries, which depends on the following factors: the physical and moral condition and readiness of the employee, his responsibility, discipline and attentiveness. One of the main factors in reducing injuries to workers in hazardous areas of a construction site is the use of mechanization and automation technologies and the introduction of robotic technology.

Conclusions

Due to the compactness and high power of robotic mechanisms, companies began to use them in the most difficult conditions and hard-to-reach places on the construction site, and robotics can significantly reduce construction time and the number of workers on site, as well as increase profits.

The study allows us to formulate the following conclusions: digital technologies help to work effectively and efficiently in the construction industry, the introduction of automation and robotics technologies can fully reduce the construction time of buildings and structures; with the help of automation and robotics, it becomes possible to erect various unique structures; the introduction of mechanized robots will make it possible to build houses of unusual shape with complex facades, arches and an unusual curved interior; the main positive factors of mechanization, automation and robotics technologies in the construction of buildings and structures are increased productivity, the ability to work in hard-to-reach and dangerous places for finding a person, as well as in bad climatic conditions; robots can reduce the amount of building materials used.

As a result of the research, the scientific problem of the analysis of special mechanized robots, which are designed for the construction of unique buildings and structures, is considered. Thanks to the solution of this problem in Russia, the use and creation of domestic tools and technologies for system automation, robotics of construction processes is increasing, which contribute to an increase in productivity and quality of installation, finishing and plastering work, and the use of robots reduces the working day at a construction site and frees people from dangerous and harmful working conditions.

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УДК 621

ORGANIZATION OF HIGH-QUALITY HEAT SUPPLY

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Abstract. At present there are many problems in the centralized heat supply system. One of such problems is organization of quality heat supply. Non-compliance of designed and actual loads entails not only worsening of life quality of citizens, but also large overconsumption of fuel.

Keywords: centralized heat supply system, cogeneration sources, heat supply.

ОРГАНИЗАЦИЯ КАЧЕСТВЕННОГО ТЕПЛОСНАБЖЕНИЯ

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Аннотация. В настоящее время в централизованной системе теплоснабжения существует множество проблем. Одна из таких проблем – это организация качественного теплоснабжения. Несоответствие расчетной и фактической нагрузок влечет за собой не только ухудшение качества жизни граждан, но и большой перерасход топлива.

Ключевые слова: централизованная система теплоснабжения, когенерационные источники, теплоснабжение.

In the Russian Federation, the centralized heat supply system, in which installations that produce and consume energy are geographically distant from each other, has received priority development. Operation of such systems requires a significant amount of heat energy, which is transmitted via many

kilometers of transport communications to heat consumption systems by means of a water coolant. Such heat supply systems usually have a traditional structure, namely: heat source, heat network and consumer. This structure was developed in the 1950's and has not changed significantly [1].

Functioning of such system has both features and disadvantages.

Features of the centralized heat supply system:

1. The running costs under the central system are comparable or lower than the charges for energy purchased individually.

2. Majority of TPP, SDPP, district boilers work on any kind of fuel, which allows to create emergency reserves to work.

3. Owner does not purchase expensive equipment (boilers).

4. Heating of the apartment does not depend on supply of energy and electricity to the house.

5. No need to enter into contracts and pay for the maintenance of gas equipment.

6. Failures are eliminated by the supplying organization in the shortest possible time at their own expense.

7. Of the heating equipment in the residential areas there are only radiators. Boiler plants are removed from residential areas, sanitary areas around them are installed, which improves the environment [2].

Disadvantages of the district heating system:

1. Losses in the networks that deliver heat to the house - the length of the pipeline can be 10 km.

2. Possible costs the supplying organization puts in the tariffs, so the payment is significantly higher than it could be.

3. Limited regulation of the temperature in the apartment due to the design of the internal house networks.

4. Impossibility to disconnect an individual apartment from the common house network without a court decision.

5. Dependence on tariffs (established by regional commissions), which the homeowner is not able to influence.

Cogeneration units – combined heat and power plants (CHP) are most often chosen as sources of the centralized heat supply system. Such sources produce two types of energy at once: heat and electricity. Cogeneration is an energy-saving technology. It makes it possible to use 85-90 % of fuel heat, turning a significant part of it into electric energy, which is fundamentally more valuable than heat. In comparison with the best schemes of separate production at thermal power plants and hot water boilers, the total fuel consumption is 20-25 % less. Accordingly, emissions into the environment are reduced. At the same time, it is important that for existing and commissioned CHP plants, the maximum load of their cogeneration equipment should be ensured, and for

general considerations, it should be sought to load them as much as possible throughout the year. Operation of the cogeneration component of a cogeneration plant makes it possible to implement the most economically efficient option of joint generation of heat and electric power.

The main equipment of the thermal power plant (TPP) are steam boilers, gas turbine and steam-gas units, electric generators, deaerators, condensers, cogeneration units at combined heat and power plants (CHPPs), network heaters (boilers) [3].

Today, equipment at a number of CHPPs in the city operates under suboptimal conditions. Low heat load leads to a high share of condensing generation, and vice versa low electric load leads to a high share of heat production at peak hot water boilers, which leads to an overall reduction in the efficiency of combined heat and power generation at CHPPs.

Non-optimal loading of CHPP is:

1. Mismatch of contractual and actual loads of consumers in the zone of district heating. Each district heating company when planning energy balances should take into account the values of loads that are specified in the contract with the consumer, as it forms the obligation of the organization to provide each consumer at this stage. But today there are a number of reasons why it would be wrong to take these “formally recorded in the contract” loads as an example. Since, consumers who have installed heat meters, economically not interested in reducing the contractual heat loads.

2. It is also necessary to pay attention to the significant discrepancies in the load declared by developers in the area of central heating. When obtaining technical conditions for connection of objects under construction, developers often overestimate estimated heat demand of buildings under construction.

An important factor is also that often the specific values used in calculations of prospective load of planning and development projects, as well as projects for objects (buildings) under construction do not meet the requirements of energy efficient construction.

Quality operation of CHP in modern conditions requires

1. Revision of approaches to calculation and provision of heat loads of consumers.

2. Change of structure and increase of efficiency of heat extraction at the expense of change of thermal schemes.

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THE USE OF ELECTRIC VEHICLES IN THE TERRITORY OF THE RUSSIAN FEDERATION

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Abstract: The overview of the Russian market of electric cars is presented in the article. The relevance of the transition of the domestic market to electric models is examined. The problems of project realization arising in the development of production and consumption of electric cars in the Russian Federation are also noted. Recommendations on increasing the demand for electric cars in the country's automotive market are given.

Keywords: electric transport, development of electric vehicles, electric motor, automobile market.

ПРИМЕНЕНИЕ ЭЛЕКТРОМОБИЛЕЙ НА ТЕРРИТОРИИ РОССИЙСКОЙ ФЕДЕРАЦИИ

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Аннотация. В статье произведен обзор российского рынка электромобилей. Рассмотрена актуальность перехода отечественного рынка на электромодели. Также отмечены проблемы реализации проекта, возникающие в развитии электромобильного производства и потребления электромобилей в Российской Федерации. Даны рекомендации по повышению спроса электромобилей на автомобильном рынке страны.

Ключевые слова: электротранспорт, развитие электромобилей, электродвигатель, автомобильный рынок.

One of the most remarkable sources that changed life around the world was the discovery of the most efficient source of energy: electricity. In our modern world, electricity is used in industry and agriculture, communication and transportation, as well as for everyday use.

Electrification of transport is also one of the main trends of our time, both globally and at the level of individual nations. Russia is no exception; the country is slowly but surely moving in the same direction. Domestic electric cars appeared much earlier than the famous American company “Tesla” (formerly “Tesla Motors”). The first model was developed back in pre-Soviet times.

Modern electric cars have a very simple device. Of course, to control motor speed, charge level control and other functions requires a fairly powerful computer. It is through it that the driver interacts with the car, each time he presses the gas pedal. The computer displays information about the car on the screen, receives commands from the driver, and so on. And electronics in this case is the most complex element [1]. If we talk about the mechanical part, the device of the electric car is reduced to a minimum, the battery feeds the engine, which rotates the wheels directly or through a gearbox. The main devices and elements in the construction of the electric car are shown in Figure 1.

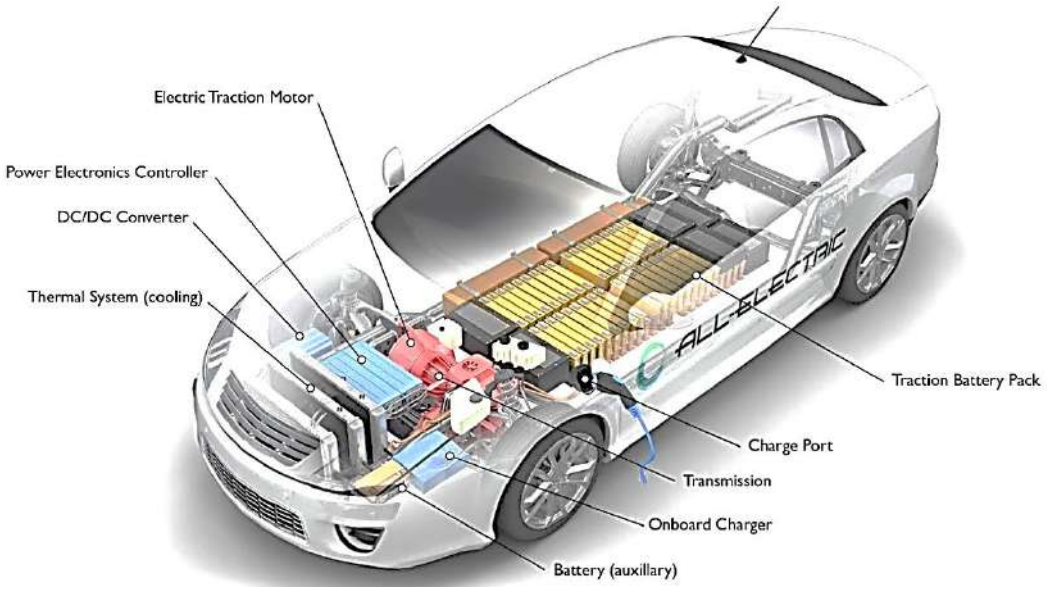

Figure 1. The main elements in the design of electric cars

The electric car market in the Russian Federation is still growing, but at a slower pace than in the People's Republic of China and European countries.

The development of the global electric car market largely depends on the government's initiative and the policies of car manufacturers. The world's leading automakers are rapidly increasing investment in electric vehicle production. So while by the end of 2018 there were about 3.000 electric cars in Russia, by June 2021 their number had increased to 12.290 cars. Most of them are used cars shipped from Asia, America, and Europe. In the Russian Federation, only the following models of electric cars are mainly represented: Renault Kangoo ZE and Twizy, and Jaguar I-Pace.

The most popular brand is Tesla, which does not even have an official representative office in Russia. Next in popularity are Porsche, Audi and Nissan. The best-selling electric car in 2021 unexpectedly became far from budget Porsche Taycan. The second place is taken by the world leader Tesla Model 3. Among used electric cars, the leader position is still held by Nissan. Accordingly, the most popular used electric car in 2021 was the Nissan Leaf (6.977 units). BMW i3 and two Tesla models (Model 3 and Model S) follow with sales of 435, 375 and 283 units respectively.

We would also like to point out the BMW i3, which was among the first electric cars to be officially available in Russia. It is a city hatchback of small dimensions. Model produced in 2018, you can buy, spending about 3.700 000 million rubles. With an urban driving style, the battery charge is sufficient for 160-180 km of mileage.

The volume of the Russian market for electric cars is insignificant compared to the U.S., China or European countries. Its share is less than 0.1 % of global consumption.

A noticeable revival in the electric car market in Russia began in 2017. That year, sales of new electric cars totaled 95 units. In subsequent years, the growth rate of the market began to increase even more [2]. The dynamics of the Russian market for new electric vehicles is shown in Figure 2.

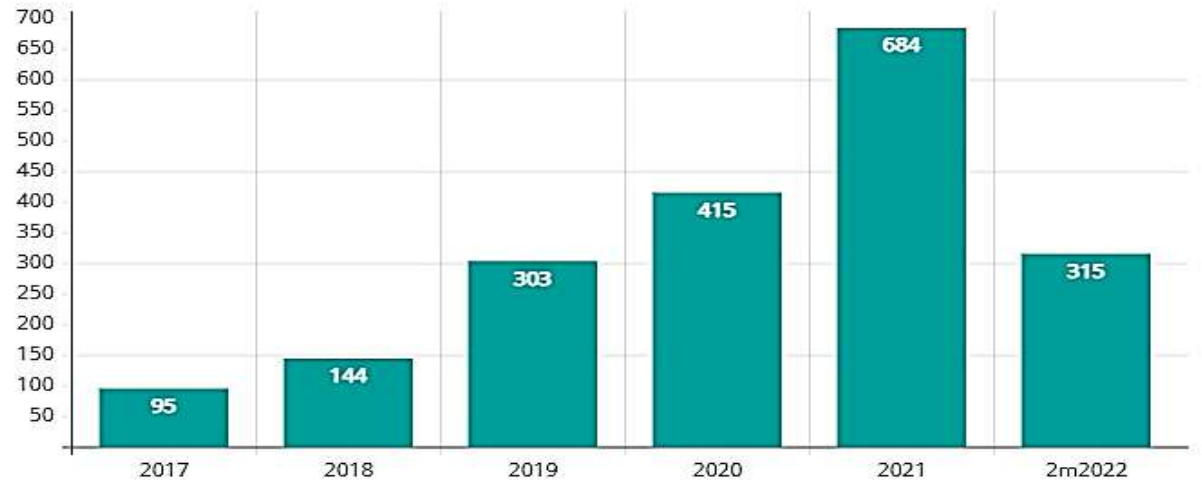

Figure 2. Dynamics of the Russian market of new electric cars in physical terms in 2017-2022, units

In 2021, more than 20 % of all sales of new electric cars are Nissan Leaf cars, with Renault Twizy, Peugeot Ion, MB EQC and Chevrolet Bolt being the least popular electric cars.

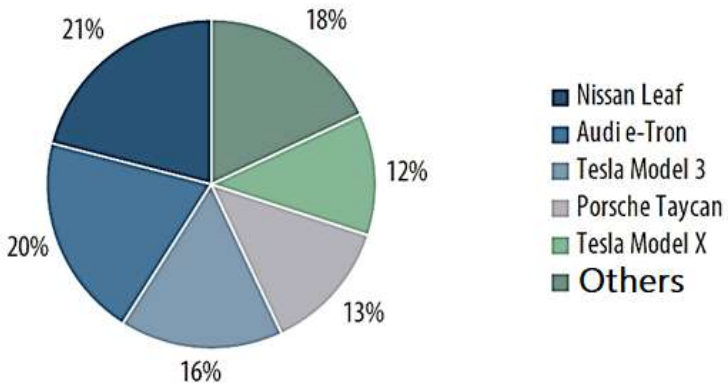

Figure 3. Structure of the Russian market for new electric vehicles in 2021, % of vehicles sold

In 2021, the market for electric cars in Russia was 12.290 vehicles. The largest number of electric cars is expected to be registered in Primorsky Krai, where imports from Japan are well-developed. Here, by the middle of last year, 1.572 such vehicles were registered, which is about every eighth electric car in the country. Almost all of them are used right-hand drive Nissan Leafs from Japan. The second place in the volume of "electric fleet" is occupied by the Irkutsk region, which has 1381 electric cars. The third place is taken by Moscow (1.360 units). The top eight regions in terms of the number of electric cars in 2021 are shown in Figure 4.

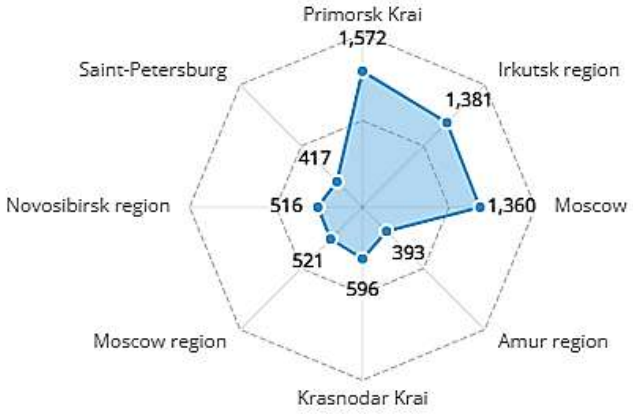

Figure 4. Structure of regions of the Russian electric car market in 2021, units

If we touch upon the reasons that do not allow the Russian market of electric cars to actively develop, we can note [3]:

1) Weak level of infrastructure. It is problematic to charge and repair an electric car outside several major cities.

2) Cold climate. At low temperatures, batteries lose charge much more actively and work less efficiently. Under these conditions, you need at least a warm garage for normal use of an electric car.

3) Phobia towards the new. Drivers accustomed to manual transmissions were afraid to switch to cars with automatic transmissions. With electric cars and hybrid models, the situation is now similar.

4) Pricing. The cost of new electric cars (as of 2021) ranges from 1.1 to 11 million rubles. In addition to Figure 5, it should be noted that the price of individual models in individual configuration can reach 30 million rubles.

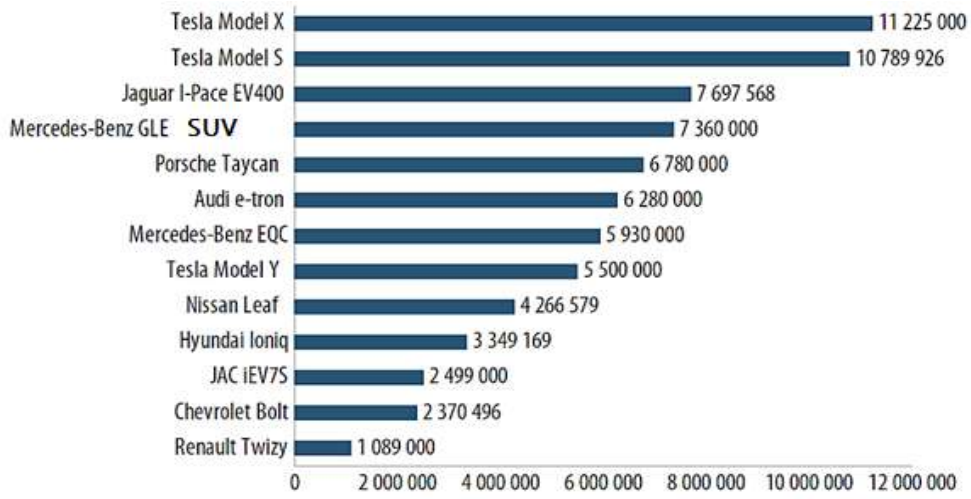

Figure 5. Price of the basic set of new electric cars in 2021, rubles

High production rates, government support for both manufacturers and buyers of electric vehicles, as well as other various incentives “around” the industry (for example, the development of a network of electric charging stations), should lead to a shock growth rate in the number of electric vehicles in the coming years [4]. Experts believe that total sales of electric cars in Russia will grow at an average annual growth rate of up to 30 %, 2022-2025, which is equivalent to an increase in sales from 12.290 cars to 35,000 cars throughout Russia. Thus, the use of electric cars in the Russian Federation will grow little by little, but every day. Over time, electric cars will completely replace all other passenger cars. Buying an electric car in today's reality is more relevant than ever: the increasing cost of fuel, the unreliability of internal combustion engines, the ever increasing taxes on ownership of standard cars, the increasing demands on environmental friendliness of cars – all this makes buying an electric car beneficial and comfortable to buy.

However, the growth in the share of electric cars is still hampered by the lack of semiconductors. Analysts say that due to the lack of chips in the first quarter of 2021 production losses amounted to 1.4 million electric cars. But by the end of 2022 the problem should be solved, but manufacturers may face another obstacle – rising prices for lithium, the main element for traction batteries. The battery is still the most expensive component of electric cars,

accounting for about a third of the cost of the entire car. And we should hardly expect it to become cheaper in 2022.

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УДК 608.001

ARTIFICIAL INTELLIGENCE IN ENERGY SECTOR

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Abstract. This paper discusses spheres of energy sector, where artificial intelligence can be used. As a result of information analysis three main directions were identified. They are: exploration of deposits of already existing fuels, data collection and analysis, discovery of new and prospective fuels.

Keywords: artificial intelligence, exploration of deposits, data analysis, development of algorithms, “digital twins”, Internet of Things, synthesis, prospective fuels.

ИСКУССТВЕННЫЙ ИНТЕЛЛЕКТ В ЭНЕРГЕТИЧЕСКОМ СЕКТОРЕ

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Аннотация. В работе рассматриваются сферы энергетического сектора, в которых может быть использован искусственный интеллект. В результате анализа были выявлены три основных направления. Это исследование залежей уже существующих видов топлива, сбор и анализ данных, открытие новых и перспективных видов топлива.

Ключевые слова: искусственный интеллект, исследование залежей, анализ данных, разработка алгоритмов, «цифровые двойники», интернет вещей, синтез, перспективные виды топлива.

Nowadays, artificial intelligence is actively developing and gradually penetrates into all spheres of our life. In parallel, new and prospective types of fuel are being developed.

But how will artificial intelligence help in the extraction and production of fuels?

Artificial intelligence helps in the:

1) Exploration of deposits of already existing fuels;
2) Data collection and analysis;
3) Discovery of new substances.

Let’s consider each point in more detail.

Artificial intelligence helps in the exploration of new deposits of various types of fuels needed for the energy sector and production. Oil and gas companies are seriously experimenting with modern technologies to increase their efficiency and revenue. Using artificial intelligence in oil and gas operations, corporations can develop algorithms for drilling on land and on the ocean floor. Organizations around the world are trying to make exploration and production processes more efficient and optimized [1].

Artificial intelligence tools can help oil and gas companies digitize records and can automate the analysis of collected geological data, which can potentially lead to the identification of problems such as corrosion of pipelines or increased use of equipment.

Machine learning also allows companies to improve productivity and production. AI has many applications in the oil and gas industry, for example, optimizing production using computer vision for faster analysis of seismic and geological data, minimizing downtime for preventive maintenance of oil and gas equipment, understanding the reservoir and modeling to predict oil corrosion risks in order to reduce maintenance costs [2].

Artificial intelligence is actively used in the creation of so-called “digital twins”. The principle of this technology is as follows: “conducting online inclusion of engineers and narrow-profile specialists of a geographically distributed team directly during repair work. The system consists of explosion-proof remote support helmets connected to tablets and software products to support business processes that are used in industrial areas” [3].

Machine learning technologies, along with neural networks and the Internet of Things, allow you to autonomously find security threats and notify employees about them. In other words, AI is able to predict and warn staff about an accident before it happens. For example, the explosion of the Deepwater Horizon oil platform. The accident has occurred on April 20, 2010, 80 kilometers off the coast of Louisiana in the Gulf of Mexico on the Deepwater Horizon oil platform at the Macondo field. The oil spill that followed the accident became the largest in the history of the United States and turned the accident into one of the largest man-made disasters in terms of negative impact on the environmental situation.

This accident was the result of a whole chain of violations and technical malfunctions. Experts say that the disaster on the platform had to happen, and it was only a matter of time.

AI performs a number of tasks in synthetic chemistry, such as:

1) Synthesizing new substances from existing ones;
2) Synthesizing a substance with the necessary characteristics;
3) Prediction what qualities a substance will have;
4) Calculating the conditions for obtaining the desired substance;
5) Evaluation of the possibilities of synthesis of substances;
6) Choosing the most suitable substance for certain purposes;

etc.

Thus, it is possible to synthesize prospective fuels with increased efficiency and reduced exhaust [4]. Artificial intelligence accumulates data on various substances, their compounds and the conditions for their production. Then, based on these data, it draws conclusions about what substances can be formed from those already existing in the database, how they can be obtained and what characteristics they will have.

Fuel is used with low efficiency. AI can tell you where it is more efficient to use a particular type of fuel. In this regard, D. Thomson wrote: “In a highly civilized age with limited energy resources, some of our technological processes may look something like if they decided to burn down an entire house in order to roast a pig carcass. Reduction of energy consumption is compatible with an increase in the standard of living”. In order to increase the efficiency of fuel use, a reasonable choice of fuel is essential. For instance, high-temperature processes require using the fuel with high performance and low ballast content [5].

So artificial intelligence will help solve problems such as inefficient use of fuel, low fuel efficiency and partly environmental pollution. Artificial intelligence is also being introduced into some areas directly or indirectly related to energy. Such as transport and industrial Internet of Things [6].

The Industrial Internet of Things (IoT) or Industrial Internet consists of a vast ecosystem of industrial devices connected by communication technologies that power systems that can monitor, collect, exchange, analyze and provide valuable new ideas to industrial enterprises. Industrial IoT devices and systems include things like connected electricity meters, wastewater systems, flow meters, pipeline monitors, and production line robots [7].

Freight traffic monitoring manages most of the IoT costs in this sector. Freight and public transport companies are increasingly equipping their vehicles with sensors that help plan maintenance, optimize fuel consumption and train their drivers.

Some vehicles have digital data recorders that are programmed to capture video images in conditions of high acceleration (potentially indicating a serious traffic accident). Connected vehicles can also monitor operating or driving behavior for insurance purposes.

Interesting facts

The StarShip/SuperHeavy run on “methalox” – liquefied Methane is the fuel and liquefied oxygen is the oxidizer. The Falcon-9 and Falcon-Heavy both use chilled RP-1 rocket fuel (which is a very refined from of Kerosene) and liquefied oxygen. RP-1 is a very popular rocket fuel but for the Mars mission, it’ll be necessary to manufacture fuel while on Mars…and making RP-1 would be insanely difficult. Methane can be made from water and CO2 (and a LOT of electricity), and a byproduct of doing that is oxygen – so Methalox can be manufactured on Mars for the return trip to Earth.

The Fischer-Tropsch process is a chemical reaction that occurs in the presence of a catalyst in which carbon monoxide (CO) and hydrogen are converted into various liquid hydrocarbons. Catalysts containing iron and cobalt are commonly used.

Carbon dioxide and carbon monoxide are formed by partial oxidation of coal and wood fuel. The benefits of this process are mainly in its role in the production of liquid hydrocarbons or hydrogen from solid raw materials such as coal or solid carbon-containing waste of various types.

Non-oxidative pyrolysis of solid organic raw materials produces syngas, which can be directly used as fuel, without conversion by the Fischer-Tropsch process. If a liquid substance similar to petroleum fuel, lubricating oils or paraffin is required, the Fischer-Tropsch process can be applied. If it is necessary to increase the yield of hydrogen, then water vapor is taken in excess, which shifts the equilibrium of the reaction, resulting in the formation of only carbon dioxide and hydrogen. In this way, liquid fuel is obtained from a mixture of gases.

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STUDY OF POLLUTANT EMISSIONS FROM AN INDUSTRIAL PLANT IN ACCORDANCE WITH PERMISSIBLE EMISSION STANDARDS

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Abstract. This article discusses the legislative aspects in the field of environmental protection. An assessment is made of the impact of the production activities of an enterprise with stationary sources of emissions into the atmosphere on environmental pollution. Recommendations are given on the organization of effective activities of the enterprise to improve the environmental safety of production.

Keywords: environment, pollutant emissions, environmental safety, pollutant concentration, atmospheric air.

ИЗУЧЕНИЕ ВЫБРОСОВ ЗАГРЯЗНЯЮЩИХ ВЕЩЕСТВ ОТ ПРОМЫШЛЕННОГО ПРЕДПРИЯТИЯ В СООТВЕТСТВИИ С НОРМАМИ ДОПУСТИМЫХ ВЫБРОСОВ

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Аннотация. В данной статье рассматриваются законодательные аспекты в сфере охраны окружающей среды. Произведена оценка влияния производственной деятельности предприятия со стационарными источниками выбросов в атмосферу на загрязнение окружающей среды. Даны рекомендации по организации эффективной деятельности предприятия по повышению экологической безопасности производства.

Ключевые слова: окружающая среда, выбросы загрязняющих веществ, экологическая безопасность, концентрация загрязняющих веществ, атмосферный воздух.

In accordance with the Law of the Russian Federation “On Atmospheric Air Protection” (№ 96-FZ), legal entities having stationary sources of harmful (polluting) substances emissions into the atmospheric air are obliged to ensure inventory of emissions of harmful (polluting) substances into the atmospheric air

and development of maximum allowable emissions and maximum allowable standards of harmful physical impact on the atmospheric air [1].

MPE is a norm of maximum permissible emission of harmful (polluting) substance into the atmospheric air, which is set for the stationary source of atmospheric air pollution taking into account the technical standards of emissions and background pollution of atmospheric air on condition that this source does not exceed hygienic and environmental standards of atmospheric air quality, maximum allowable (critical) loads on ecological systems and other environmental standards.

The main objective of the draft standards of permissible emissions (MPE) is a scientifically substantiated assessment of the impact of production activities of the enterprise, which has stationary sources of emissions into the atmosphere, on the pollution of the natural environment.

In order to develop a draft MPE, an inventory is carried out, which identifies processes with pollutant emissions, determines stationary and non-stationary sources of emissions into the atmosphere, their quantity and parameters.

The project is developed in accordance with the Order of the Ministry of Natural Resources of Russia N581 dated 11.08.2020. "On Approval of the Methodology for Development (Calculation) and Establishment of Norms of Permissible Emissions of Pollutants into the Atmospheric Air" [2].

Let us consider an enterprise, the main activity of which is the production of mineral wool boards on synthetic binder. Thus, in the production from 57 sources (of which 43 are organized) air pollution is emitted 24 names of pollutants in the amount of 263.0237575 g/s and 4683.132 t/year.

According to the order of the Ministry of Natural Resources of Russia No. 581 of 11.08.2020. "On approval of the methodology of development (calculation) and establishment of norms of permissible emissions of pollutants into the atmospheric air" p.5. for facilities of I and III categories the maximum permissible emissions are established only for highly toxic substances, substances with carcinogenic, mutagenic properties (substances of I, II hazard class) if they are in the emissions [2].

Thus, a list of pollutants for which permissible emission limits are developed has been defined: Manganese and its compounds/manganese (IV) oxide/; Nitric acid (by molecule HNO_3); Sulphuric acid by molecule H_2SO_4; Dihydrosulphide (Hydrogen sulphide, dihydrosulphide, hydrosulphide); Benz/a/pyrene; Hydroxybenzene (phenol) (Oxybenzene; phenylhydroxide; phenyl alcohol; monohydroxybenzene); Formaldehyde (formic aldehyde, oxomethane, methylene oxide).

According to Order N581 of the Ministry of Natural Resources and Environment of Russia dated 11.08.2020. "On Approval of the Methodology for Development (Calculation) and Establishment of Norms for Permissible Emissions of Pollutants into the Atmospheric Air", accounting of background concentrations of pollutants is carried out when the condition is met:

$$qj > 0{,}1 \text{ MPC (in shares of MPC)},$$

where qj (in shares of MPC) is the value of the maximum surface concentration of j-th pollutant in the atmospheric air, created (without taking into account the background) by emissions from stationary sources in the zone of influence outside its sanitary protection zone or on the border of the nearest residential area.

If the surface concentration of a pollutant in the atmospheric air formed by emissions of any pollutant does not exceed 0.1 MPC outside the boundaries of the land plot where the object of negative impact is located, then when calculating the maximum permissible emissions of such pollutant the background level of atmospheric air pollution is assumed to be 0, and consideration of the background level of atmospheric air pollution for mixtures of pollutants having summation action (combined action), which includes

Calculations of concentrations and dispersion of emissions of harmful substances in the surface layer of the atmosphere without taking into account the background pollution from sources located in the territory of the industrial site showed that the condition qj>0.1 is fulfilled for formaldehyde. Calculation of formaldehyde dispersion was carried out taking into account the background.

The dispersion maps (Figure 1, Figure 2) of formaldehyde without regard to background concentrations and with regard to background concentrations are given.

Thus, it is revealed that the contribution to atmospheric air pollution from the enterprise is less than the background concentrations. Also, no exceeding of the established MPC for formaldehyde has been detected. Recommendations on organization of effective activity of the enterprise to improve environmental safety of production [3; 4]:

1. Conduct environmental monitoring at the enterprise and monitor compliance with environmental regulations;

2. Equipping water and air pollution sources with treatment plants and facilities.

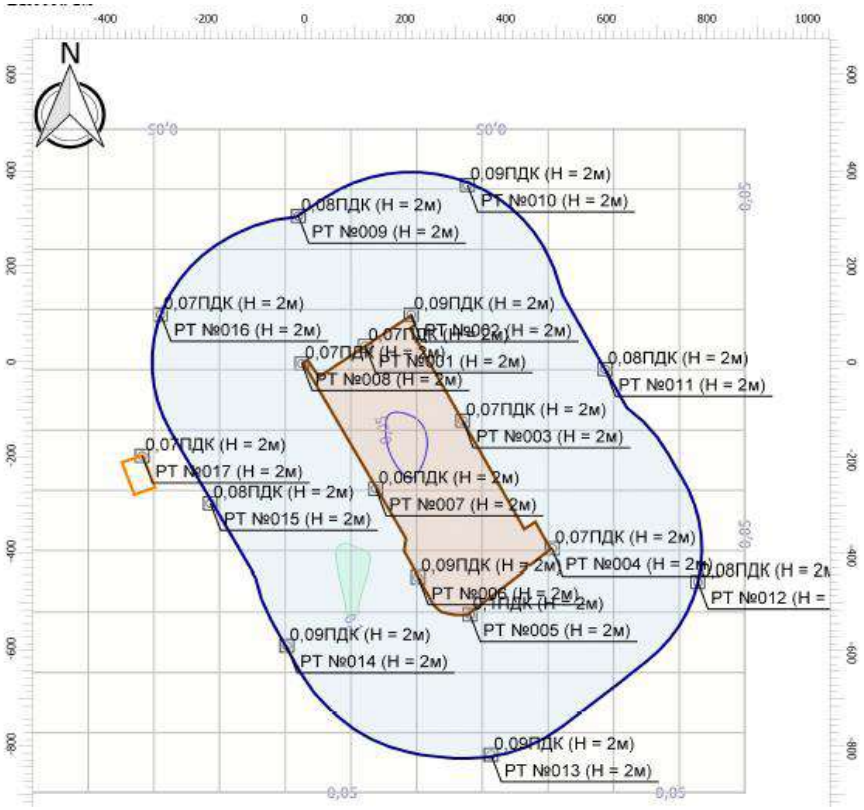

Figure 1. Dispersion of formaldehyde without regard to background concentrations

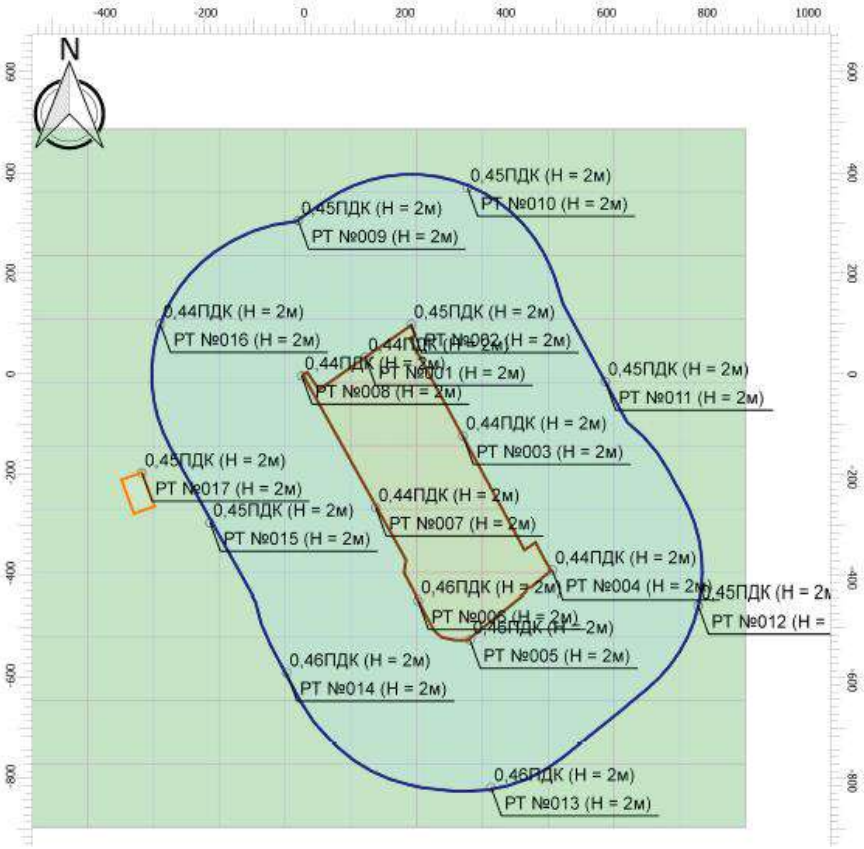

Figure 2. Dispersion of formaldehyde with regard to background concentrations

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OVERCONSUMPTION AND ITS IMPACT ON THE ENVIRONMENT

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Abstract. This paper discusses the phenomenon of overconsumption and its impact on the environment. The analysis examines certain aspects of the problem of consumption in various spheres of human life, their examples and solutions.

Keywords: overconsumption, carbon footprint, greenhouse gasses, pollution, microplastic, water crisis.

ИЗБЫТОЧНОЕ ПОТРЕБЛЕНИЕ И ЕГО ВЛИЯНИЕ НА ОКРУЖАЮЩУЮ СРЕДУ

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Аннотация. В данной работе изучается явление чрезмерного потребления и его влияние на экологию. В ходе анализа рассматриваются отдельные аспекты проблемы потребления в разных сферах жизни человека, их примеры и пути решения.

Ключевые слова: чрезмерное (избыточное) потребление, углеродный след, парниковые газы, загрязнения, микропластик, водный кризис.

Overconsumption describes a situation where the use of resources exceeds the sustainable potential of the ecosystem. It is a new phenomenon, which appeared in industrial countries in the 1970s and was caused by consumerism or economic order where consumers were encouraged to buy a larger amount of goods and services than they actually need.

Overconsumption has a severe impact on our environment. It leads to serious ecological problems such as an increasing carbon footprint, resource depletion, environmental pollution, etc.

Distribution around the world.

Consumerism is a problem of developed countries with economic sustainability. One of the reasons for the overconsumption is global inequality, which allows some people to spend a huge amount of resources, effort, time and money on things that are not necessary. For example, the average African family uses 5 gallons of water a day, while the average American family consumes more than 300 gallons a day on average. It happens due to the presence of a colossal financial gap between people from different continents. While someone is suffering, someone is wasting vital resources.

Overwatering.

Humanity forgets that drinking water is an exhaustible resource. While 70 % of the Earth surface is covered with water, only 3 % of it is available for drinking and irrigation purposes. The biggest part of our water sources is stored in glaciers and located in areas of permafrost. Due to global climate change, humanity has already lost tons of fresh water, which could be used in the future [1].

Nowadays we can see a water crisis in several regions of our planet. In our society of overconsumption, we waste millions of liters of water on useless items because of our carelessness.

One cup of coffee requires 130 liters of water! Average T-shirt requires 2500 liters of water and a pair of jeans requires around 10000 liters. Today more than 1.1 billion people do not have access to freshwater, 2.4 billion people do not have access to safe water and risk becoming infected with terrible diseases such as cholera, water-borne illness and typhoid fever [2]. World population is expected to increase by 2.5 billion by 2050. So, possible solutions for solving problems caused by overpopulation are in great need over the next decade.

Food consumption.

Food production causes a very negative impact on the ecology. Agricultural food system is to blame for more than 30 % of the global anthropogenic emissions (or greenhouse gasses emission, which appears as a result of human activity) [3]. Global protein overconsumption is one of the biggest ecological problems nowadays. According to Dr. Max Roser, one kilogram of beef costs our atmosphere 99.48 kilograms of CO2. Lamb and Mutton – 39.72 kilograms, Dairy – 33.3 kilograms, Prawns – 26.87 kilograms. For the comparison 1 kilo of bananas during its cultivation emits less than a kilogram of CO2 (Table 1) [4].

Table 1 – Greenhouse gas emissions per kilogram of food product

Food product (kilogram)	Greenhouse gas emission (kilograms)
beef	99.48
lamb	39,72
dairy	33,3
rice	4,45
rye	1,57
potatoes	0,46

While meat and dairy have the biggest carbon footprint of all food products, the consumption of protein per capita is 37 % higher than recommended. Overconsumption is responsible for tons of CO2.

Clothing consumption.

Humanity has reached the time of “fast-fashion”. Clothing becomes “unfashion” or “untrendy” after a few months after a purchase and goes straight into the garbage. For the last 15 years, the clothing consumption has increased by 36%. Indeed, clothing overconsumption has a severe impact on the environment. The fashion industry is responsible for 1.2 billion tons of greenhouse gas and 22 million tons of microplastic, which pollutes oceans (which is 35% of the amount of the microplastic in the ocean) [5; 6]. Small companies that make clothing from recycled materials or control their pollution emissions and resources consumption cannot compete with global clothing giants.

Reasons of overconsumption.

However, why are we overconsuming? What pushes us to waste a large amount of money and resources on the stuff, which we don’t really need?

There are few reasons, which can explain human behavior:

– Prestige. Our desire to buy useless stuff is based on the need for recognition. The consumer motive of prestige is far from the rational use of things. Often, people buy particular things to show a high level of income and success (e.g. some luxury products or expensive brand clothing.

– Culture of overconsumption. Advertisement, celebrities and capitalism as an economic system teaches us to buy certain products. Culture of consumption shows people that purchases can make them happy even when it’s not true.

– Lack of knowledge. Most of people don’t really know impact of their consumption on the ecology.

– Possible solutions might be:

– Education. First of all, we need to educate people around us. Usually they don’t even know what impact has an extra cup of coffee or a new dress on the environment.

– New taxes. Government can create new taxes in order to force people change their consumption habits

– Promote alternative fashion and vegetarianism in order to reduce a carbon footprint of carbon and food industry.

– Reusing and recycling items which has been already produced.

To sum up, we can say that the main goal is to inform people all over the world about the dangers of excessive consumption and environmental pollution, the importance of recycling and the involvement of world corporations and countries in these processes.

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HOW INFORMATION TECHNOLOGIES HELP PEOPLE WITH MENTAL HEALTH PROBLEMS

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Abstract. The article provides examples of information technologies that help people to cope with mental health problems. Their effectiveness and benefits for patients are considered. It is stated that when using these information technologies, the number of people suffering from this disease has significantly decreased.

Keywords: information technologies, mental health, telehealth, artificial intelligence, machine language.

КАК ИНФОРМАЦИОННЫЕ ТЕХНОЛОГИИ ПОМОГАЮТ ЛЮДЯМ С НАРУШЕНИЯМИ ПСИХИЧЕСКОГО ЗДОРОВЬЯ

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Аннотация. В статье приведены примеры информационных технологий, которые помогают людям справиться с проблемами психического здоровья. Рассмотрена их эффективность и польза для больных. Констатируется, что при использовании данных информационных технологий количество страдающих от данного недуга значительно уменьшилось.

Ключевые слова: информационные технологии, психическое здоровье, телемедицина, искусственный интеллект, машинное обучение.

According to official statistics, mental health and substance abuse disorders affect more than 13 % of the world's population, and the current pandemic and political situation seem to have led to this number increase [1]. In fact, the problem that was invisible to many people has now almost become a global issue despite the fact that 60 % of the people who suffer from such disorders do not receive care or go undiagnosed [2].

Statistics also imply that anxiety, depression and substance abuse – the most common mental health illnesses – affect 284, 264 and 107 million people in the world respectively [1]. Talking about Belarus, the number of people

diagnosed with mental disorders has increased by 55 % within 15 years, and the growth is still dramatic.

There is a saying ‘Change is the essence of life. If you do not change, you shall perish’. And while we can all argue endlessly about whether technological progress has a positive influence on humanity or not, it does help a lot of people with mental disorders, anxiety specifically. A particular impact could be seen around these solutions that support preventive care.

Telehealth basically provides long-distance patient and clinician contact, care, advice, intervention, monitoring, and remote admissions. It seems to be blatantly obvious that for those who live with a mental health condition, the first step of appealing for help is often an extraordinarily difficult one, which is why the ability to receive support and have a piece of advice via the Internet greatly lowers barriers to accessing care [2]. Moreover, telehealth has other advantages.

First of all, it is its convenience. Even if you live in a small town with no psychologists at all, you can still receive care and extensive consultations from a qualified specialist. Such meetings can happen anytime, anywhere, which is highly convenient for those who cannot attend in-person appointments due to different reasons. It is said that the COVID-19 lockdowns have been associated with large increases in telemedicine visits in the USA for various mental health conditions. These include different forms of anxiety, manic depression, insomnia, substance abuse, overactivity and others.

Another advantage is anonymity. Unfortunately, there is still a lot of social stigma attached to mental illness, which results in fewer people seeking help. Although it has to change, and it certainly will, telehealth makes it possible for people to receive solid help without other people being involved.

Last but not least, statistically, telehealth visits are two times cheaper in comparison with in-person ones [2]. And while people are losing their jobs because of the COVID-19 pandemic, it may seem as a key advantage.

Another critically important side of information technologies that is very useful for people who suffer from mental illness is so-called artificial intelligence (AI). Latest polls indicate that people usually tend to be more honest with robots than their fellow citizens [2]. Indeed, it is easier for us to tell something to someone who we believe cannot spread gossips about the state of our health. That is why AI tools and apps are gaining popularity among different groups of people.

There are many apps designed to support those struggling with their mental health. Some of them use artificial intelligence to act as an emotional therapist chatbot. Wysa is one of them. Its developers say they created this tool “in an effort to make the world more mentally resilient”. Not only is that every conversation anonymous, but it is also clinically safe since Wysa uses cognitive-behavioral techniques [3].

Another app that can be used as “a pocket therapist” is called Youper. It provides its users with an opportunity to visit their doctors online and have their medications delivered to them [3]. It also has user-friendly system of symptom monitoring. The techniques that are used by the developers are proven by

Stanford University scientists and said “to be effective for improving symptoms of anxiety and depression”. All the therapists are experienced specialists, most of them have certificates of the most trusted organizations, including Mental Health America [4].

There are also some AI apps that specialize in a narrower area. For instance, the “meQuilibrium” app is a platform that uses employee data to create customized solutions that address burnout, purpose, and wellbeing, or “Neurotrack” that is useful for those suffering from memory loss diagnosis [5].

Machine learning that is an essential part of artificial intelligence can also help those suffering from their mental condition a lot. It is said that neuroscientists around the world are now starting to use it to develop treatment plans for patients. It is also used to identify an inordinate number of markers for mental health disorders before they may declare themselves. But what is really impressive is the fact that ML helps psychiatrists predict who may be at risk of a particular disorder. Such predictions are often borne out, which shows that ML can be considered a highly effective technique of detecting mental disorders.

Moreover, after having diagnosed a mental illness, a lot of specialists face a problem when trying to find the right dosage of their medication. If it is not correct, it may impair people’s health, which is it is terribly important to find the optimum dose as fast as possible. ML algorithms open up a marvelous opportunity for mental health professionals to identify various types of mental disorders and develop remarkably accurate treatment plans and medication dosages [6].

While it is vital to diagnose patients with mental illness, it is also significant to predict crises. It is perfectly feasible if we can “detect a pattern of stress, isolation, or exposure to triggers”. Machine learning algorithms can use self-provided data and passive data from cellphones and social media as a basis to help specialists understand whether an episode is oncoming for a patient or not [6].

Moreover, technologies can be successfully used as a suicide prevention mechanism. Unfortunately, suicide has now become a leading cause of death globally [7]. Suicide prevention is a considerable challenge that requires “a system approach incorporating public health strategies, screening at-risk individuals, targeted interventions, and follow-up for suicide survivors and those bereaved by suicide”. Although there are some warning signs, such as social withdrawal, increased alcohol use or dramatic mood swings, detecting them is often hard even for experienced specialists. However, the increasing prevalence of cellphones and the use of the Internet and social media platforms offer the potential for background data collection, which allows psychiatrists to detect suicidality automatically [8].

Numerous studies have established the connection between social connectivity and mental health. They show that people who have depressive symptoms often tend to group together. Therefore, tracking how a social network changes over time and detecting changes in social connectivity may

provide vital information about emerging episodes of depression and suicidal behavior [8].

There are also a number of apps that can provide its users with effective interventions that are required in order to manage the crisis situation. One of them is called “ibobbly”. It is based on Acceptance and Commitment Therapy, which was developed by Steven Hayes in 1982, but presented in a graphical form.

To draw a conclusion, it seems especially important to mention that mental health is as much vital as our physical heath, although stigma surrounding it is still common. It undoubtedly leads to delays in treatment, and it also reduces the chances that a person with such illnesses will receive appropriate clinical care. Despite that, we cannot but mention that we should use every available opportunity to help those who are struggling with such disorders. Thankfully, in the era of high technologies it is possible to receive help from top specialists around the world via different apps. These new technologies are changing the way different groups of people handle mental health dramatically.

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SIMULATION OF THE OPERATION OF THE CONTROL CHANNEL OF A MOBILE SNOW MELTING PLANT

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Abstract. A simulation of the operation of the control channel of a mobile snow melting plant in the Multisim program was carried out to verify the correctness of the developed electrical schematic diagram of the information and measurement control channel of the plant.

Keywords: snow melting plant, snow disposal, snow mass cleaning, electrical schematic diagram, trigger.

МОДЕЛИРОВАНИЕ РАБОТЫ КАНАЛА УПРАВЛЕНИЯ МОБИЛЬНОЙ СНЕГОПЛАВИЛЬНОЙ УСТАНОВКИ

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Аннотация. Проведено моделирование работы канала управления мобильной снегоплавильной установки в программе Multisim для проверки правильности разработанной электрической принципиальной схемы информационно-измерительного канала управления установки.

Ключевые слова: установка снегоплавильная, утилизация снега, очистка снежных масс, электрическая принципиальная схема, триггер.

Currently, environmental pollution has acquired the status of being extremely urgent. Pollution has many causes, and one of them is the untimely sweeping and disposal of snow.

Snow pollution occurs in two stages. When snowflakes form, they absorb pollutants from the atmosphere, so the snow that has fallen is already polluted. Then there is even more pollution of the snow that has already fallen, pollutants settle on it from the atmosphere, and also come from the underlying soils and

rocks [1]. It can be concluded that snow pollution occurs for the same reasons as atmospheric air pollution.

Thus, a huge amount of dangerous chemicals and compounds gets into snow. When snow melts, these chemicals enter the soil, the drains and reservoirs, and then into the organisms of plants and animals, including the human body. In the snow taken for analysis in the city of Kazan, excess of the maximum permissible concentration for suspended solids, nitrites, phosphates, phenols, fluorides, petroleum products, iron, copper, zinc, aluminum, manganese, mercury, nickel, cobalt was revealed [2].

At the moment in Russia ways of snow disposal do not have any methods of cleaning from external pollutants that accumulate in snow masses.

Therefore, a device that will not only remove snow from the streets, but also clean it is needed. A mobile snow melting plant described in patent No. RU 2695676 [3] is suitable for this. The proposed device performs melting and carrying out mechanical and chemical cleaning of snow masses. The plant will help improve the environmental situation. Figure 1 shows a diagram of the mobile snow melting plant.

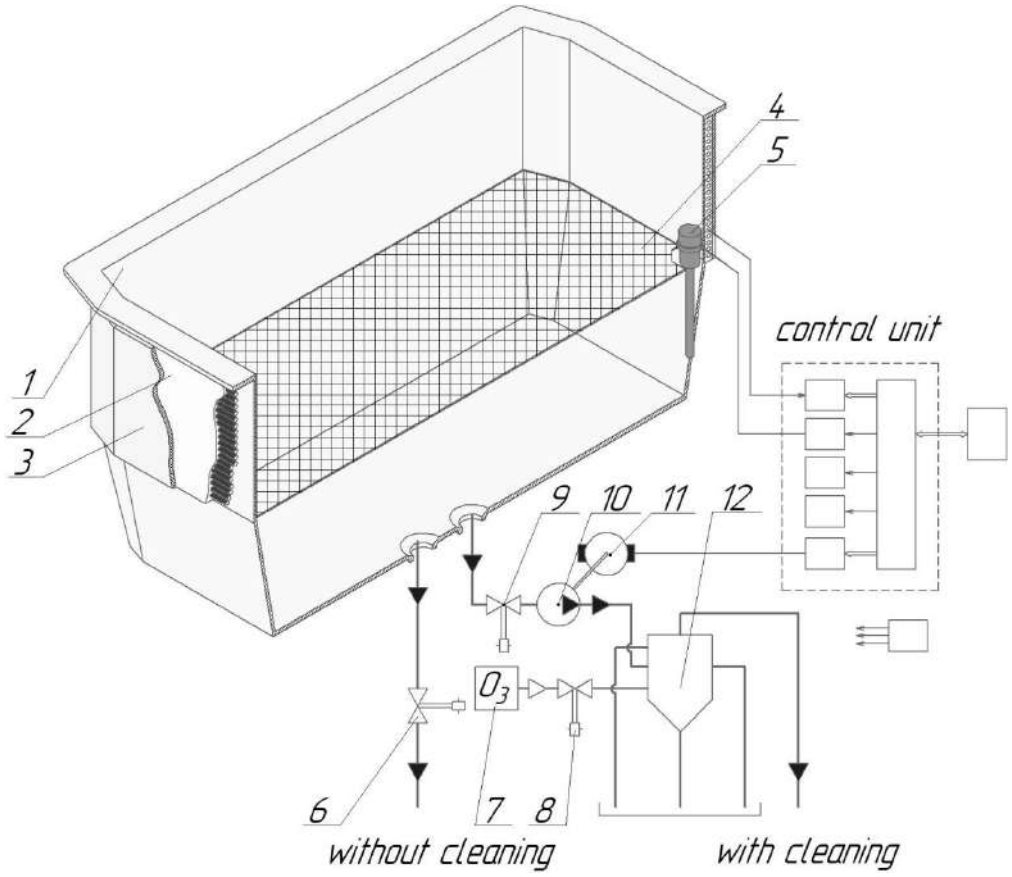

Figure 1. Diagram of a mobile snow melting plant

The principle of operation of the mobile snow melting plant is that the snow is placed into the snow melting box 1 with thermal panel 2, from the heating of which the snow melts. The liquid passes through the grate 4, thus the liquid is cleared of coarse debris. When the maximum liquid level is reached,

the liquid level sensor 5 is triggered and the control panel receives information about the need to open the liquid drain valve. Then the user chooses the program “with cleaning” or “without cleaning” by himself / herself. If there is no need to clean the melted snow, the water leaves the plant through the drain without cleaning (solenoid valve 6). If snow cleaning is necessary, the electric drive 11 of the hydraulic pump 10 is activated, which feeds the contaminated liquid through the solenoid valve 9 into the two-stage hydrocyclone-oxidizer 12. Oxidizer from the oxidizer cylinder 7 enters the hydrocyclone-oxidizer through the solenoid valve 8. After passing through the hydrocyclone-oxidizer, the purified liquid exits the plant through the drain with cleaning, and the pollutant concentrate and its neutralization products go to the sludge box [4].

Figure 1 shows the electrical circuit diagram of the information and measurement control channel of the mobile snow melting plant.

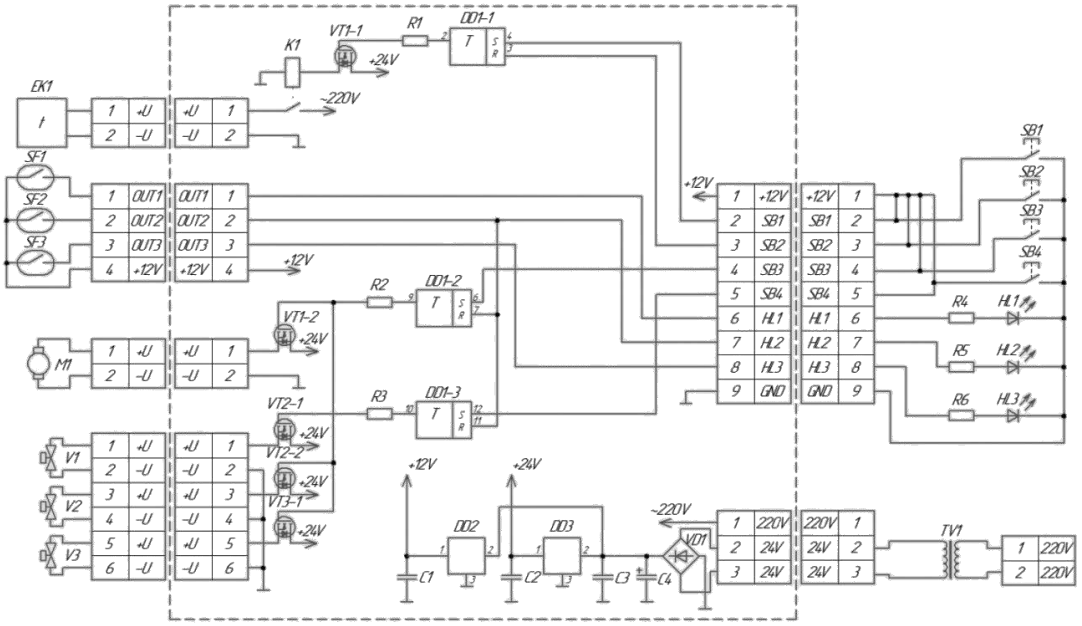

Figure 2. Electrical circuit diagram of the information and measurement control channel of the mobile snow melting plant

The correctness of the operation of the developed scheme is checked with the help of the Multisim program. To do this, consider the signals at the inputs and outputs of triggers using the Logic Analyzer tool.

The first trigger is required to turn on / off the thermal panel. Figure 3 shows a simulation of the operation of the first trigger. The top two lines (2 and 3) correspond S and R inputs, and the bottom one (3) to the trigger output. A signal from the button SB1 (S1) is sent to the input S, a signal from the button SB2 (S2) is sent to the input R. Thus, when the button SB1 is pressed, the trigger output switches from the logical zero level to the logical one level, the thermal panel turns on. When the button SB2 is pressed, the trigger output switches from the logical one level to the logical zero level, the thermal panel turns off.

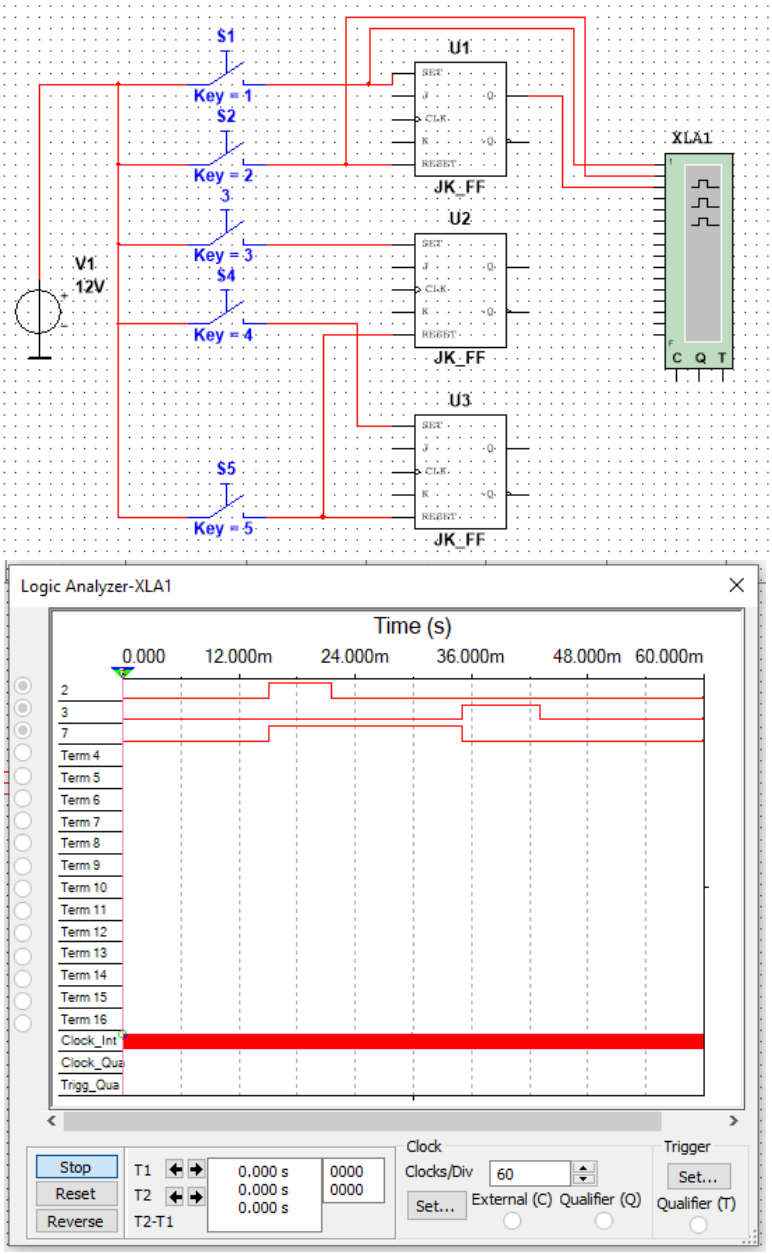

Figure 3. Simulation of the operation of the first trigger

The second trigger is required to turn on/off the program “with cleaning”. Figure 4 shows a simulation of the operation of the second trigger. The top two lines (4 and 5) correspond S and R inputs, and the bottom one (7) to the trigger output. A signal from the button SB3 (S3) is sent to the input S, a signal from the sensor SF2 (S5) is sent to the input R. When the button SB3 is pressed, the trigger output switches from the logical zero level to the logical one level, the electric drive turns on, the valves V2 and V3 open. When the sensor SF2 is triggered, the trigger output switches from the logical one level to the logical zero level, the electric drive is turns off, the valves V2 and V3 close.

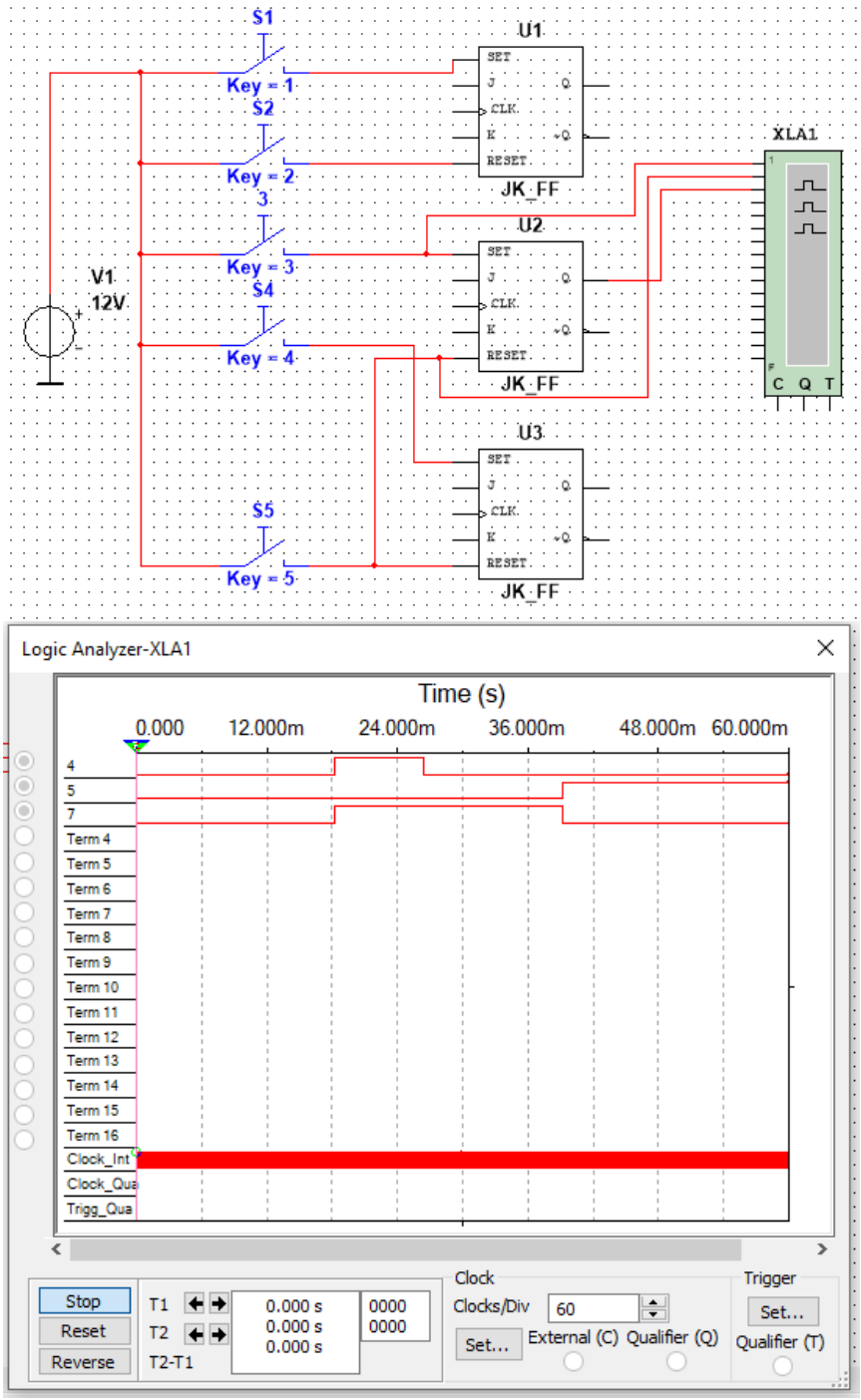

Figure 4. Simulation of the operation of the second trigger

The third trigger is required to turn on / off the program “without cleaning”. Figure 5 shows a simulation of the operation of the third trigger. The top two lines (6 and 5) correspond S and R inputs, and the bottom one (7) to the trigger output. A signal from the button SB4 (S4) is sent to the input S, a signal from the sensor SF2 (S5) is sent to the input R. When the button SB4 is pressed, the trigger output switches from the logical zero level to the logical one level, the valve V1 opens. When the sensor SF2 is triggered, the trigger output switches from the logical one level to the logical zero level, the valve V1 closes.

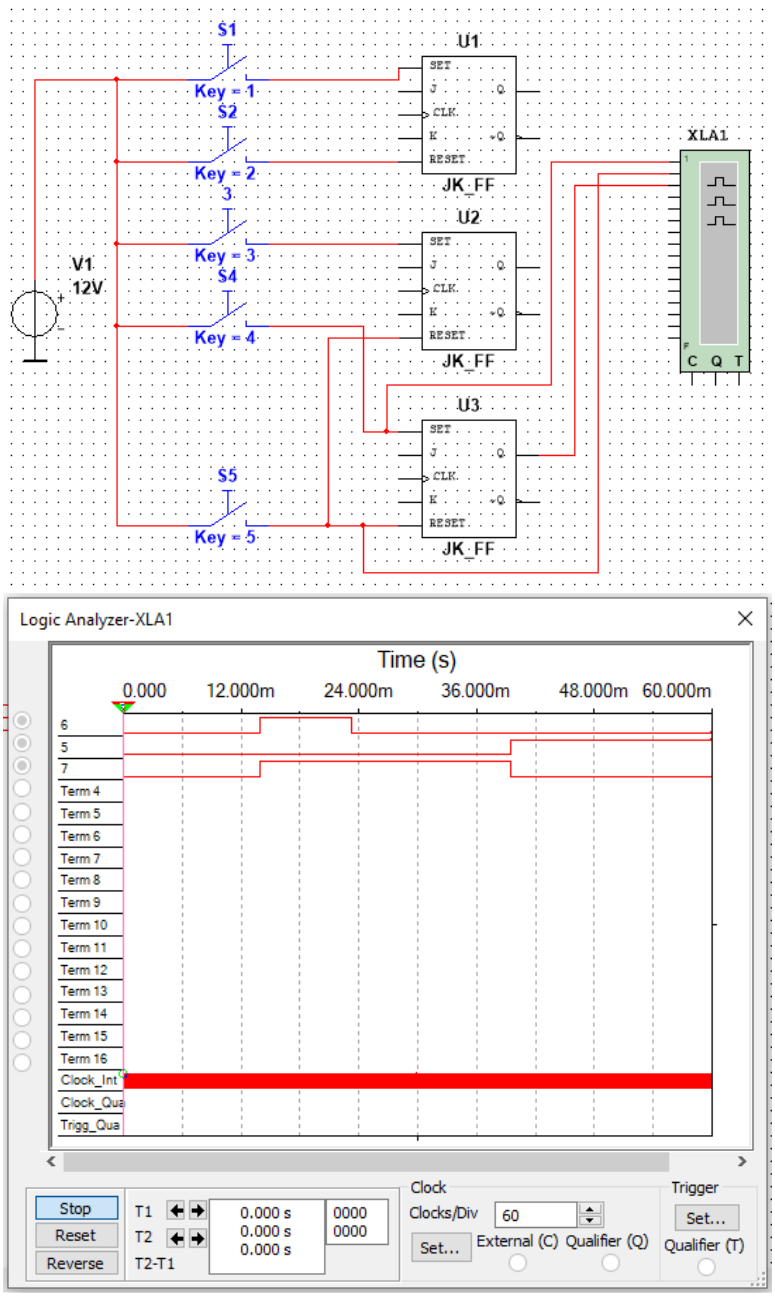

Figure 5. Simulation of the operation of the third trigger

The simulation results allow us to conclude that the developed scheme of the information and measurement control channel provides all operating modes of the mobile snow melting plant.

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PROSPECTS FOR THE DEVELOPMENT OF BOILER EQUIPMENT

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Abstract. Boiler equipment is discussed in the article. The development and modernization of the boiler plant are analyzed. The transition to a single (combined) air-fuel system is considered.

Keywords: boiler equipment, boiler, boiler unit, energy, fuel system.

ПЕРСПЕКТИВЫ РАЗВИТИЯ КОТЕЛЬНОГО ОБОРУДОВАНИЯ

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Аннотация. В данной статье рассматривается котельное оборудование. Проанализировано развитие и модернизация котельной установки. Рассмотрен переход на единую (объединенную) воздушно-топливную систему.

Ключевые слова: котельное оборудование, котел, котлоагрегат, энергетика, топливная система.

At the present stage, the development of human civilization is impossible without the widespread use of energy. The main forms of energy currently used are heat and electricity. The energy industry, which analyzes all the relationships between energy sources (energy resources), thermal energy and devices for generating work (electricity), belongs to the field of thermal power engineering, the technical basis of which is the thermal power plants of thermal power plants (TPP), which consist of boilers and steam turbines [1].

The history of modern thermal power engineering began quite recently with the invention of the first steam boiler, which was built by Englishman Thomas Savery in 1698. This boiler was the basis of the Savery's engine, which was used as a pump for pumping water from the mines, but was not very efficient, because it was of low power, lost steam heat during the cooling of the

container, and worked intermittently – water was pumped out of the mines in separate portions. Savery's engine also required a lot of fuel, up to 80 kg of coal was required for 1 horsepower per hour, and the depth of water supply by this machine did not exceed 30 meters. In addition, the pump was quite dangerous to operate, because due to the high steam pressure, the tanks and engine pipelines sometimes exploded. However, this invention has inspired other enthusiasts and inventors to work towards the creation of similar devices. The idea of using steam remained unchanged, but the design of Savery's engine was changed [2]. From that moment on, all the efforts of engineers were directed to improving the efficiency (efficiency) of the boiler design. So, after a while, instead of the tank, they began to use a long cylinder, which was surrounded by masonry, in order to reduce heat loss when it was heated and thereby reduce fuel consumption. But the surface washed by hot gases in such boilers was very small, so they produced very little steam, in addition, hot gases mostly went into the pipe, reducing the already low efficiency of the boiler.

At the beginning of the XVIII century the design of the steam boiler was significantly changed. Hot gases began to be let through pipes surrounded by water on all sides, thereby significantly increasing the surface area washed by hot gases, and at the same time the boiler performance increased. The next improvement occurred at the end of the XIX century – direct-flow boilers were invented. The water in them turned into steam as it moved through the pipes: water is supplied to the pipes from one side, and steam comes out from the other [3].

Over the next 100 years, other requirements for boilers appeared, in addition to efficiency.

The main requirements for boilers in the XXI century are maximum efficiency, high environmental safety and multi-fuel capacity, that is, the ability to operate reliably and economically on all types of hydrocarbon fuels (coal, fuel oil, diesel fuel, biofuel, shale fuel oil and natural gas) and fuels based on them (fuel mixtures, suspensions, emulsions and oil waste), without polluting the environment [4].

In general, a boiler plant is a combination of a boiler (boilers) and equipment, including the following devices: fuel supply and combustion; purification, chemical preparation and deaeration of water; heat exchangers for various purposes; source (raw) water pumps, network or circulation pumps – for water circulation in the heat supply system, make-up pumps – for water compensation, consumed by the consumer and leaks in the networks, feeders for supplying water to steam boilers, recirculating (mixing); feed tanks, condensing, hot water storage tanks; blast fans and air duct; smoke pumps, gas duct and chimney; ventilation devices; automatic control and safety systems for fuel combustion; heat shield or control panel [5].

Boiler plants, depending on the nature of consumers, are divided into energy, production and heating and heating. According to the type of heat carrier obtained, they are divided into steam (for generating steam) and hot water (for generating hot water).

It is customary to conditionally show individual elements of the boiler plant circuit diagram in the form of rectangles, circles, etc. and connect them with each other with lines (solid, dotted), denoting the pipeline, steam pipelines, etc. (Figure1).

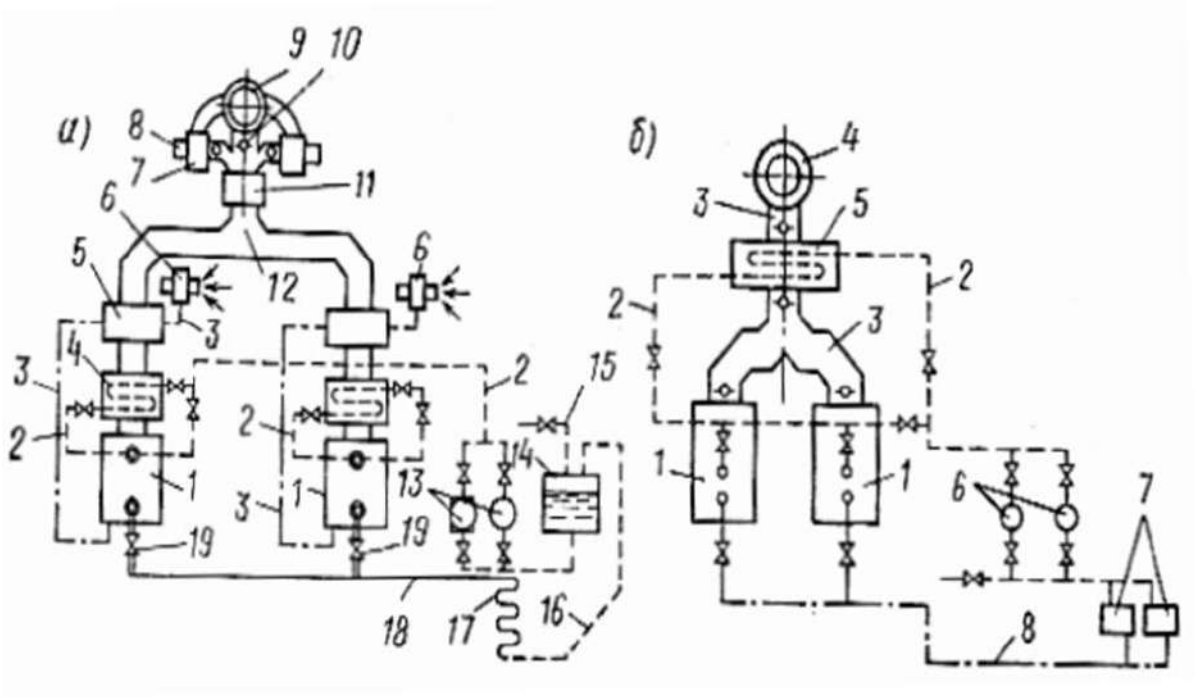

Figure 1. Diagrams of steam and hot water boiler plants

There are significant differences in the schematic diagrams of steam and hot water boiler plants. A steam boiler plant (Fig. 1, a) of two steam boilers 1, equipped with individual water 4 and air 5 economizers, includes a group ash catcher 11, to which the flue gases are supplied along the collecting 12 flue. To suck the flue gases in the area between the ash catcher 11 and smoke exhausters 7 with electric motors 8 are installed in the chimney 9. Gates (flaps) 10 are installed for the operation of the boiler room without smoke exhausters.

Steam from the boilers through separate steam lines 19 enters the common steam line 18 and through it to the consumer 17. Having given off heat, the steam condenses and returns through the condensate line 16 to the boiler room in the collection condensate tank 14. Additional water is supplied to the condensate tank through the pipeline 15 from the water supply or chemical water treatment (to compensate for the volume not returned from consumers).

In the event that part of the condensate is lost at the consumer, a mixture of condensate and additional water is supplied from the condensate tank by

pumps 13 through the supply pipeline 2, first to the economizer 4, and then to the boiler 1. The air necessary for combustion is sucked in by centrifugal draft fans 6 partially from the room boiler room, partly from the outside and through air ducts 3 is supplied first to the air heaters 5, and then to the furnaces of the boilers.

The hot water boiler plant (Fig. 1, b) consists of two hot water boilers 1, one group water economizer 5 serving both boilers. Flue gases leaving the economizer through a common collection hog 3 enter directly into the chimney 4. The water heated in the boilers enters the common pipeline 8, from where it is supplied to the consumer 7. Having given off heat, the cooled water is first sent through the return pipeline 2 to the economizer 5 and then back to the boilers. Water in a closed circuit (boiler, consumer, economizer, boiler) is moved by circulation pumps 6.

One of the main parts of a boiler plant designed to burn fuel in order to convert its chemical energy into heat is called a furnace or furnace device. The furnace should provide complete and stable combustion of fuel with low heat losses [5].

There are several ways of burning fuel in the furnace, they are divided into layered and chamber. Layer furnaces are designed for burning solid lump fuel, chamber furnaces are designed for burning pulverized, solid, liquid and gaseous fuels. In layered furnaces, solid fuel is burned on a grate. Each type of fuel, as is known, has its own calorific value, therefore, the heat stress of the boiler's furnace volume, and consequently, the heat transfer during its heating with combustible mixtures with different caloric content, is not the same [6].

Multi-fuel boilers have been developed to work simultaneously with different types of fuel. But versatility has also become the main disadvantage of multi-fuel boilers – they have several separate fuel systems for the preparation and supply of each type of fuel, which need maintenance and keep running in working condition regardless of their practical use.

Equipping boilers with several separate fuel supply systems with their own mechanisms and devices significantly complicates not only the design of the entire boiler plant, but also complicates the operation and maintenance of the boiler complex as a whole.

When preparing the used fuel mixture, two boiler systems are involved: fuel supply and air supply. To date, they are able to prepare only a fuel-air combustible mixture. The main disadvantages of the fuel-air combustible mixture are the primary fuel and secondary air in its preparation, as well as the inability to obtain the optimal ratio of fuel and oxidizer in it. This means that the basis of the fuel-air combustible mixture is fuel, the pressure (flow) of which is changed (increased or decreased) by the boiler operating modes, and the air at the same time performs a secondary role. The operation of the boiler on the fuel-

air combustible mixture always leads to fuel overspending, which means a decrease in the environmental cleanliness (safety) of the installation as a whole.

There is a replacement of the fuel and air supply (two) boiler systems with a single (combined) air-fuel system. The combined fuel and air system of the boiler includes a fan (for gas heating) or a compressor (for heating with liquid fuel and coal dust), an air supply pipeline, a self-priming air-fuel spray pump, a fuel consumption tank, a suction pipeline with a receiving filter. The functions of the fuel pump in the combined air-fuel system are performed by a self-priming air-fuel spray pump, which operates on a differential pressure of air supplied from a fan or compressor and prepares an air-fuel mixture. To increase the environmental safety / cleanliness of the boiler plant, the preparation of the combustible mixture takes place before the boiler is fired. Replacing two boiler systems (fuel and air supply) with one (combined air-fuel) system simplifies the design of the boiler complex, which means the process of its operation and maintenance as a whole [4].

Boiler equipment, since the creation of the first boiler, is constantly updated. New highly efficient technologies are being developed and implemented, changes are being made to the design of the boiler complex and fuel combustion processes. In general, the process of obtaining thermal energy is becoming more economical, safe and environmentally friendly every year. Thermal power engineering is actively developing, constantly optimizing the process of obtaining energy.

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BROWSERS, THEIR FEATURES AND DIFFERENCES IN THE INTERFACE AND VISUALIZATION OF WEB-DOCUMENTS

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Abstract. The article gives an idea of what browsers are, examines the history of their emergence, and also defines their features and differences in the interface and visualization of web documents. In addition to general information about browsers, this publication discusses in more detail some of the most popular Internet browsers, such as: Internet Explorer, Opera, Google Chrome, Safari, Mozilla Firefox, Microsoft Edge. Also, a browser such as Chromium is considered separately, which is open source, thanks to which the user is given the opportunity to design a convenient Internet browser for him.

Keywords: browser, interface, html, css, cross-browser compatibility, user, chromium.

БРАУЗЕРЫ, ИХ ОСОБЕННОСТИ И ОТЛИЧИЯ В ИНТЕРФЕЙСЕ И ВИЗУАЛИЗАЦИИ WEB-ДОКУМЕНТОВ

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Аннотация. Статья дает представление о том, что такое браузеры, освещает историю их возникновения, а также определяет их особенности и отличия в интерфейсе и визуализации web-документов. Помимо общей информации о браузерах, в данной публикации рассматриваются более детально некоторые наиболее популярные интернет-обозреватели, такие как: Internet Explorer, Opera, Google Chrome, Safari, Mozilla Firefox, Microsoft Edge. Также отдельно представлен такой браузер, как Chromium, который имеет открытый исходный код, благодаря чему пользователю дается возможность сконструировать удобный для него интернет-обозреватель.

Ключевые слова: браузер, интерфейс, html, css, кроссбраузерность, пользователь, chromium.

The term “browser” can be interpreted as a specially designed program used both for browsing websites and for other functions. In turn, such sites represent a certain set of code, where the browser converts this very code into the easily perceived and visual content that we usually see on the screen when visiting a wide variety of sites. Browsers are installed on devices such as: personal computer, laptop, tablet and smartphone.

The first browser to have a graphical interface that was not only text on a black background was NCSA Mosaic, created in 1993. One of his merits is that he acted as a base for the development of other web browsers, after his developers disclosed the source code to a wide range of interested persons. In 1994, when one of the most popular browsers of its time, Netscape Navigator, was created based on NCSA Mosaic, it was an amazing success, which brought significant profit for its developer. The internal name of Netscape Navigator was the now widely known name – Mozilla.

Based on the success of Netscape Navigator, Microsoft decided to develop its own browser, and in 1995, using the developments of NCSA Mosaic, Internet Explorer was created. It is this browser that subsequently becomes an integral part of all operating systems of this company. Since the Windows operating system was installed on the vast majority of computers, Internet Explorer has successfully gained a dominant position in this area, covering at least 95 % of the entire market. Subsequently, this served as the closure of the Netscape Navigator project, which was unable to compete with such a monopoly.

Before leaving the information market, Netscape makes several more transactions, including the purchase of AOL Time Warner, which releases the Navigator source code to the public. And subsequently, AOL transfers all its rights and developments to a new company – the Mozilla Foundation, which continued the development of their ideas.

The next stage in the development of this area is the creation in 1996 of Opera, which, with such positive aspects as light weight and fast page loading, becomes at that time a popular alternative to Internet Explorer for Russia, the CIS countries, and the whole world as a whole.

Due to its dominant position in the market, Microsoft did not take action to update Internet Explorer systems until October 2006, which resulted in a decrease in its role – this browser begins to lose its market position. However, by this period, Internet Explorer had already acquired a reputation for being poorly protected, having “holes” in security and “hanging” when processing a large amount of browser information, which also did not contribute to its popularity among users. And even now, despite the emergence of new and improved versions, Internet Explorer is not widely used. The latest version is Internet Explorer 11, and despite the dislike of users for this browser, Microsoft

decided to stop its further development, and already in Windows 10 a new product called Microsoft Edge is used.

November 2004 is indicative of the release of the Mozilla Firefox web browser, which was based on the Mozilla Suite project, which was positively received by the audience. In turn, in 2006, Apple creates its own product - Safari, and in 2008, Google enters the market, releasing the well-known Google Chrome.

At the moment, the world knows a whole lot of web browsers with their own unique properties and diverse functions. Studying the graph of the popularity of browsers around the world allows us to draw the following conclusion: Google Chrome occupies the leading position, followed by Mobile Safari, Android Browser, Firefox, Opera, Chrome mobile.

Let's characterize some of the presented browsers.

Google Chrome. It is one of the fastest, clearest and most popular programs of its kind. Chrome is one of the leading browsers in its market, with updates released almost weekly and containing a large number of progressive innovations. It is the basic ideas of Chrome that are currently the basis for the functioning of many other web browsers, including such as: Yandex Browser, Opera, Orbitum, etc. The market of this browser has a wide range of applications, extensions, themes and games.

Safari. A browser specially developed by Apple for the Mac OS operating system. At one time, a version of Safari designed for Windows was released, but since about 2012, new versions for this site have not been released. Among the main advantages of this browser it is worth noting: innovative technologies and fast speed. A distinctive feature is also the “glossy interface”. The main disadvantage of Safari is that it only supports Apple operating systems.

Mozilla Firefox. A fairly popular browser, along with Google Chrome and others. It's just as fast and aesthetically pleasing. It has a unique interface and the ability to increase its functionality by installing a variety of extensions. As V. Bryukolov notes in his article: “Users noticed this browser due to the presence of a large number of plug-ins and settings, the ability to open web pages in one window, as well as a higher level of security compared to Internet Explorer” [1, p. 9]. The program is universal: it is supported by all operating systems. Updates happen periodically. The creation of a large load on the PC or laptop system is a certain disadvantage of this browser.

Opera. This is one of the most popular browsers among users of the countries of the former Soviet Union. Opera is known for its attractive interface, fairly high speed, as well as the ability to install various extensions and widgets. The program has periodic updates and a significant number of its unique features. The negative feature of Opera is its inconvenience for the average user,

as it is often used by experienced users who have a certain amount of knowledge in the field of information technology.

Separately, it is worth highlighting a browser such as Chromium, since it is its source code that is used by many companies when creating other Internet browsers. The main distinguishing feature of such “descendants” in comparison with their prototype is a set of additional functions that the creators endow them with.

Chromium is a free and open source browser developed by Google in 2008. But at the same time, this browser is not endowed with Google services and support for media content: so, if you need to get special plug-ins, you need to install them yourself. In its essence, Chromium acts as a kind of constructor, with the help of which any user has the opportunity to design the most convenient browser for him. By bringing the software to market, Google gave the right to every person to use the source code of their browser when creating various projects. Note that the specified web browser is not suitable for use by beginners, since it has its own set-up difficulties.

Exploring the features and differences in the interface, we will also take into account the main functions of browsers. Its main task is to display web resources. To execute it, a request is sent to the server, the result of which is displayed in the browser window. Resources are usually HTML documents, or PDF files, JPG images, and more. Using the URI (Uniform Resource Identifier) it is possible to determine the location of such a resource [2].

Specifications such as HTML and CSS allow you to set the features of processing and displaying HTML files by the browser. The W3C Consortium, which implements standards for the Internet, participates in their development.

For a significant period of time, browsers met only part of the specifications, and it was necessary to create separate extensions for them, which caused significant compatibility difficulties for web developers [3]. At this point, most browsers meet all of the specifications to one degree or another.

In the modern period of time, it should be noted that the user interfaces of most browsers have common features [4]. Among the main components of the browser interface are: the address bar for entering the URI, the navigation buttons “Back” and “Forward”, bookmarks, the buttons for updating and stopping page loading, the “Home” button for returning to the main page.

Note also that it is impossible to talk about the existence of such a specification that would define the standards of the user interface of the browser [5]. The current interfaces are the result of long-term development and improvement, as well as partial copying of developers from each other. The HTML5 specifications do not specifically state the contents of the browser interface, but do provide some enumerations of its main elements [6]. Among them are the address bar, status bar and toolbar. The presence of specific

functions, such as, for example, the download manager in Firefox, is not excluded.

Speaking about the differences in the rendering of web documents by browsers, it is worth mentioning such a term as cross-browser compatibility. This category can be defined as the same display and operation of the site in different browsers. This should be taken into account at the layout stage, since certain browsers display HTML documents differently and not always correctly.

This problem boils down to the fact that different “engines” can be used by browsers, which lead to different perception and processing of some html tags and css styles, as well as the content of such tags. The browser engine performs the functions of loading, processing, displaying and calculating data. And even pr and the presence today of a significant number of different browsers, when they are decomposed by types of engines, we can say that the number of such “engines” is relatively small, since the development of your own engine is a rather laborious task.

We also note that browsers have come a long way in their development since the release of Chrome, which occupied a significant part of the information market. More modern browsers have been able to bridge the gap in portability and functionality, and even in areas like speed and privacy, by nearly surpassing Chrome. V. Buluchev and A. Baranov note that: “Important aspects of browsers: security, functionality, and how fast pages load.” [7, p. 361].

After conducting research and comparative analysis, we can come to the following conclusion: it is impossible to single out the best browser. Each of the ones we have considered has its own set of advantages, disadvantages, and even unique features, and, therefore, taking into account specific characteristics, each user will be able to find the most suitable browser for him.

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MODERN PROBLEMS OF WELDING PRODUCTION

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Abstract. The paper examines the history of welding, its development and significance in the modern technological process. As a result of the analysis, problems and ways to solve them were also considered.

Keywords: welding, welding production, technological process.

СОВРЕМЕННЫЕ ПРОБЛЕМЫ СВАРОЧНОГО ПРОИЗВОДСТВА

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Аннотация. В работе представлена история возникновения сварки, её развитие и значимость в современном технологическом процессе. В результате анализа были также рассмотрены проблемы данной отрасли и пути их решения.

Ключевые слова: сварка, сварочное производство, технологический процесс.

Any social process or emerging technology is not a sudden idea. Every event is natural. Everything happens the moment when the conditions are right for it to happen. It is not for nothing that many historical periods are named after discoveries, tools and the level of human development of that time. All processes are connected deeply with the past and the future. Our present depends on what happened yesterday and what we should expect tomorrow. And the welding process is no exception.

Welding is a technological process of creating an integral connection through the establishment of interatomic, intermolecular bonds between the parts of the product to be joined during their heating and plastic deformation. Welding finds its application in connecting metals, their alloys, composite materials, thermoplastics in all areas of production, as well as in medicine.

The history of welding production begins in the 19th century. This technological process owes its origin and development to the work of Russian

scientists, Vasily Vladimirovich Petrov (who discovered a continuous electric arc in 1802), Nikolai Nikolaevich Benardos (proposed and produced in 1880-1890 all the main types arc welding), and Nikolai Gavrilovich Slavyanov (carried out welding under slag protection) [1].

For the period of several centuries of existence, the technology has undergone significant changes that have made it quite popular and advanced. Currently, there is no single production, industrial enterprise that can do some of their activities without the use of welding. Modern welding and cutting methods are based on the use of energy of almost all known types: mechanical, chemical, electrical, electro-mechanical, radiation, etc. This, however, does not mean that the entire range of energy sources for welding purposes has already been used. For example, among ray sources of energy, such as neutron beams, ion beams, etc. are still waiting for their time to be used.

However, this technological production, like other large processes, has its own problems.

1. Automation and robotization problems of welding processes. The main, final task of welding production is the creation of rational welded structures of a given pre-set reliability. This task is extremely broad and multifaceted. New materials with desired properties are being developed - composite, powder, ceramic, etc. At present, a significant part of welded structures is manufactured by manual arc welding with coated electrodes. However, the main disadvantage of arc welding with stick electrodes is the use of manual labor, which requires a highly skilled welder. It should be noted that in order to obtain a high effect from mechanization, it is necessary to mechanize not only the process of making a welded joint itself, but also all related operations: transportation of products, their installation and removal from assembly and welding fixtures, tilting, etc. Therefore, the so-called complex mechanization of welding production is necessary. Of course, the complex mechanization requires significantly higher financial expenditures, but they usually do pay off very quickly. In this case, the welder only has to start the machines and control the progress of welding. It is advisable to employ such automatic welding installations in mass production, for example, vehicles (bicycles, motorcycles, cars, etc.). There are many serious and profound scientific and technical problems to be solved in order to be able to build a space welding robot. Such a robot must have a sufficiently powerful power source, have a developed system for receiving external information that allows one to find the welding object, correctly orient the working body (for example, an electron beam installation) relative to the product, and control the welding process. The welders will also have a long way ahead before they can create an “underwater” welding robot. Here, it is necessary to solve new problems that related to the peculiarities of the environment.

More than 95 % of the ocean has depths inaccessible to welding divers. Even at depths of just over 100 m, almost insoluble difficulties arise in performing the simplest welding operations, for example, welding eyes to sunken ships for attaching hoisting cables. Therefore, in the future, assembly

and welding operations at such and greater depths will have to be performed by underwater autonomous robots [2].

2. Problems in the field of diagnostics and prediction of welded structures failure. The main trend of technological progress in industrialized countries is associated with an increase in the parameters' values of new machines, units and structures being created – power, load capacity, operating temperature, environmental activity, service life, etc. First of all, this concerns such newest areas of technology as nuclear energy, aircraft and shipbuilding, space technology, vehicles, etc. Deviations in the operating modes of units and structures or their destruction can lead to serious consequences.

Design engineers and developers are trying to take into account the possible causes of such deviations, but, given that many structures have been operating for decades (gas pipelines, large bridges, hydraulic structures, etc.), this cannot be fully done.

From the above mentioned, it becomes obvious that ensuring the reliability of products must be strictly controlled not only at the stage of their manufacture, but also during the entire service life. This can be achieved by creating special diagnostic systems capable of automatically detecting the critical state of the structure, which will allow undertake the necessary measures in a timely manner to prevent an accident.

To create such systems, it is necessary to study the patterns of development of internal defects in structural materials at the stage of a pre-destructive state, master the methodology for predicting probable failure situations, develop and create special equipment for these purposes. What principle is the diagnostics of the destruction of materials based on? Let's do a simple experiment to answer this question: take a tin rod and bend it. When bending, you can hear a specific crackling sound, i.e. the plastic deformation of tin, which always accompanies destruction, is clearly audible without any devices [3].

The same phenomenon can be found in other metals, but the level of sound vibrations in them is so low that special amplifying equipment is required to listen to them. This phenomenon is called acoustic emission (AE).

Thus, if special catching sensors (acoustic receivers) are attached to the working structure, then it is possible to fix the moment of occurrence and propagation of a crack in the most loaded structural element with the help of amplifying equipment. Of course, this is a greatly simplified model of acoustic emission. The first real AE systems that have been developed at the Institute of Electric Welding named after E.O. Paton showed that in order to implement the idea of diagnostics and prediction of the destruction of welded structures, it is necessary to solve a set of problems, the main of which are the following: study of the regularities of the occurrence and propagation of elastic vibrations in the metal of a structure during the accumulation of its damage, the formation of micro cracks and their propagation over the cross section of structural elements; creation of information-measuring systems for the collection and analysis of AE and other information necessary for making a decision on the state of the

structure; development of software for processing incoming information and predicting the behavior of the structure, etc.

3. Aspects of welding professionals. According to our observations, currently, there is a trend towards a decrease in the level of professional skills of welders. The potential of domestic welding production is quite large. The share of the national product made using welding and related technologies is 50-60 %. Currently, about 200 thousand people are employed in this area. Out of these, about 10-12 thousand are qualified welders [4].

What can lead to a decrease in the level of professionalism of welding specialists? As already mentioned, unique high-rise structures, residential, public and industrial buildings, transport, communications, household appliances, etc. are made on the basis (using) a variety of joints, including welded joints - about 50-70 %.

In terms of strength, they should not be inferior, at least to the base metal, otherwise destruction cannot be avoided. No one want low-quality welding to become the cause of production shutdowns and man-made disasters, which are already quite numerous in the world.

“Cultivating” a welding specialist is not easy. As you know, a certain experience is achieved in at least three years. And professionalism is the highest degree of knowledge and level of skills of a welder. In the meantime, educational institutions are producing rather weak workers. For example, some vocational schools assign to graduates with 5-6 professions. Of course, it is impossible to master them well in a short period of training. Welding does not enjoy high prestige in our country and there are not so many who want to learn it. And here, in our opinion, there is a wide field for the system of the Ministry of Education. After all, it is simply is a must thing for existing welders to prepare next generation. Situations are not uncommon when, after the departure of an experienced employee, enterprises cannot find those who want to fill a vacancy, which undoubtedly has a negative effect on the production process.

Nowadays situation shows convincingly highlights the acute shortage of welding specialists under the age of 30. But the share of workers of pre-retirement age is steadily growing. The reason for this, unfortunately, is simple: imbalance between the degree of complexity of work and the amount of corresponding wages [5].

Another disturbing moment: although working welding specialists sometimes have fairly high ranks, further improvement of their qualifications is not always received due and sufficient attention.

The material factor is certainly important, but it is also necessary to create such conditions for the welding specialist to fall in love with his profession and be proud of it. Unsatisfactory conditions and factors, as a rule, destabilize production and lead to low quality and defective products. These factors are usually known to specialists, but they are not analyzed, and the degree of their impact on quality formation is not determined. This leads to unpredictable breakouts and, most importantly, a lack of information on the basic level of quality, the applied technological process. Our main task in welding is to master

such progressive technologies and welding techniques, in which the formation of defects is reduced to a minimum.

Today's students that study welding and young specialists in welding will certainly be involved in the process of solving these and other problems, since the creators and operators of new critical welded structures, machines and units should be able to prevent accidents and disasters, like Chernobyl.

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ROLE OF MODELING AND SCADA SYSTEMS IN THE DEVELOPMENT OF AUTOMATED PROCESS CONTROL SYSTEMS

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Abstract. This article discusses the importance of the use of modeling as a method of scientific knowledge and SCADA systems in the development of automated process control systems in production.

Keywords: automated process control system, SCADA system, modeling, forecasting, efficiency, visualization, control.

РОЛЬ МОДЕЛИРОВАНИЯ И SCADA-СИСТЕМ ПРИ РАЗРАБОТКЕ АВТОМАТИЗИРОВАННЫХ СИСТЕМ УПРАВЛЕНИЯ ТЕХНОЛОГИЧЕСКИМ ПРОЦЕССОМ

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Аннотация. В данной статье рассматривается важность применения моделирования как метода научного познания и SCADA-систем при разработке автоматизированных систем управления технологическим процессом на производстве.

Ключевые слова: автоматизированная система управления технологическим процессом, SCADA-система, моделирование, прогнозирование, эффективность, визуализация, контроль.

Given the active pace of market development and the extensive number of homogeneous goods, each production manager wants his enterprise and, as a result, the product to remain competitive in the market.

The competitiveness of the enterprise is understood as the real and potential ability of the enterprise, taking into account the capabilities available to it to design, manufacture and sell goods that are more attractive to consumers in terms of their consumer and cost characteristics than the goods of competitors [1, p. 254].

To ensure that the company remains competitive in a market economy, managers are forced to look for ways to improve production efficiency with the minimum permissible decrease in product quality.

According to GOST 15467-79, product quality means a set of product properties that determine its suitability to meet certain needs in accordance with its purpose [2].

One of these methods is process automation in production, during which an automated process control system (APCS) is created.

The generalized APCS architecture is shown in Figure 1.

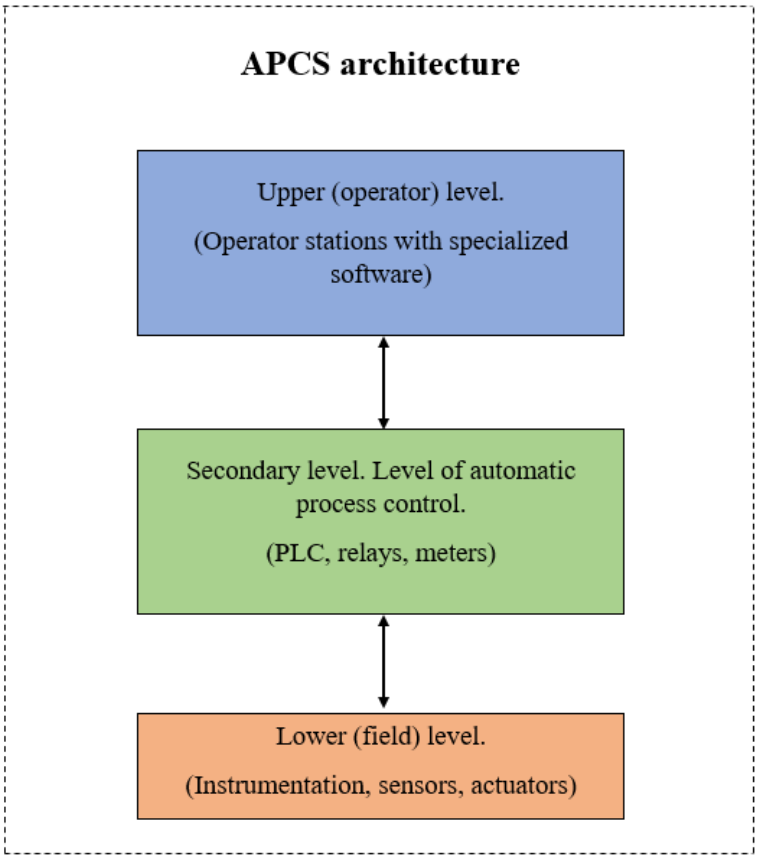

Figure 1. Generalized APCS architecture

The upper level devices are automated workstations (AWS) of operators (dispatchers). The dispatcher's AWS refers to a computer with certain technical characteristics suitable for performing the necessary operations and specialized software installed on it, which will allow you to easily and clearly view the current state of the technological process and its parameters in real time, as well as make decisions on system control and make changes to system parameters.

The secondary level architecture is an automatic process control layer. At this level, there are programmable logic controllers that can function without human input. The controller refers to a specialized technical device designed to receive information from the upper and lower levels, process it and generate a control signal according to a pre-laid program.

The lower level of architecture is called field. It houses sensors and actuators that are located directly at the control object and collect data on the progress and parameters of the technological process.

Process modeling and SCADA system application are integral to APCS development.

Modeling in this case refers to the construction of a model of a real object, process or phenomenon in virtual space in order to study and predict behavior under certain conditions [3, p. 4].

Due to the rapid pace of technology development, computer modeling is gaining popularity. Computer modeling combines mathematical (formulas), graphic (images), imitation modeling (experiments and experiments) and is carried out using specialized software and hardware components.

The modeling is intended for a deeper study of the technological process, identification of the most important parameters to be paid attention to when developing APCS, as well as for conducting experiments without stopping production.

The modeling steps are shown in Figure 2.

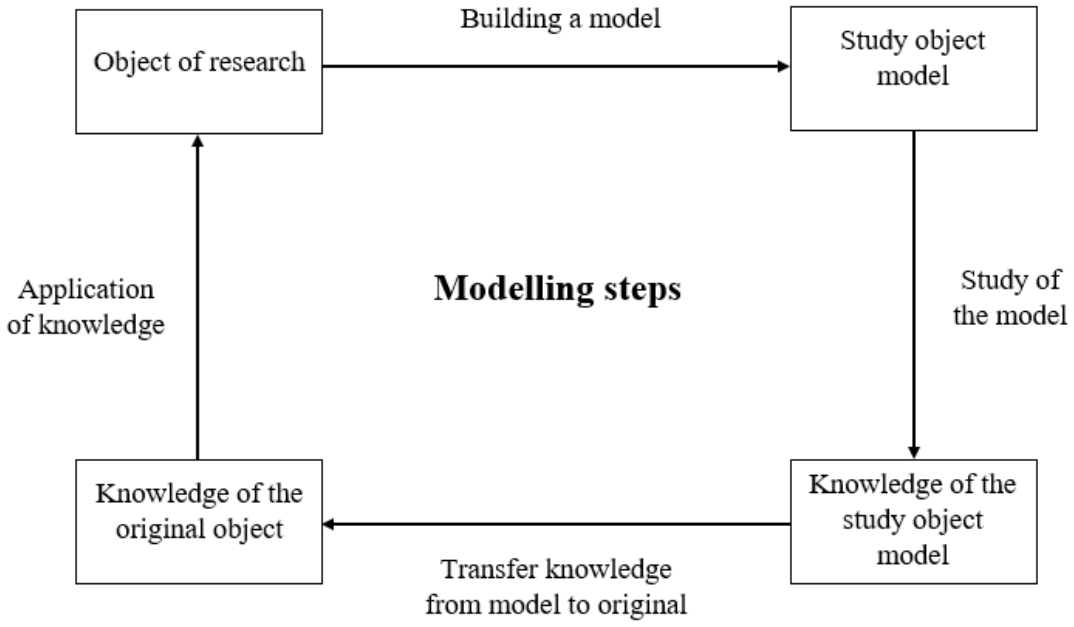

Figure 2. The modelling steps

The SCADA system is a component of the APCS and is designed to provide communication between all levels of production automation and process visualization at the operator's automated workplace. According to the generalized APCS architecture (Figure 1), the SCADA system is located at the upper (operator) level [4, p. 3].

The generalized structure of the SCADA system is shown in Figure 3.

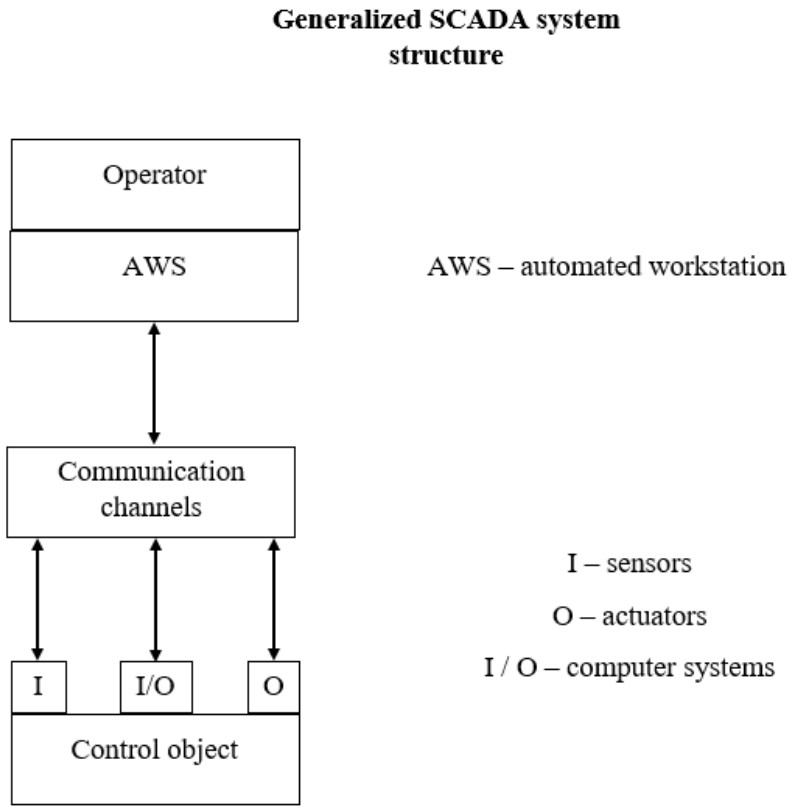

Figure 3. Generalized structure of the SCADA system

The automated workstation of the operator is a computer with an installed specialized software designed for communication between the control object and the operator.

Communication channels are required to transfer information from sensors (parameters of the control object) and actuators (IM position) to AWS and in the opposite direction. Mobile networks, radio waves, dedicated communication lines, etc. can be used as communication channels.

The sensors are designed to obtain the parameters of the technological process, with the subsequent transfer of information to the screens of operators, and the actuators are designed to interact with the control object by regulating the process parameters.

The range of tasks and functions covered by the SCADA system is huge, ranging from collecting information from sensors and generating a control signal for actuators located directly near the automation object, which reduces the risk of harm to the health of personnel, to planning production tasks, generating trends and reports.

One of the important functions of the SCADA system is archiving information about the process. That is, processing and storing information in archives for a certain period. This feature makes it possible to evaluate events that occurred during the process and, based on this information, to develop preventive measures in case of emergencies.

The combined use of SCADA systems and modeling in the development of automated process control systems allows you to increase production efficiency, reduce production costs, and provide more accurate control over each stage of production.

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RELIABILITY ANALYSIS OF POWER EQUIPMENT OF TRACTION ROLLING STOCK

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Abstract. One of the most loaded structures and at the same time the weakest elements of the power equipment of traction rolling stock is insulation. The analysis of the operation of electric locomotives' power equipment from the negative impact of climatic factors on it is carried out. It is revealed that in order to ensure reliable and safe operation, a system of maintenance and repair of rolling stock is necessary, taking into account the zonal conditions of operational features.

Keywords*:* electric rolling stock, insulation, climatic factors, reliability, electric machines.

АНАЛИЗ НАДЕЖНОСТИ ЭНЕРГЕТИЧЕСКОГО ОБОРУДОВАНИЯ ТЯГОВОГО ПОДВИЖНОГО СОСТАВА

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Аннотация. Одной из наиболее нагруженных конструкций и в то же время самым слабым элементом силового оборудования тягового подвижного состава является изоляция. Проведен анализ работы энергетического оборудования электровозов на предмет негативного воздействия на него климатических факторов. Выявлено, что для обеспечения надежной и безопасной эксплуатации необходима система технического обслуживания и ремонта подвижного состава с учетом зональных условий эксплуатационных особенностей.

Ключевые слова: электроподвижный состав, изоляция, климатические факторы, надежность, электрические машины.

The reliability of traction rolling stock is one of the main tasks of the railway industry. The economic well-being of the whole country depends on its smooth operation. The weakest link in rolling stock equipment is insulation structures. Insulation is significantly affected by heat and moisture.

During the operation of the power equipment of electric locomotives, from the negative impact of climatic factors on it, natural and artificial influences can be distinguished. Moreover, natural impacts depend primarily on external conditions, which are characterized by the current weather: temperature, humidity, atmospheric pressure, precipitation, wind. In turn, artificial impacts are formed during the direct operation of power equipment and other objects located nearby [1; 2]. From the point of view of the influence of climatic factors on the reliability of insulation structures of power equipment, natural climatic influences are of the most significant interest.

To maintain electric locomotives in working condition and ensure reliable and safe operation, a system of maintenance and repair of rolling stock is necessary, taking into account zonal operating conditions.

The issues of humidifying the insulation of electrical equipment of electric locomotives always require a lot of attention. Special attention to the issues of moisture resistance of electrical insulation is associated with the development of railway transport. The moisture resistance of the equipment is associated with an increase in electrical equipment failures due to insulation breakdown.

The impact of extreme negative temperatures on the insulation of power equipment leads to an increase in its resistance, a decrease in leakage currents and a decrease in reverse voltages. These residues contribute to slower consumption. Cyclic exposure to negative and positive temperatures leads to irreversible changes in insulation resistance and a decrease in its breakdown voltage.

Electrical equipment of electric locomotives by the nature of their work is in high humidity conditions for a significant part of the year. Moisture penetrates into the pores and capillaries of the insulation, impairing its dielectric properties. Even newly manufactured and impregnated insulation absorbs moisture no worse than old insulation [3].

A significant amount of precipitation, coupled with the shortcomings of ventilation systems for cooling traction engines of electric locomotives, leads to the fact that moisture settles directly on the insulation surface. Moreover, a sharp wetting of the insulation may occur with a higher degree of probability, which, in turn, leads to an electrical breakdown [3].

Humidification of the atmosphere is closely related to the peculiarities of the thermal regime, atmospheric circulation and the nature of the underlying surface. At an air temperature of 25-40 °C, with an increase in temperature by 2-3 °C, relative humidity decreases from 100 to 90 %, with an increase in temperature by 5 ° C – from 100 to 75-85 %, with an increase by 10 °C – to 55-60 %.

The penetration of moisture into the insulation can occur simultaneously at several levels: at the molecular, intermolecular and capillary levels. The latter of them is of the most significant interest, since in most insulation systems used in the construction of electrical equipment, especially after prolonged operation, pores, micro-cavities and through channels are formed. Their occurrence is

mainly due to the shortcomings of the existing insulation repair technology using convective electric furnaces. In this case, in the process of surface heating with hot air, a crust forms on the insulation surface, through which vapors of volatile organic substances subsequently break through. During operation, with the constant impact of vibration forces on the polymer insulation, micro cavities can turn into microcracks, forming connected channels.

The presence of micro cavities is caused by the appearance of cracks and insulation stratification, shrinkage of the material during aging. Voids and channels can also appear in the process of applying insulation to conductors, in particular, when using tape materials that form folds, layers and loosely connect. Significant voids are also observed between the grounding conductors of the windings of auxiliary electrical machines. Impregnating varnishes, which contain about 50 % of volatile substances, do not fill the resulting space. At high humidity, such channels can be excellent conductors of moisture, which can penetrate to a depth due to the capillary effect. Under the influence of these forces, the surface of the liquid is covered with a uniformly stressed thin film, which tends to give the liquid the shape of a volume with a minimum surface. The surface tension forces create a molecular pressure in the liquid characteristic of its surface, which leads to the penetration of moisture through the micro-cavities.

In many cases, premature failure of the insulation of electric transport equipment can be prevented by systematically monitoring the moisture content in the insulation and, if necessary, drying it [4]. Considering the above, it is clear that with the combined impact of all climatic factors, the main indicator of insulation reliability – dielectric properties – deteriorates to a certain extent. Climatic factors are determined by annual, seasonal, daily fluctuations in temperature and relative humidity, as well as the number of days and intensity of precipitation in the form of snow, rain, fog. Thus, it is necessary to improve diagnostic methods and tools, as well as maintenance and repair technologies, in order to reduce the degree of influence of climatic conditions on the reliability of equipment.

Long-term monitoring of the power equipment of electric locomotives has shown that the parameter of the flow of their failures during insulation breakdown is more significant in some areas of operation of electric locomotives, in others – less, especially in winter. It is necessary to create adaptive systems to maintain optimal values of temperature and humidity conditions for insulating structures of electric locomotives to increase the reliability of insulating structures of electric locomotives operated in various areas of operation on railways.

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GREENWASHING – NOT TRUTH BUT FAKE

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Abstract. The conservation and conscious living movement is attracting an increasing number of followers. Different generations are striving to make sustainability a way of life in both the industrial and domestic spheres. The market is currently witnessing a proliferation of different products with the prefix "eco". The article provides examples of the unfair application of the 'green label' to goods in order to increase profits. The phenomenon of such a speculative approach is called "greenwashing". Examples of the use of greenwashing and ways to eradicate it are discussed.

Keywords: environment, conscious living, greenwashing, eco-friendly, ecological goods, profit, natural product, deception, packaging materials.

ГРИНВОШИНГ – НЕ ПРАВДА, А ФЕЙК

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Аннотация. Движение за сохранение природы и осознанный образ жизни привлекает все большее количество последователей. Представители различных поколений стремятся сделать устойчивое развитие нормой жизни и в индустриальной сфере, и в бытовой. В настоящее время на рынке наблюдается рост различных товаров с приставкой «эко». В статье приводятся примеры недобросовестного применения к товарам «зелёной марки» с целью увеличения прибыли. Явление такого спекулятивного подхода получило название «гринвошинг». Рассматриваются примеры использования гринвошинга и пути его искоренения.

Ключевые слова: окружающая среда, осознанная жизнь, гринвошинг, экологичность, экологические товары, прибыль,

натуральный продукт, обман, упаковочные материалы.

Environmental conservation and conscious living movements are currently growing in popularity. Due to the current ecological situation, humanity starts thinking about living on the “green side” [1, p. 98] and looking for sustainable ways of production, consumption and existence [2, p. 2]. The demand for environmentally friendly products is growing and consumers want to buy “clean” products. Issues relating to the technology of the production process such as: who manufactures the goods, the conditions under which they are manufactured; whether they are tested on animals; and the environmentally friendly disposal and recycling of goods have been given tremendous attention [1, p. 98].

In an attempt to respond to public demand, manufacturers use the prefix “eco” to traditional products and eco-clothing, eco-products and eco-food emerge. As a consequence, in the 1980-90s green marketing arose – a way to win consumer loyalty, increase brand awareness and sales through the creation eco-friendly goods or use eco-friendly technologies, and investing in nature protection programs. [2, p. 3].

Such advertising has a psychological factor – by buying eco-products consumers perceive their actions as a contribution to solving environmental problems [2, p. 5].

Sounds positive enough. But what was in real life?

Dishonest activities of unscrupulous marketers, greenwashing appears – a k a dirty, “green” marketing a demonstration of the environmental friendliness of a product or the actual activities of a company, rather than the actual state of affairs [2, p. 7].

Greenwashing has nothing to do with a conscious approach to the manufacturing of goods and products. By hiding behind flashy “green” pictures and labels, businesses do nothing to minimise harm from their production. In this way, profits are increased without much effort, by brazenly deceiving ordinary consumers.

So how can we recognise greenwashing? Greenwashing has distinctive, specific signs:

1) Non-existent labels – no confirmed eco-labels, or visually labeling of products similar to original eco-labels.

2) Ambiguity in position an eco-product based on one statement that conceal important disadvantages.

3) Absence of evidence – lack of information about the ecological safety of the good, amid unsubstantiated promises of environmental friendliness by the producer.

4) Ambiguity in statements – the use of “empty” phrases, e.g. “100 % natural” – that is words without proof, but convinces of the usefulness of the

product.

5) Futility of specifications – demonstration of the obvious fact as a dignity e.g. sunflower oil with vitamin E (this vitamin is already present in the oil).

6) "The lesser of two evils" – in the production of harmful products with an indication of their benefits, such as alcohol labeled "organic".

7) A blatant lie - an outright saying by the fabricator about something that does not exist, such as the presence of a certificate that does not exist [2, p. 7-8; 3].

Greenwashing is not always a deliberate way of making super-profits through deception. Some manufacturers, while striving to use environmental techniques and promoting them in some aspects, are completely oblivious to the need for an informed approach in other areas of their business as well.

Famous representatives of the fashion industry (Chanel, Gucci, Versace and others) gave up using natural fur switching to substitutes, and consumers are actively supporting them. However, this is one aspect of the celebrity fashion houses. By refusing to use natural fur, couturiers have not abandoned the use of natural leather, thus damaging the fauna. Artificial fur coats, on the other hand, are not environmentally friendly as it is more difficult to recycle them and the complete decomposition period of such a piece of clothing is more than 300 years, like plastic [1, p. 99].

The fight against plastic is another global trend, but it is also implying greenwashing. One of the leaders in fraud is bottled water. We are shown on labels and advertisements beautiful landscapes of genuine nature, crystal-clear rivers and lakes, from which the manufacturer pours water into bottles. The water may indeed be clean, but the bottles in the water is in are made of hard disposal plastic [1, p. 100].

Sometimes manufacturers are caught completely cheating: the brand of children's cosmetics "Princessa" indicates the phrase "eco kids" on the packaging of its products, although the composition includes various parabens and petroleum products as one of its components. The Russian cosmetics brand "Chistaya Liniya" decides to release a "bio" line of products, but the composition of which does not contain natural ingredients. The Belarusian company "Vitex" indicated on the packaging of its products from the line of cosmetics "Organic Therapy care" the international sign "Ecocert", which shows the natural origin of the products. After the scandal "Vitex" continues producing its products, but without this international certificate [2, p. 8].

Of course, there are positive examples of companies, such as IKEA, which uses a lot of wood in its furniture production, but implements advanced forestry methods, without damaging vast areas of forest [2, p. 6].

Claims of ecological labels on the packaging of breakfast cereals,

yoghurt, crisps and juices greatly increase sales. Consumers are not always conscious when choosing organic products and often do not understand where there is real concern for natural resources and where a standard marketing ploy is used [1, p. 100].

We are confused by the beautiful and loud words on the packaging: “natural”, “no additives”, “no gmo”, and the producers fraudulently increase their profits taking advantage of the lack of consumers’ awareness.

Incomplete consumer literacy in reading product labels and understanding of waste disposal procedures also plays a role in greenwashing spreading.

A survey shows that some consumers are ready to overpay a little and buy a product in “eco-friendly” paper packaging rather than the same in plastic. But paper packaging only at first sight seems less harmful than plastic one, as this type of container refers to composite packaging materials such as TetraPak (consisting of 75 % cardboard, 20 % polyethylene and 5 % aluminum foil). Such compound looks more natural than plastic, but its production requires wood (i. e., logging), and most recycling share of such packaging is based on splitting the complex material into separate components. Nevertheless, in Russia such packaging is practically not recycled due to the complexity of the type of secondary raw materials, but recycling of the same plastic is developing [1, p. 101-102].

Greenwashing is found not only as a result of labeling basic products, cosmetics or clothes with greenwashing. One can often see a lot of advertisement for houses made of eco-materials or located in a “protected” area with genuine nature, but in fact the materials are very common, and it is forbidden to build in nature reserves. The point of such advertising is that demand breeds supply.

People's initial desire for a conscious way of life, to care for the environment – which is a positive thing in itself – created the conditions for the emergence of greenwashing. How did the positive intentions contribute to the negative phenomena? The answer is to make a profit at the lowest possible cost. Organic products cost more than their non-organic analogues because they are more expensive to produce.

Of course, we can follow some rules to live more sustainably and avoid greenwashing in our lives. Firstly, choose products in reusable glass packaging, as environmentally friendly products cannot be sold in plastic (although sometimes opting for plastic is smarter). Secondly, respond appropriately to green packaging, eco, bio, natural labels. Third, consult international certificates and sources to help understand the sorting and recycling of household waste. Fourthly, change our lifestyle to conscious consumption [1, p. 102].

However, shifting the entire responsibility for adhering to an informed lifestyle onto the shoulders of consumers will not achieve the expected results.

We believe that the key role in improving environmental quality should be played by manufacturers, company holdings and the government, creating a comfortable and low-cost ecosphere for ordinary users. People would be more willing to take care of the environment if there was an incentive system for sorting waste, buying ecological goods and saving resources. It is hard to imagine pensioners who are willing to overpay for bio-kefir in a glass bottle instead of buying it in TetraPack box, or who are able to drive halfway across the city with rubbish to the waste sorting bins.

In general, green marketing has a great potential for development, companies can manifest themselves in a new niche with a growing perspective, and alternatives are being created for consumers to choose from and savings in the planet's resources and energy consumption are increasing [2, p. 9].

The phenomenon of greenwashing is unfair competition by producers and deception of consumers. Every customer wants to buy organic products, but no one wants to be cheated. It is true that organic goods or products are sold at a much higher price than conventional products, and the buyers often chooses what is cheaper.

Of course, we can follow the rules mentioned above, but for the most part, environmental issues are in the hands of manufacturers and those in power. Their main concern is not to make standard products environmentally friendly, but to make environmentally friendly products the standard [4].

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THE USE OF CONTACTLESS VOLTAGE INDICATORS UP TO 1000 V FOR OVERHEAD LINES MADE WITH A WIRE OF THE SIW BRAND

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Abstract. The relevance of the chosen topic is due to the need to speed up the process of inspection of overhead lines up to 1000V, in order to clarify the topology of existing networks in places where it is difficult to determine the passage of the necessary SIW brand wire (self-supporting insulated wire) without destroying the insulating layer of the wire.

Keywords: overhead line, voltage indicator, sensitivity, electromagnetic field, insulation.

ПРИМЕНЕНИЕ БЕСКОНТАКТНЫХ УКАЗАТЕЛЕЙ НАПРЯЖЕНИЯ ДО 1000 В ДЛЯ ВОЗДУШНЫХ ЛИНИЙ, ВЫПОЛНЕННЫХ ПРОВОДОМ МАРКИ СИП

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Аннотация. Актуальность выбранной темы обусловлена необходимостью ускорить процесс обследования воздушных линий до 1000 В в целях уточнения топологии существующих сетей в местах, где трудно определить прохождение необходимого провода марки СИП (самонесущий изолированный провод), не разрушая изоляционный слой провода.

Ключевые слова: воздушная линия, указатель напряжения, чувствительность, электромагнитное поле, изоляция.

Currently, 0.4 kV networks are the most confusing in their topology. Their condition leaves much to be desired, along with this, a lot of 0.4 kV overhead lines (0.4 kV overhead lines) pass through the supports with a joint suspension, sometimes the number of passing 0.4 kV overhead lines with a joint suspension can reach 10, or even more (Figure 1). And all these lines the network company must maintain, reconstruct, complete, and perform other work. However, information in network companies about their 0.4 kV lines is often unreliable, since all current data about these lines are contained on paper, which are lost, filled in and edited by different people.

Figure 1. Location of six overhead lines on the support

Now network companies are trying to put in order information about the condition, topology and characteristics of these lines. To do this, the team goes to the necessary transformer substation, disconnects the 0.4 kV switch of the required line, begins to pass along the line, climb to the support with the help of manholes, or a car equipped with a cradle in search of the same disconnected line with the help of voltage indicators among all the “abundance” of wires, then marking it on the supporting circuit and moving on to the next point. This survey continues until the required overhead line-0.4 kV is fully determined.

To determine the necessary line, contact voltage indicators are used, for such purposes it is not necessary to determine the voltage value, which is obviously known, but it is necessary to record only the presence or absence of it.

Contact voltage indicators up to 1000 V can be single-pole (Figure 2) and two-pole (Figure 3), with LED, sound and mixed indication [1].

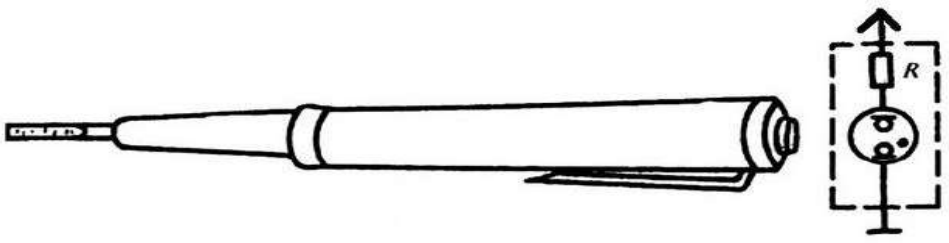

Figure 2. Single-pole voltage indicator

Figure 3. Two-pole voltage indicator

The use of such voltage indicators implies touching one of the probes of the exposed live part of the wire [2; 3]. However, at present, most of the 0.4 kV overhead lines are made of self-supporting insulated wire (SIW). To determine the absence or presence of voltage on such wires, it is necessary to clean the contact point from the insulation layer, or look for a section of wire where it is already exposed. When removing the insulation from the M&A wire, which can already lead to subsequent overlaps, the current-carrying part of the wire is often damaged and, together, such errors reduce the dynamic strength of the wire, and this is a direct path to line breakage. To avoid such consequences, this study suggests using contactless voltage indicators for such purposes, which are currently designed to search for hidden wiring (Figure 4).

Figure 4. Contactless voltage indicator (hidden wiring detector)

Also, a contactless voltage indicator will be useful when performing technological connection of new consumers to the overhead lines of a network organization. Since according to the technological maps, before connecting the consumer, the team should briefly:

- disconnect the necessary 0.4 kV outgoing line in the transformer substation;
- take measures to prevent erroneous or spontaneous switching on of switching devices by locking the drive handles and doors;
- post security posters;
- install a universal portable grounding at the connection points of the overhead line to the switchgear, then lock all doors;

- in some cases, it is required to install a portable grounding on the overhead line, in the work area;

- at the place of technological connection, climb to the support;

- find the necessary wire and proceed to the implementation of technological connection.

As you can see, the preparatory activities take some time. The time of such operations as the search for the necessary line for the installation of portable grounding, or the search for a line to connect the consumer depends on how quickly the disconnected line will be determined on which one or another type of work will be performed. However, the implementation of these measures may require disconnecting several lines at the same time if an overhead line with non-insulated wires runs in parallel (Figure 5) and the work is carried out at a distance of less than 60 cm from the live parts. As a result, it turns out that several overhead lines on which electric energy consumers are located are disconnected for the duration of the work. And the longer consumers are disconnected, the more the under-output of electricity increases.

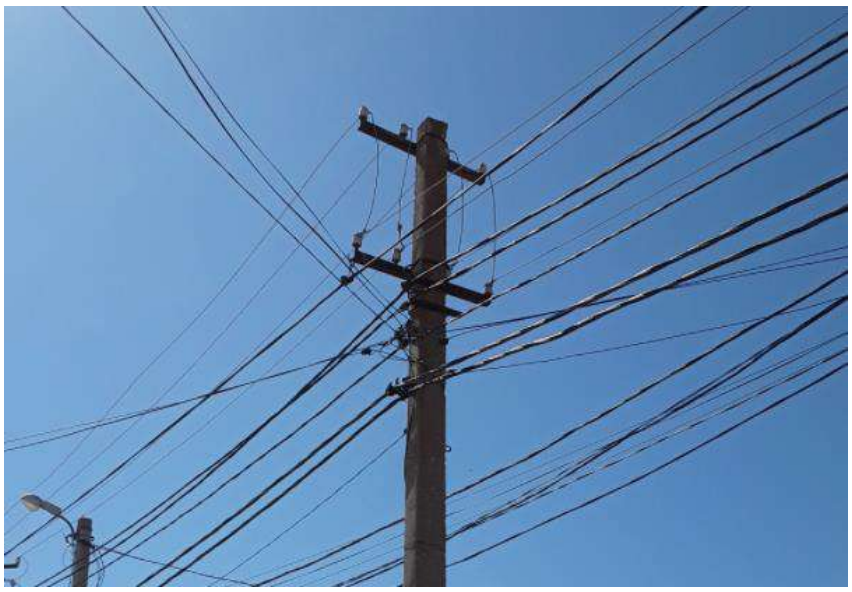

Figure 5. Passage of several overhead lines by joint suspension, including uninsulated

Despite the fact that this solution seems simple, it is necessary to conduct research on the sensitivity of this device to the electromagnetic fields of a three-phase line, as well as the influence on it of electromagnetic fields induced from overhead lines passing through a joint suspension of voltage class up to 1000 V and over 1000 V [4]. Based on the ongoing research, the need for shielding the device will also be considered [5]. These studies and computer modeling are already underway and soon it will be known about the viability of this idea – the use of contactless voltage indicators in the examination of SIP brand wires.

The use of such a device will significantly reduce labor and resource costs for the survey, as well as the performance of work on a 0.4k V overhead line, which in turn will reduce the economic costs of this type of work. Meanwhile,

the device can be used in conjunction with an operational rod, which prevents injuries to crew members, since there will be no need to climb on the support, because the examination will be carried out from the ground.

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STATE AND PROSPECTS FOR THE DEVELOPMENT OF BIOGAS ENERGY IN RUSSIA

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Abstract. The analysis of biogas in the Russian power market is presented in the article. In addition, the paper considers examples of optimal implementation of biogas plants in energy-deficient regions, examines the reasons for the low level of development of biogas in Russia, and presents the prospects for the development of this industry in the future.

Keywords: biogas, biofuels, alternative energy sources, waste products.

СОСТОЯНИЕ И ПЕРСПЕКТИВЫ РАЗВИТИЯ БИОГАЗОВОЙ ЭНЕРГЕТИКИ В РОССИИ

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Аннотация. В данной статье представлен анализ биогаза на рынке российской энергетики. Кроме того, в работе рассмотрены примеры оптимального внедрения биогазовых установок в энергодефицитные регионы, изучены причины низкого уровня развития биогаза в России и представлены перспективы развития данной отрасли в будущем.

Ключевые слова: биогаз, биотопливо, альтернативные источники энергии, отходы.

Nowadays, energy production plays one of the main roles in the existence of humanity. The development of technology, all kinds of industry plants and comfortable life of people is no longer possible without heat and electricity.

Each year, the amount of energy consumed is growing rapidly. However, considering the fact, that the need for energy is growing, and the resources for its production are depleting and becoming more expensive, the world is rapidly approaching the energy crisis. Another reason for the looming crisis is the

critical environmental situation caused by the heavy pressure of energy production on the environment.

Considering these and many other factors, there is a question of studying and developing alternative sources of energy. In particular, of all existing and developing alternative energy sources, biogas is of the greatest interest. In this article, we will consider the real picture of what place biogas occupies in the energy market in the world and Russia at the moment, what is the reason for this situation, and what prospects await it.

A gas that is formed during the decomposition of organic matter in the process of methane fermentation. Biogas can be produced from any organic matter, but most often it is waste from livestock complexes and food industries, such as sugar mills. It can be produced in any region of the country and used as a means of additional energy both in large cities and in small remote settlements.

Biogas plant works according to the following principle. In nature, the decomposition cycle takes on average from six months to a year, depending on the type of organic matter. At a biogas plant, this process is reduced to sixty days. First, the raw material enters the plant (Figure 1). There are two ways to do this: the biomass is pumped out of the container, where it enters through a drain extended, for example, from a farm. Effluent from it first enters a large collection tank, and then, through a pipeline laid underground, everything flows into a preliminary mixing tank. A special loader is used for materials. After the mass has entered the digester tank, the first stage of digestion begins. This tank is inhabited by methane-producing bacteria that feed on the incoming organic matter. Here, thanks to the rotating blade, bacteria colonies are evenly distributed over the “food”. Further, the biogas formed in the digester tank is collected in a special tank – gas holder. During this process, the gas goes through several stages of purification, including removal of hydrogen sulfide.

At the end of this chain, gas is compressed by a compressor, enters the cylinders of a gas piston engine, which produces electricity to the network. The amount of biogas depends on the composition of the substrates and the organic matter they contain.

With the help of a biogas plant – a special device for the processing of organic matter – not only biogas is obtained, which can later be used to generate electricity and heat, but also biofertilizers that do not increase the nitrate content in the soil and have a positive effect on crop yields. Thus, any organic product taken as a raw material can be reused [1].

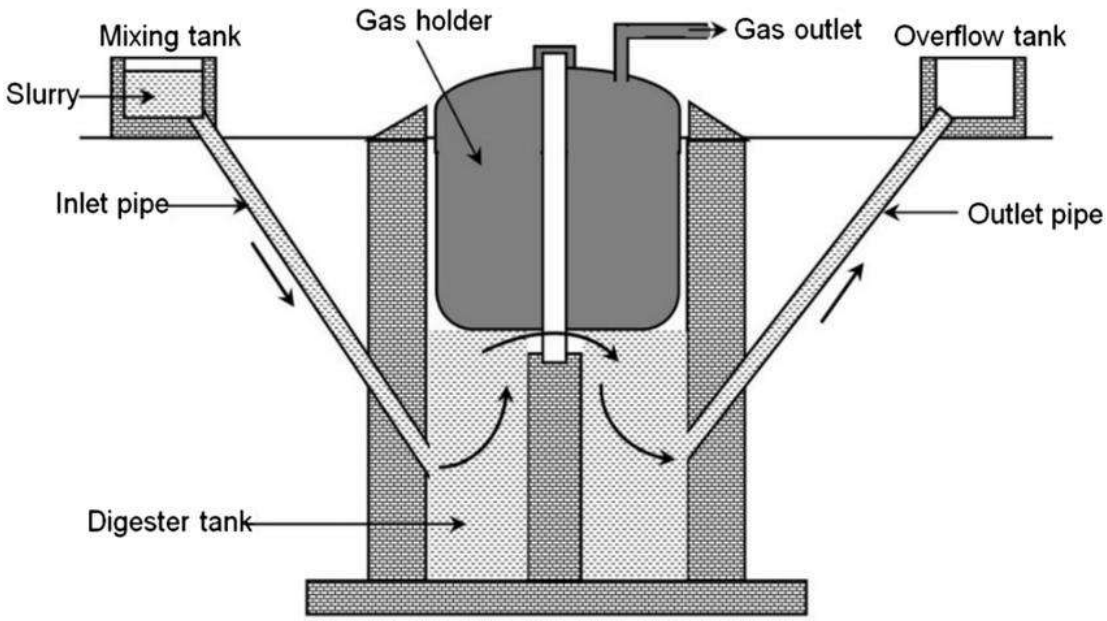

Figure 1. Biogas plant
1. Mixing tank with inlet pipe. 2. Digester. 3. Compensation tank. 4. Gas holder. 5. Water jacket. 6. Gas pipe

The main reason for the increased interest in biogas is the easy availability of raw materials for its production, and, as a result, the constancy of energy production. Besides, from the ecological point of view, production of biogas is also profitable – this kind of energy allows recycling wastes from agrarian complex, reduces pollution of sewage and soil in the surrounding area. Another significant advantage over other alternative sources is obtaining environmentally friendly fertilizers after anaerobic digestion of raw materials.

One of the leading countries in production of biogas and its successful implementation in everyday life is China. This country is by right considered a leader in biogas market – annual volume of produced biogas in China is 14 billion m^3, which exceeds values of annual biogas production in Europe and USA several times. Since 2003, the country has started a large-scale project "National Program for development of rural biogas energy" which is aimed to increase the number of households using biogas for domestic needs. With the support of the Chinese government, the introduction of domestic reactors (volume 6 – 8 m3, daily power – 11 kWh) in residential buildings was launched, and by 2005 their number exceeded 10 million. Thermal energy generated by such units on average covers more than 80 % of the energy needs of a family of four people. The installation is simple in design and use, and this is one of the reasons for the success of the project. The development program in China has demonstrated the environmental and economic benefits of domestic biogas reactors – heating costs for residents have decreased significantly, since the plant runs on vegetable peels and other plant waste, which abound in rural areas.

In addition, the amount of harmful emissions has decreased and it has become possible to recycle household waste, which, before the launch of the project, poisoned the land at landfills.

As of 2019, the total power of all biogas production in China, including household generators, reached 5.5 GW. China's experience shows that this technology is applicable and has every chance of success in other countries on a rural scale [2].

In comparison with Chinese experience, Russian level of biogas industry is rather low. In Russia, the introduction of modern and technically complex technologies takes place locally, for example, in the Belgorod region.

Belgorod is called the “meat” capital of Russia – Belgorod region is the leader in the number of poultry and livestock enterprises. The main impetus for the development of biogas in this region was the problems of waste management of the intensively developing agrarian complex. In the period from 2010 to 2012, the Belgorod region has achieved impressive results – in December of 2011 the installation “Baitsury”, located near the existing pig farm for 16 thousand animals, was put into operation. “Baitsury” has a power of 0.5 MW and is the first industrial-scale biogas plant in Russia to pass all certification procedures. The most significant achievement of the Belgorod Region is the biogas plant “Luchki” – the largest industrial-scale plant in Russia, launched in 2012 [3]. Its power reaches 2.4 MW. Each year, “Baitsury” generates up to 57.000 kWh, and the generated electricity is enough to meet the daily needs of the residents of the Prokhorovsky District, where the plant is located.

The comparison of the indicators of the stations “Baitsury” and “Luchki” is given below (Table 1).

Table 1 – Comparison of the indicators of the stations “Baitsury” and “Luchki” [4; 5]

Comparison criterion	“Baitsury”	“Luchki”
Processing of raw materials	54.1 ths. tons	95 ths. tons
Power generation	3.7 to 7.4 mln kWh	29.3 mln kWh
Heat production per year	from 1,6 to 3,2 thous. Gcal	27.3 thous. Gcal
Production of organic biofertilizer per year	13,2 thous. tons	90 thous. tons

In Russia, interest in alternative sources is currently weak and is unlikely to increase in the next few decades. Firstly, Russia is rich in traditional energy sources; accordingly, unconventional energy is simply not in demand now. Because of this, the profitability of such projects is low, investments for construction of biogas plants are difficult to achieve. Secondly, there is no legislative framework to support RES (renewable energy sources), and there are no governmental strategies to support the renewable energy industry [6].

After reviewing the experience of other countries and comparing their results with Russia's results in the development of biogas industry, we can say that there is no positive dynamics. There are a number of good reasons for this, which have also been considered and analyzed in this article. There is no shortage of energy sources in Russia, but because of geographical features of the country, there are many energy deficient regions, where the introduction of biogas plants would be a solution of some domestic problems. Without appropriate legislative measures and the support of the population, the situation will not change, so it is worth remembering that a lot depends on us and the society in which we live.

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DECISION SUPPORT SYSTEMS IN GEOLOGY

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Abstract. This article is devoted to decision support systems (DSS) in geology. The definition of decision support systems and their features of functioning in geology is given. At the end, a conclusion is made about the advantages of using DSS in geology and further prospects for their implementation.

Keywords: decision support system (DSS), geology, functioning, working process, working team.

СИСТЕМЫ ПОДДЕРЖКИ ПРИНЯТИЯ РЕШЕНИЙ В ГЕОЛОГИИ

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Аннотация. Статья посвящена системам поддержки принятия решений (СППР) в геологии. Дано определение систем поддержки принятия решений и особенности их функционирования в геологии. В заключении делается вывод о преимуществах использования СППР в геологии и о дальнейших перспективах их внедрения.

Ключевые слова: система поддержки принятия решений (СППР), геология, функционирование, рабочий процесс, рабочая команда.

Before talking about the usage of decision support systems in geology, it is necessary to define geology as a science.

Geology is the study of the structure, evolution and dynamics of the Earth and its natural mineral and energy resources. The subject of geology studying is the process of evolution of the Earth and through that, its history as a planet.

Except scientific value, geology is widely used in a great variety of spheres of human activities such as construction industry, commercial industry and energetics [1]. Geological research allows to examine the surface, understand the peculiarities of soils and rocks and make all the necessary calculations connected with the further works. The usage of geological examination allows to reduce the costs of constructing, prevent any accidents

and catastrophes and make a long-term prognosis of the industrial and resource facilities of a particular area.

To achieve all that, geological research needs an extreme accuracy in calculations, the latest modern technical equipment and perfect system of management. One of the tools that help to make the process of geological research more accurate and efficient is decision support system.

Decision support system (DSS) is a set of tools that provide the formation (modeling) of alternative solutions at different stages of decision-making, their analysis and selection of options that meet the specified conditions [2]. The other definition is that DSS is a system that provides information necessary for tactical planning and the activities of decision makers. So, decision support systems are used for creating multiple solutions and choosing the best of them according to the provided circumstances. They are implemented in many processes in different spheres of human activities, such as economics, sciences, construction, engineering, military and administration. Their usage makes the process of work faster and easier for CEOs, company managers and officials.

Now, it is necessary to understand, how DSSs can make the process of geological research more efficient.

First of all, specialists collect all the necessary data connected with condition of soils and rocks. By taking soil tests and making deep analysis, geologists can make first decisions on the further strategy. Some side effects are also considered and geologists hold consultations with other departments or scientists, for example, engineers and meteorologists.

When all the data are collected and structured, they are presented to the automatic DSS. This system is processing the data and creates all the possible variants and solutions that can be made according to the given conditions [3]. Now all the people involved into any commercial or constructing project obtain a pack of possible solutions based on the resources, natural conditions and time at their disposal.

Now the working team has two choices: to choose the best decision from those provided or to put this responsibility on the decision support system. It is worth mentioning, that the decision made by the DSS is the most reasonable as it obeys to the computer algorithms which were originally laid down while its development. Nevertheless, here the first complication and contradiction can be observed. As the computer algorithm may provide the best decision for the given circumstances, the number of the circumstances laid down into the system is limited, though it can be very extensive. There is always a possibility of some side events and complications that can’t be calculated by the DSS. For example, the local weather can be extremely changing and any long-term predictions are impossible. Or there can be problems connected with the budgets and interconnections with other departments along with the additional tasks that occur while the entire working process and that also can’t be predicted and calculated.

Despite the mentioned problems, many CEOs, managers and officials trust decision support systems as they still help to save time and avoid long and unproductive discussions among the members of the project [4]. DSSs are also widely used in geology at the stage of development of deposits and creation of the reports on soil conditions.

However, the usage of decision support systems also faces a number of complications in this sphere. The nature of the soil can be not static as well as the nature of the weather, the human factor and the time limits should also be counted. All these side facts also cannot be included into original algorithms.

The solution to these problems that don't allow to use DDSs every time can be in permanent support of decision support systems so that the changes in the algorithms and given data and conditions would be made in real time. This implies a particular specialist whose main and only responsibility is to react to the information they receive from the team of geologists or any other team that work together with the geologists. The efficiency of the DSS may grow dramatically and there are some spheres that already use this method, such as finances, air and space spheres and sphere of IT technologies itself.

So, everything that was mentioned above leads to the conclusion that the usage of decision support systems in geology and in other spheres of human activity has its advantages and disadvantages.

The advantages of the DDSs implementation are the possibility of saving time and resources as the computer makes all the necessary calculations according to the provided data and laid down conditions. There is no need in long and unproductive discussion as DSS may even give a one single decision for the task. The usage of automatic decision support systems also makes the work of managers, CEOs and officials easier as they are already supplied with the possible solutions to the problems and possible strategies and tactics of working processes. The work of computer system on processing data can help to avoid the human factor on this stage of work, so any mistakes in results are hardly possible.

To achieve all that, decision support systems apply several popular methods:

- Method of regression and dispersion analysis;
- Multivariate and discriminant analysis;
- Analysis of survival and forecasting time series;
- Analysis of categorical data;
- Structural, spatial and factor analysis.

Many companies, both public and private use DSSs in the work. For example, the largest oil companies, such as Saudi Arabian Oil Co, China Petroleum and Chemical Corp. and Exxon Mobil Corp. widely use decision support systems on their recyclable factories and drilling rigs. Their implementation is truly helpful in the cases of emergencies developments of new deposits.

On the other hand, it is impossible to load the system with all the possible scenarios, which means that some problems may occur while creating long-term strategies. Despite their high effectiveness in the process of analyzing data because of the absence of the human factor, DSSs can't be guaranteed from the human factor that may appear on any other stage of work and that, in some cases, can lead to total irrelevancy of the decisions that were made at the first stages. To these representatives of human factor can be attributed misunderstanding between the departments or members of the one department, mistakes made during the process of construction or development, reduces of budgets or changes in deadlines, even initially incorrect data that were loaded into the decision support system program.

There have been may cases, especially in oil and gas industries, when the DSSs couldn't prevent catastrophes at enterprises and these catastrophes led to human tolls. Of course, the problem is not in the systems themselves but in the excessive trust from the side of people. An example of Ocean Ranger can be given here. Ocean Ranger was a mobile offshore drilling oil rig. A storm caused some damages in control room and the stuff was not able to secure the situation, as they thought that nothing critical had happened.

The main conclusion of the work is that it is better not to trust DSSs completely as the abilities of computers are limited even in the present digital era. However, these systems can be upgraded even now by including addition number of specialists that will be responsible for their maintenance and editing of data. Moreover, consultations with geologists and other specialists needed in order to understand or at least be aware of all or majority of accidents that may happen during the working process. The development of informational technologies themselves can lead to the higher effectiveness, as the programs and computers will be working faster, obtain more functionalities and deal with more sophisticated data. That will better the process of production, and production preparations and also can help to prevent disasters at the enterprises and save human lives.

So, the implementation of decision support systems in geology and other spheres of human activities has wide perspectives and has all the possibilities to make the process of geological research more accurate and efficient.

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INDICATOR FUNCTIONS OF SNOW COVER FOR ASSESSMENT OF ATMOSPHERIC AIR POLLUTION FROM VEHICLE EMISSIONS

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Abstract. The indicator functions of the snow cover were used to assess the polymetallic pollution of the surface layer of the atmospheric air from motor vehicle emissions. The study was carried out on the territory of the city of Kazan with a dominant air input of metals from multiple stationary and mobile sources of pollution. A high polymetallic load was found under the influence of mobile sources of pollution.

Keywords: metals, content, snow cover, pollution level.

ИНДИКАТОРНЫЕ ФУНКЦИИ СНЕЖНОГО ПОКРОВА ДЛЯ ОЦЕНКИ ЗАГРЯЗНЕНИЯ АТМОСФЕРНОГО ВОЗДУХА АВТОМОБИЛЬНЫМИ ВЫБРОСАМИ

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Аннотация. Индикаторные функции снежного покрова использовались для оценки полиметаллического загрязнения приземного слоя атмосферного воздуха от автомобильных выбросов. Исследования проводились на территории города Казани с преобладающим атмосферным поступлением металлов от многочисленных стационарных и передвижных источников загрязнения. Установлена высокая полиметаллическая нагрузка под влиянием мобильных источников загрязнения.

Ключевые слова: металлы, содержание, снежный покров, уровень загрязнения.

Today, 80-90 % of air pollution in large cities is accounted for by road transport (in Kazan in 2020 it was 92 %). The number of transport units annually increases by an average of 30 %. The number of emissions is determined by the mode of movement due to the congestion and

underdevelopment of the city's road network (in the “start-stop” mode, emissions of pollutants increase by 2-3 times); low environmental performance of vehicles; low technical condition of vehicles.

When burning fuel liquids, solid suspended particles are also emitted into the atmosphere, which, when inhaled by a person, can lead to disruption of the functioning of many internal organs, primarily the respiratory organs. In addition, these suspended solids have a negative impact on the environment, in particular on water bodies, turning into dust, which often interferes with plant growth.

Nitrogen oxides interact with water vapor to form nitrous and nitric acids, which by their action lead to various disorders of the respiratory and circulatory organs [1].

High vehicle traffic leads to a significant deterioration in air quality in surrounding residential areas. Three pollution zones are formed in residential buildings: a zone of maximum pollution (located between the source of emissions and buildings), a zone of moderate pollution (located behind buildings), a zone of low pollution – a zone that is significantly remote from the source of emissions (having a diffuse structure of pollutant concentration isoline).

Narrow streets with a high density of buildings adjacent to the source of pollution, in light winds, also create conditions for the concentration of pollutants. The main reason for the high level of air pollution in the city is vehicle emissions due to incomplete combustion of fuel, the use of cars with low-emission engines, insufficient density of traffic routes and inefficient traffic management [1].

The bulk of gas emissions settle in the immediate vicinity of roads. The rest, depending on the terrain, wind direction, soil type, vegetation cover, and the presence of forest protection plantations, can extend up to 200 m from the roadway.

But in the areas of operation of highways, the quality of atmospheric air is also formed under the influence of high-altitude stationary sources that carry out high-temperature emissions with a high rate of exit of the gas-air mixture from the pipe. These sources include thermal power plants, the emissions of which form background pollution in a significant part of the urban area. Therefore, for such sources, it is necessary to apply the best available technologies (BAT) to clean up emissions.

Snow cover is an effective accumulator of aerosol pollutants coming from the lower layers of atmospheric air [1].

The chemical composition of the snow cover is formed as a result of the absorption of gases, water-soluble aerosols by the snow cover and the interaction of solid particles settling from the atmosphere with the snow cover.

Two ways of pollutants entering the snow cover can be distinguished – as a result of wet leaching and dry deposition of pollutants from the lower layer of atmospheric air. Wet leaching refers to the capture of pollutants by snow during its formation in a cloud and subsequent fallout to the underlying surface. Dry precipitation of pollutants occurs under the action of gravitational forces, due to the capture of aerosol particles by precipitation directly during precipitation [2].

The relationship between particulate matter grinding and wet washout depends on many things: the duration of the cold period, the frequency and intensity, the physicochemical properties of pollutants that cause snow formation, the size of aerosols, etc. Due to the presence of a large number of wet washout processes, the proportion of dry skin is usually is 30 %. However, nearby sources of coarse aerosols account for 70 to 90 % of dry matter [2; 3].

The assessment of the level of snow cover pollution was carried out according to geochemical indicators in the coverage areas of stationary sources (Heat and Power Plant) and mobile sources nearby (highways) in the territory of Kazan. The area of construction of combined heat and power plants № 2 in the aviation area was chosen for study, which is located next to the residential area and is located on busy highways. The study area is found in Figure 1 with the coverage areas of stationary and mobile sources and sampling points highlighted.

Snow sampling took place over the entire depth of the snow cover, enveloping the method from the side of 10 meters. Snow samples weighing up to 6 kilograms were placed in polyethylene bags and melted at elevated temperature to contain metals in the soluble mixture and solid snow sediment.

Determination of metal content was carried out in the snow cover according to the recommendations of РД 52.04.186-89. Determination of metals Cd, Pb, Cu, Zn was measured by atomic absorption spectrometry on an “AAnalyst 400” instrument, which made it possible to determine a wide range of metal concentrations and to process data using the AA WinLab32 software package in the Microsoft Windows 2000 environment.

The metal content in the snow sample was calculated using the formula:

$$X=A*V1/V$$

A – metal content in the analyzed sample of snow water, found according to the calibration curve, mg/dm^3; V1 – sample volume after dilution (concentration), cm^3; V – the volume of the analyzed snow water sample.

At present, any environmental assessment systems are based on the principle of comparison with hygienically justified maximum permissible levels of concentration of individual components. Snow cover is not a habitat for living organisms, unlike air, water and soil, and its existence is temporary seasonal. Therefore, state standards for the content of pollutants (maximum permissible

concentrations or maximum permissible intakes) have not yet been developed for snow.

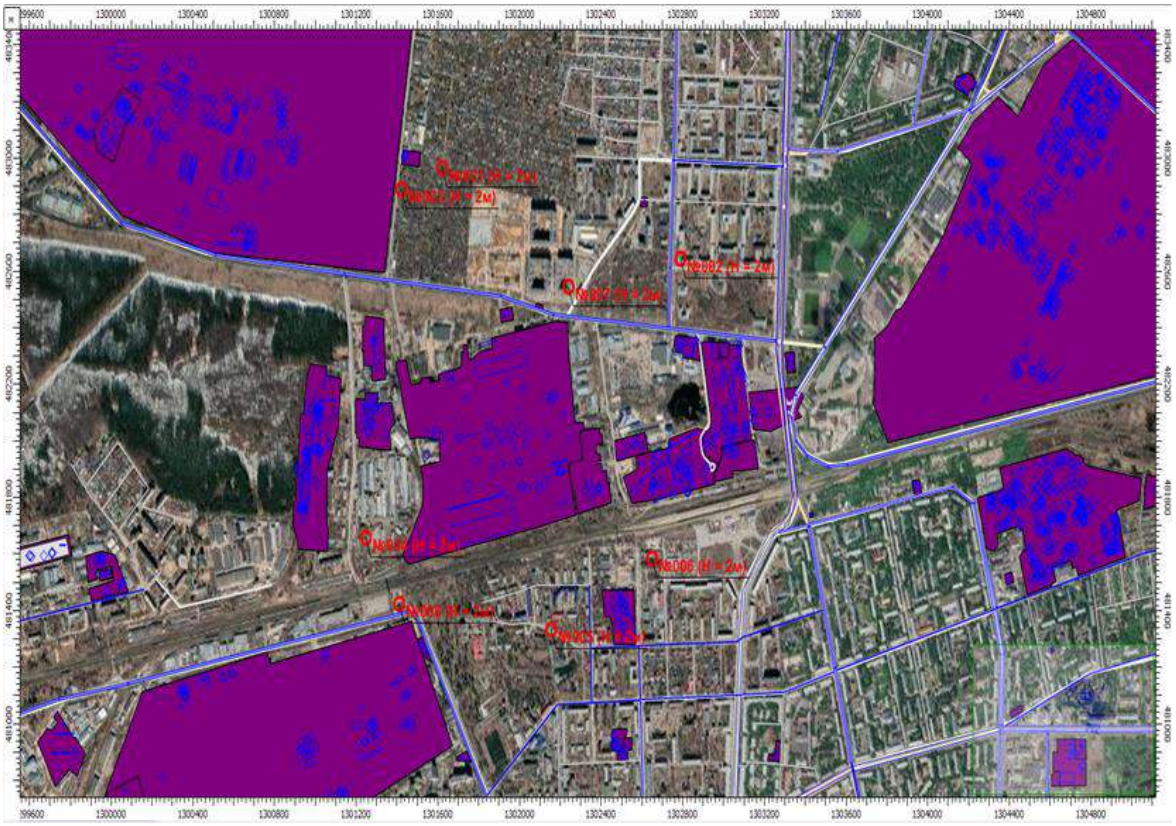

Figure 1. Visualization of pollution sources and sampling points in the study area

The degree of metal accumulation in the snow cover was determined in comparison with the natural background, which is described in detail in [4; 5].

Metal concentration coefficients were determined, which are the ratio of the measured metal content in snow to its background content. The concentration coefficients (Kc) were calculated according to the formula: Kc = $Ci/C_{к_1}$, where Kc is the concentration coefficient; Ci – the concentration of the element in the solid sediment of snow sampled within the city; $C_{к_1}$ – the concentration of the element in the solid snow sediment of the Kc background area. The calculation of Kc showed that in the snow cover in the zone of influence of highways, elevated concentrations of metals are found, exceeding the background for Pb by 2.2-3.6 times; for Cd by 3-12.1 times, for Cu by 0.9-4.1 times; for Zn 1.45-8.25 times.

To determine the degree of polymetallic pollution of the snow cover, we used (formula 1) the total indicator of pollution [3; 6]:

$$Zc = \Sigma Kci - (n-1)$$

Where Zc is the indicator of total pollution; Kci are the concentration factors of elements, n is the number of determined metals in the snow cover.

The study of polymetallic snow pollution in the area of emission sources of Thermal Power Plant № 2 showed the maximum values Zc = 28, which allows us to characterize the level of snow pollution as moderately dangerous. In

the areas of operation of highways, the maximum value Zc = 32 is set, which allows us to characterize the level of snow pollution as dangerous. Thus, we have established a significant influx of metals into the surface layer of the atmosphere with mobile sources of pollution, which requires measures to reduce the polymetallic transport impact.

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CAUSES AND NEGATIVE CONSEQUENCES AND WAYS TO PREVENT THE DEGRADATION OF THE PLANT WORLD

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Abstract. This article presents the statistics of deforestation throughout the country and in Russia in particular. Examples of combating deforestation, punishment for illegal deforestation are considered. It was revealed that in Russia most of the forests suffer precisely because of fires, and not from human hands.

Keywords: deforestation, deforestation, deforestation.

ПРИЧИНЫ И НЕГАТИВНЫЕ ПОСЛЕДСТВИЯ И ПУТИ ПРЕДОТВРАЩЕНИЯ ДЕГРАДАЦИИ РАСТИТЕЛЬНОГО МИРА

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Аннотация. В данной статье представлена статистика исчезновения лесов по всей стране и в России в частности. Рассмотрены примеры борьбы с обеслесиванием, наказание за незаконную вырубку лесов. Выявлено, что в России большая часть лесов страдает именно из-за пожаров, а не от рук человека.

Ключевые слова: обезлесивание, вырубка лесов, исчезновение лесов.

Forests are called the “lungs of planet Earth” for a reason. Mankind lives and breathes only thanks to forestry, which produces oxygen. But, unfortunately, the destruction of forests is increasing, and it seems that it is not going to slow down.

Deforestation is a global problem in all countries of the world. It is the process of deforestation in order to transfer land to other uses such as pastures, wastelands, fields and plantations. Both intentional human logging and natural disasters such as hurricanes, climate change, and more can lead to deforestation. These processes, according to the forecast of the US Institute of Maryland, by

the middle of the 21st century will lead to a decrease in forest area by more than 400 million hectares [1].

Forests strongly influence the state of the ecosphere and make up more than 80 % of the phytomass of the entire planet - they occupy almost a third of the land (26 %), or about 4 billion hectares. More than half of the planet's green areas are located in five countries: China (5 %, or 220 million hectares), USA (8 %, or 310 million hectares), Canada (9 %, or 347 million hectares), Brazil (12 %, or 497 million hectares) and, of course, Russia (20 %, or 815 million hectares). The World Resources Institute notes that it is in these countries that the largest number of primary forest species has been preserved [2].

One of the riches of Russia is the endless forests located throughout the territory of our country, but even here, there is a problem of deforestation. This article will review the statistics of deforestation in the world and Russia, present examples of combating this phenomenon and measures to reduce deforestation.

Since ancient times, mankind has been cutting down forestry for agriculture and the seizure of foreign territories. But the main reason for deforestation was the need for food, because there was not enough space for pastures and growing crops.

Tropical forests were in the most damaged. The development of forests in the tropics progressed gradually. Over the past two hundred years, agriculture began to develop in tropical forests, which launched the growth of exports of goods, and since the middle of the 20th century, timber exports have increased tenfold. At the same time, the population of tropical areas was growing rapidly, which led to deforestation and degradation of the planet's ecosystems.

In the same time, active colonization of European forests began. Forests in the Mediterranean have suffered from mankind since the beginning of the Middle Ages, which led to the felling and complete destruction of ancient conifers. Forests in Asia and North America have also been eliminated and are particularly vulnerable and face the greatest number of threats. The forests of South and North America have shrunk by nearly 90 %, and deforestation in South Asia has been almost as severe. Two-thirds of the lowland tropical forests in Central America have been converted to grassland since 1950 and 40 % of all tropical forests have been completely lost. Madagascar has lost 90 % of its forest resources, while Brazil is facing the loss of more than 90 % of its Atlantic forest. Several countries have declared deforestation an emergency.

Statistics of deforestation in recent years by country (Table 1):

Table 1 − Deforestation statistics by country

Country	*Area, thousand ha*
Congo	*0,608*
Indonesia	*1,605*
USA	*1,74*
Brazil	*2,157*
Canada	*2,45*
Russia	*4,139*

Global corporations are also contributing to the fight against deforestation. In order to embody its commitment to respect the environment, Nespresso coffee brand, together with Colombian designer Joanna Ortiz, have developed a limited collection of coffees and accessories “Gifts of the Amazonian forests”. The collection is inspired by the beauty of nature and aims to draw attention to the problem of the destruction of the Amazonian rainforest in Brazil, the area of which only from 2020 to 2021 decreased by 13 thousand square km is the highest figure since 2006.

For nearly 20 years, Nespresso has supported ecosystems. To help local communities that call the forest home, the company has taken under its protection 10 million trees (47 thousand hectares) in the Amazon forests in the La Pedrera region (Colombia). The work is carried out in collaboration with Conservation International (International Society for the Conservation of Nature) and the community of Madroño (a locality and municipality in Spain).

In Russia, large companies do not lag behind foreign ones. Thus, the management of S7 Airlines in 2019 announced a fundraiser for planting 1 million trees. The company deducted 100 rubles from each ticket sold for flights to Siberian destinations.

The first planting of seedlings began in September 2019, and the campaign continues to this day. After each stage, the air carrier posts progress reports and plans to take care of the plants for two years. In 2021, new seedlings appeared in the Omsk, Novosibirsk, Tomsk, Kemerovo regions, Altai and Krasnoyarsk territories, in Khakassia and Buryatia [3].

“Pyaterochka” retailer, “Zewa” brand and the Forest Stewardship Council (FSC Russia) have launched a competition to select reforestation and forest care projects. At the end of October 2021, the jury evaluated 14 works from enterprises from the Leningrad, Arkhangelsk, Bryansk, Tomsk regions, the Republic of Mari El and beyond. After studying the projects, the experts selected the six most relevant ideas. They will receive 50 % of the amount needed for implementation.

Thanks to the support of brands, the work will be carried out on an area of more than 350 hectares. According to the organizers, in all the selected projects, the main emphasis is not on planting seedlings, but on the subsequent effective care of the growing forest. Such forest management activities are not yet very common in the country, but they are no less relevant and necessary.

The Russian government is also actively fighting deforestation. Illegal deforestation in Russia entails punishment depending on the severity of the crime (Article 260 of the Criminal Code of the Russian Federation). If the actions of the criminal resulted in the loss of a small number of plantations, then the fine for deforestation will not exceed 500 thousand rubles. If an act of poaching was committed by a group of persons, using their official position, then the amount of sanctions will be from 500,000 to 1,500,000 rubles. For a crime committed on an especially large scale, a punishment of 1,000,000 to 3,000,000 rubles is provided.

Under Article 8.28 of the Code of Administrative Offenses of the Russian Federation, a fine in the amount of 3-4 thousand rubles is provided for individuals, provided that the equipment for deforestation was not used. For officials, a fine is 20-40 thousand rubles, for legal entities, including individual entrepreneurs – from 200,000 to 300,000 rubles [4].

The joint efforts of the Russian government and Russian companies are gradually reducing the problem of deforestation. According to Rosleskhoz (Federal Forestry Agency), reforestation work in Russia, scheduled for 2021, has been completed by 98 %. Reforestation is carried out within the framework of the federal project “Forest Preservation”. As of the beginning of December, with a plan of 1.2 million hectares, work was carried out on an area of 1.18 million hectares. This is 56 thousand hectares more than last year.

The largest area of reforestation was recorded in the Irkutsk region, one of the most affected by forest fires in recent years. In the region, 155 thousand hectares were restored in 2021, last year the region was also the leader in forest restoration – 145 thousand hectares. In 2021, the cultivation of new forests was also most actively carried out in the Krasnoyarsk Territory (103 thousand hectares), Yakutia (95 thousand hectares), and the Vologda Oblast (80 thousand hectares). Arkhangelsk region (78 thousand ha), Komi Republic (59 thousand ha), Khanty-Mansi Autonomous Okrug (34 thousand ha).

The annual target for artificial reforestation was achieved by 87 %: with the planned 239 thousand hectares, crops were planted on an area of 208 thousand hectares, which is almost 15 thousand hectares more than in 2020. The maximum areas also fall on the Irkutsk region – new forests are planted on 17 thousand hectares. The Vologda region is also among the leaders (10 thousand ha), Tver (10 thousand ha) and Leningrad (9 thousand ha) regions. In the Urals Federal District, the volume of work planned for the year was completed by 49 %, in the Far East – only by 43 % [5].

Statistics show that a large number of forests are being cut down in Russia, but the country is actively and successfully fighting this. Forest areas are being restored, although not in 100 % volume, but there is a noticeable positive trend in the fight against deforestation.

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DETERMINATION OF VITAMIN C CONTENT IN VEGETABLES AND FRUITS BY IODOMETRY

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Abstract. Rational human nutrition consists of food of animal and vegetable origin and one of its conditions is the presence of a sufficient number of vitamins. Vitamins are low-molecular-weight organic compounds of various chemical nature that are necessary for a person to function normally. One of the most important natural antioxidants is vitamin C (ascorbic acid), which takes part in a number of biochemical processes. The key problem in the era of COVID-19 is that vitamin C affects the state of our immunity. Man, in the course of evolution has lost the ability to biosynthesis of ascorbic acid. In addition, vitamin C is considered the most unstable of all water-soluble vitamins, which is not able to accumulate in the human body. That's why people should get it with food. But in what foods and how much vitamin C is contained? The answer to this question can only be given by a detailed study.

Keywords: vitamin C, ascorbic acid, fresh juices, vegetables, fruits, berries, iodometry method.

ОПРЕДЕЛЕНИЕ СОДЕРЖАНИЯ ВИТАМИНА С В ОВОЩАХ И ФРУКТАХ МЕТОДОМ ЙОДОМЕТРИИ

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Аннотация. Для работы мы изучили теоретическую информацию о витамине С, его химические и физические свойства, влияние на организм человека. Овладели йодометрическим методом определения аскорбиновой кислоты в исследуемых растительных продуктах. В ходе исследования мы проанализировали и сравнили полученные результаты. Нами была подтверждена первая гипотеза о том, что содержание витамина С можно проверить в домашних условиях, а также опровергнута вторая гипотеза, которая говорит о том, что содержание витамина С во фруктах и ягодах выше, чем в соках овощей, так как рекордсменом по содержанию витамина

стал репчатый лук. Доказали, что третья гипотеза является спорной, поскольку есть исключения – ягоды облепихи.

Ключевые слова: витамин С, аскорбиновая кислота, свежевыжатые соки, овощи, фрукты, ягоды, метод йодометрии.

Iodometry is a method of redox titration based on reactions associated with the oxidation of reducing agents with free iodine I2.

The interaction of ascorbic acid with iodine occurs according to the equation:

$$C_6H_8O_6 + I_2 = C_6H_6O_6 + 2HI.$$

As a working solution, a 5 % iodine solution (pharmacy iodine tincture) is used. The end of the reaction is fixed by changing the color of the starch solution to blue [1].

To determine the content of ascorbic acid, the following plant products were taken:

Fruits: orange, Tangerine, lemon, grapefruit, Granny Smith Green Apple, Golden Delicious Yellow Apple, Royal Gala Red Apple, pear, kiwi, mango, pineapple, nectarine, peach, fig peach, plum.

Berries: sea buckthorn, green grapes, pomegranate, avocado, kyzyl, gooseberry.

Vegetables: bell pepper, white cabbage, tomatoes, potatoes, carrots, onions, Peking cabbage, cucumber, beetroot, garlic, melon.

Instruments: measuring cup, pipette, beaker, juicer.

Reagents: starch, distilled water, 5 % iodine solution.

Progress of work:

1. Calculated the number of drops in 1 ml of iodine tincture and the volume of one drop.

1 ml. 5 % r-ra. iodine – 50 drops.

V (1 drop of 5 % r-ra. yoda): 1/50 = 0.02 ml.

Answer: V (1 drop of 5 % r-ra. iodine) = 0.02 ml.

2. I prepared starch paste.

3. Squeezed the juice manually or with a juicer.

4. Measured 20 ml of juice and diluted with distilled water to a volume of 100 ml.

5. Poured 1ml of starch paste and mixed.

6. I added a 5 % iodine solution drop by drop from a pipette until a stable blue staining appeared, which did not disappear for 10-15 seconds.

7. Knowing the volume of the spent iodine solution, I determined the amount of ascorbic acid in a certain volume of the studied material.

8. Entered the measurement results (the number of drops of iodine tincture) in the table.

9. Built a diagram based on the measurement results. (Diagram 1.)

10. Calculated the daily intake of orange juice by people of different ages.

Based on the table data, knowing the daily rate of ascorbic acid consumption by people of different ages, it is possible to calculate the daily rate of consumption of vegetable and fruit juices.

For example, the daily intake of freshly squeezed orange juice [2]:

– Girls 14-18 (65mg): 8.4 mg – 20 ml
65mg - x ml
65 *20 / 8.4 = 154 ml
– Boys 14-18(75 mg): 178.57 ml
– Women 19 and older (75 mg): 178.57 ml
– Men 19 and older (90 mg): 214. 29 ml
– Children 1-3 years old (40 mg): 95. 24 ml
– Children 4-8 years old (45 mg): 107.14 ml
– Children 9-13 years old (50 mg): 119.05 ml

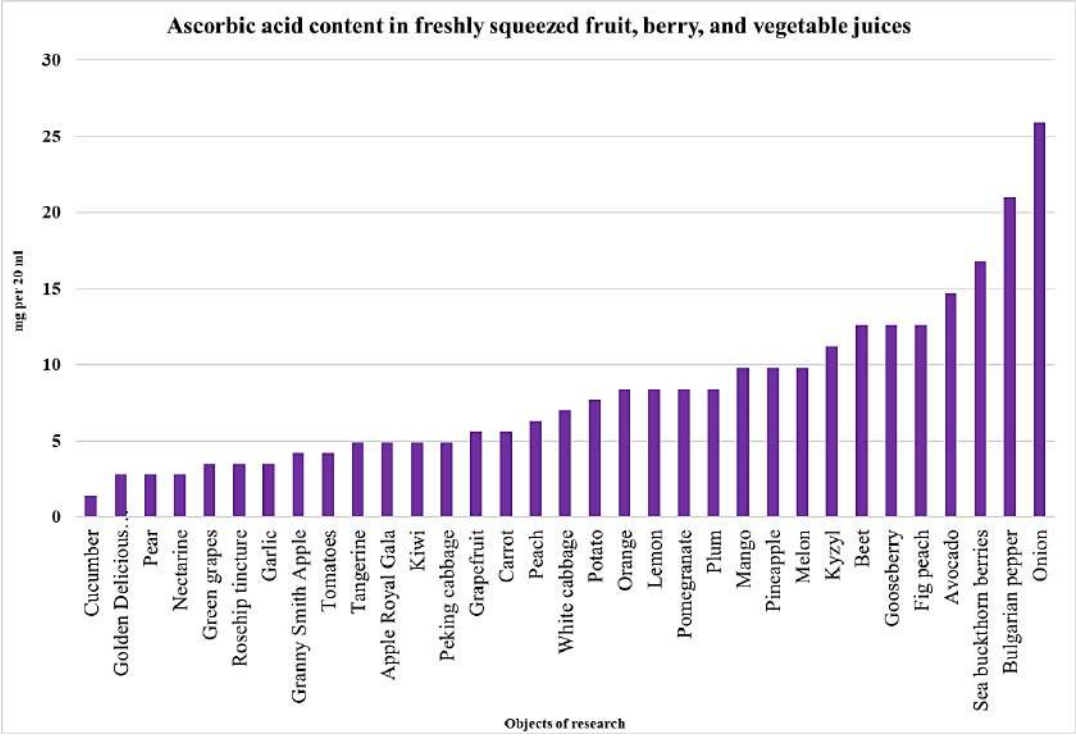

Figure 1. Ascorbic acid content in freshly squeezed fruit, berry and vegetable juices

Conclusion. Thus, the largest amount of vitamin C is contained in onions, Bulgarian pepper is in second place, sea buckthorn berries are in third place. The lowest content of ascorbic acid in cucumber, Golden Delicious yellow apple, pear, nectarine, garlic and green grapes. In the remaining samples, the amount of vitamin C is in the range from 5 to 10 mg per 20 ml. The measurement results coincide with the results from the scientific literature. As a result of this research work, it can be said that many products of plant origin contain a certain amount of ascorbic acid and, of course, have a positive effect on the functioning of the human body [3].

To determine the effect of temperature treatment on the content of ascorbic acid in freshly squeezed juice, the following plant products were taken: orange, lemon, tangerine, grapefruit, sea buckthorn berries [4].

Progress of work:

1. Squeezed the juice.
2. Poured into a container and heated the juice to a boil.
3. Cooled the juice at room temperature.
4. Determined the amount of vitamin C in fruit juice by iodometry.

– Distilled water and starch paste up to 100 ml were added to 20 ml of juice.
– I added a 5 % iodine solution to the juice solution drop by drop from a pipette until the solution acquired a blue color that did not change for 10-15 seconds.
– Calculated the required number of drops to change the color of the juice solution.

5. Performed the necessary calculations and recorded the measurement results in a table.
6. Squeezed the juice.
7. I poured the juice into the vessels and put it in the freezer until it completely crystallized.
8. I took it out of the refrigerator and waited until the ice turns into a liquid state at room temperature.
9. Determined the amount of vitamin C in fruit juice by iodometry.
10. Carried out the necessary calculations and recorded the measurement results in a table.
11. Built diagrams.

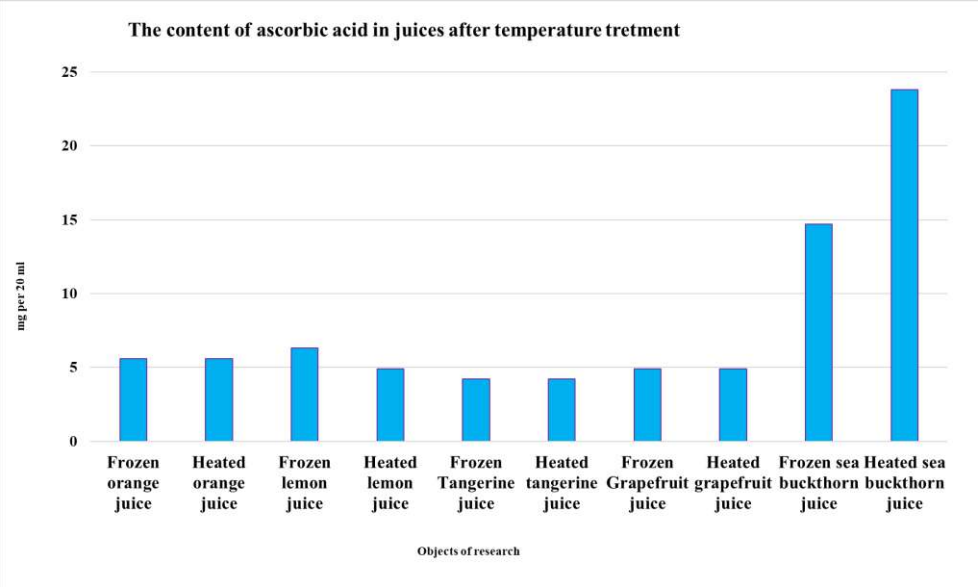

Figure 2. Ascorbic acid content in juices after temperature treatment

Conclusion. After temperature treatment, the vitamin C content in citrus juices decreases approximately the same both during cold and hot processing.

The exception was the juice of sea buckthorn berries. After the temperature treatment of sea buckthorn juice, the vitamin C content not only practically did not change during cold treatment, but also increased during hot treatment! After reading additional literature, I found a simple explanation for the unusual result of the study. It turns out that there are no enzymes in the composition of this berry, which are activated under the influence of high temperatures and neutralize vitamin C.

Conclusion on the laboratory work done.

In the course of the experimental work carried out, the following patterns were identified.

Ascorbic acid is present in all the studied samples of fruits, berries and vegetables, but its content in various plant samples differs significantly. The largest amount of vitamin C was found in onions, Bulgarian pepper is in second place, sea buckthorn berries are in third place.

After heat treatment, the vitamin C content in citrus juices decreases significantly approximately the same both during freezing and during hot processing.

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УДК 62-791.2

MEASUREMENT OF AIR FLOW FOR REVERSIBLE FLOWS WITH AN ION-LABEL FLOW METER

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Abstract. The article considers options for the implementation of an ion-label air flow meter for use in supply and exhaust ventilation systems. A comparative analysis of the structural and functional schemes, the algorithm of the devices, as well as the justification of the requirements for functional elements and nodes is carried out.

Keywords: flow, ion label, amplifier, electrode, generator, integrator, comparator, microcontroller.

ИЗМЕРЕНИЕ РАСХОДА ВОЗДУХА ДЛЯ РЕВЕРСИВНЫХ ПОТОКОВ ИОННО-МЕТОЧНЫМ РАСХОДОМЕРОМ

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Аннотация. В работе рассматриваются варианты реализации ионно-меточного расходомера воздуха для применения в приточно-вытяжных системах вентиляции. Проводится сравнительный анализ структурно-функциональных схем, алгоритма работы устройств, а также обоснование требований к функциональным элементам и узлам.

Ключевые слова: расход, ионная метка, усилитель, электрод, генератор, интегратор, компаратор, микроконтроллер.

In relation to the tasks of measuring the air flow velocity and operating conditions characteristic of many objects, converters based on unipolar ion labels are the most promising. The latter is a local area of the air flow with an increased concentration of unipolar ions formed as a result of a short-term spark discharge produced in the incoming flow. Such a label can be formed in a small volume of flow, and its gas-dynamic properties practically do not differ from the

properties of the air medium, which ensures full compliance of the parameters of the movement of the label with the characteristics of the airflow.

An important advantage of unipolar ion tags is the possibility of their registration in a non-contact way, namely with the help of metal electrodes, on which, due to the effect of electrostatic induction, a pulse signal is induced during the passage of a charged tag. In this case, the electrodes can be isolated from the flow by a dielectric material, which ensures high reliability of the converter when exposed to moisture, dust, etc. [1].

In Figure 1 and Figure 2 the structural and functional schemes of the ion-label gas flowmeter (ILGF) for reversible flows are presented in two versions:

1) when using one tag generator and four tag recorder electrodes;

2) when using two label generators and two label recorder electrodes.

In the first variant, the terminals from the electrodes of the label recorders are connected to the same functional elements (Figure 1). The implementation of this connection option is possible, since air flows move to the flow meter only in two directions: either from one side of the device, or from the other.

Since the charge time of the label is 100-130 ms, the label passes through the first pair of electrodes and does not reach the second pair of electrodes [2].

The electrodes of the recorder are made in the form of insulated rings with a diameter equal to the diameter of the flow channel and are located from each other at a distance equal to one and a half radii of the flow channel.

In order for the microcontroller to be able to determine the direction of the air flow velocity, it is necessary to invert the polarity of the two electrodes of the label recorder, on the one hand. Thus, the sine wave of the signal received from the reverse polarity electrodes will be inverted (Figure 3).

Based on the simplicity, reliability and good interchangeability of the components, option 1 of the ILGF structural and functional scheme for reverse flows was chosen.

Figure 4 shows the time diagrams of the measuring circuit signals.

Functional diagram of the ion-label airspeed meter (Figure 1, Figure 2) contains a flow channel in the form of a tube with a diameter D, in the input part of which there is a spark gap 1 connected to a high-voltage pulse generator (PG). Along the course of the air flow in the flow channel, two isolated annular electrodes 2 and 3 of the ion label recorder are located at a distance ΔL relative to each other.

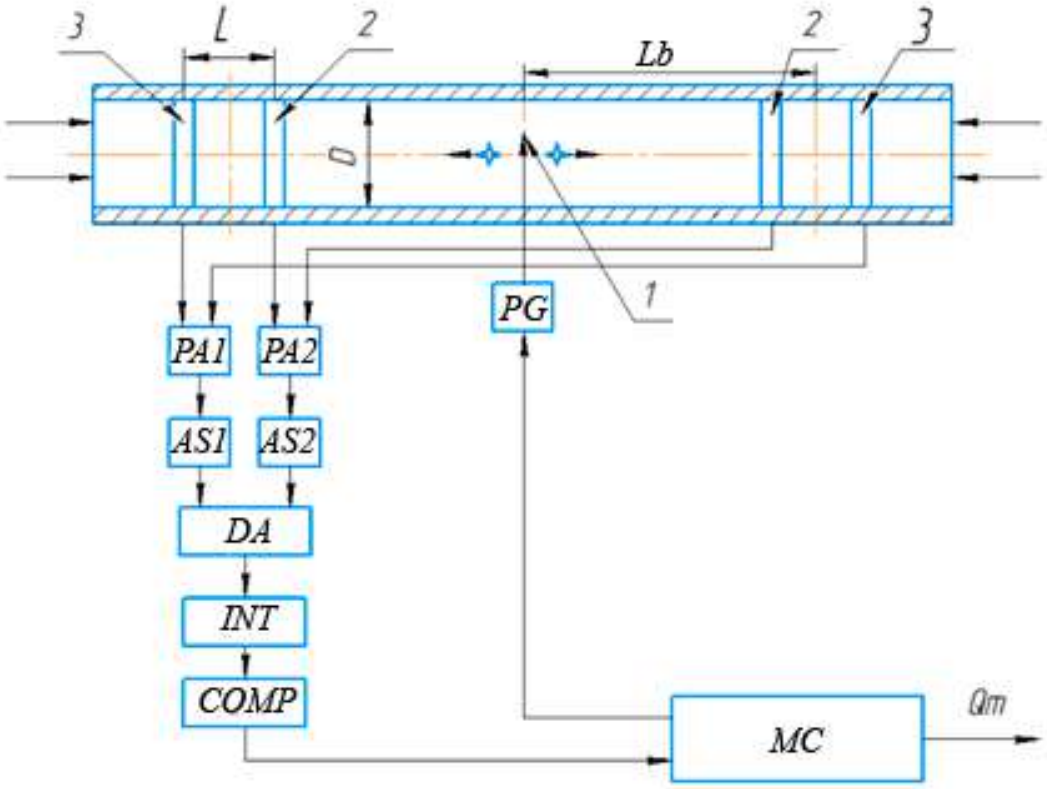

Figure 1. Structural and functional scheme of ILGF option 1

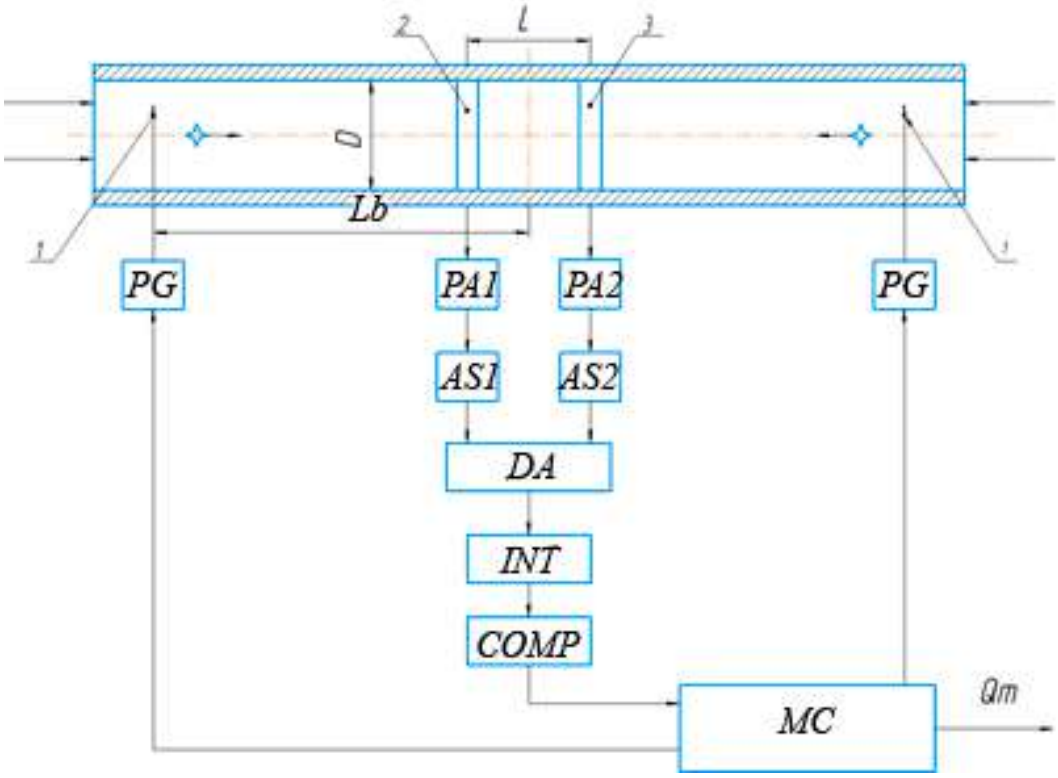

Figure 2. Structural and functional scheme of ILGF option 2

In this case, the diameter of the electrodes is equal to the diameter of the flow channel, and the placement distance from the spark gap to the first electrode 2 is $L_b - \Delta L$, where $\Delta L = 1.5R$ (R is the radius of the flow channel). Electrodes 2 and 3 through the pre-amplifiers PA1 and PA2 and analog switches AS1 and AS2 are connected to a differential amplifier DA, the output of which is connected to the comparator COMP through the integrator INT. The output of the comparator is connected to the input of the MC microcontroller, the control output of which is connected to the PG generator. With MC, we receive a ready-made information signal Q_m on gas consumption.

The gas airspeed meter works as follows. In accordance with a given program, the MC generates pulses at a certain frequency at the control output, which trigger the PG label generator. A short high-voltage pulse enters the spark or corona spark gap and causes a spark or corona breakdown, respectively. As a result of the breakdown in the vicinity of the spark gap, the air is ionized, and ions with an electric charge are formed, thus an ion label is formed, which moves along with the air flow.

When a charged ion label passes near the electrode 2, a current pulse is induced on the latter, which is amplified by the pre-amplifier PA1. The pulse U_{pa1} at the output of PA1 has the form shown in Figure 4, b. A similar pulse U_{pa2} is formed at the output of PA2, but since the electrode 3 is separated from the electrode 2 at a distance of ΔL, the pulse U_{pa2} has a corresponding time delay relative to the pulse U_{pa1}. Analog switchers AS1 and AS2 allow to open the circuit at time t_0-t_1 (duration approximately 200ms) in order to eliminate interference from the PA at the input of the remote control (Figure 4, a). Next, both pulses are fed to a differential amplifier, at the output of which a signal of difference $U_{pa1} - U_{pa2} = U_{da}$ is formed (Figure 4, c). This signal is fed to the INT integrator, the output signal of which U_{integr} (Figure 4, d) goes to the comparator COMP. The comparator fixes the temporary position of the intersection point with a zero-level U_{integr} signal. The output signal of the comparator is sent to the MC, where a time interval is formed, the beginning of which corresponds to the moment of generation of the ion label, and the end to the moment of crossing the boundary of the base distance L_b, which is located between electrodes 2 and 3 at an equal distance from them 0.5 ΔL. According to the duration of the time interval τ in MC, the air flow velocity $V = L_b / \tau$ is calculated. The measurement result is stored in the memory of the microcontroller [2].

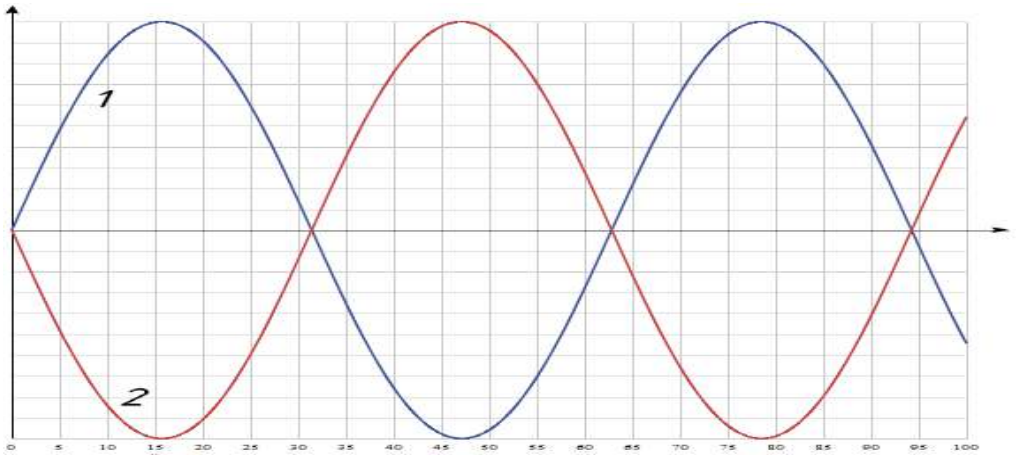

Figure 3. Time diagram: 1-for non-invertible polarities of the recorder electrodes; 2-for invertible polarities of the recorder electrodes

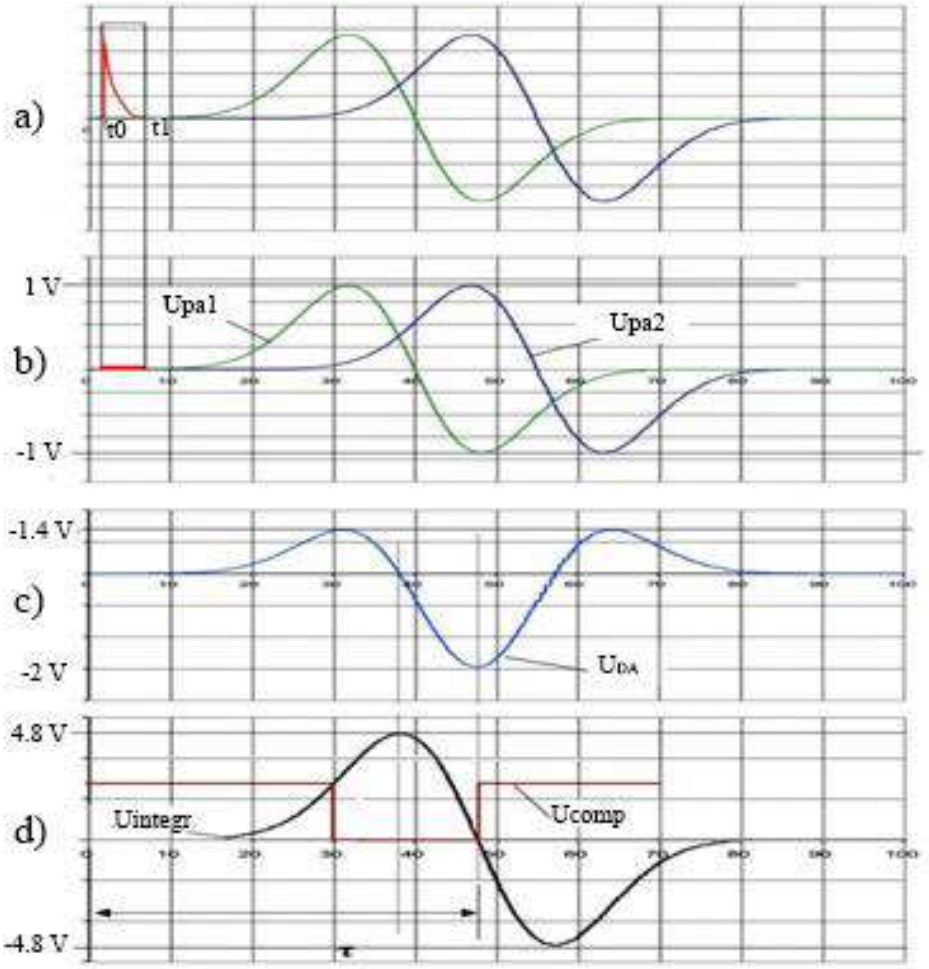

Figure 4. Time diagrams

The principle of operation of ion-label converters is based on the formation in a controlled flow (by pulsed local ionization of its particles) of a brightly colored region (label) with an electric charge, and subsequent registration of signals induced at the receiving electrodes during its movement at a fixed (base) interval.

The PG generator should create labels depending on the pulses coming to it. The spark gap of the generator, or rather its end, should be installed close to the axis of the pipe [3].

Informative signals that come from the recording electrodes during the flight of the base distance mark are pulses of induced current of small magnitude, with an amplitude of about 10^{-9} A. Since these signals are small in amplitude, they need to be amplified. For this purpose, current amplifiers on operational amplifiers are used.

Due to the smallness of the input resistance, the current amplifier has practically no reverse effect on the circuit in which the current is measured. In addition, the influence of the capacitance of the connecting lines is eliminated, since this capacitance is connected in parallel to the low input resistance of the current amplifier and therefore the time constant due to it is very small. The output resistance of the current amplifier is small, as with any voltage feedback amplifier.

The accuracy of the ion-label meter is largely determined by the errors that occur during the registration of the label or the formation of a time interval during which the label passes a fixed base distance, the position of the characteristic point of the signal induced at the receiving electrode.

Therefore, it is advisable to use an ion label recorder made according to a differential scheme (Figure 5). The implementation of the differential principle of signal conversion makes it possible to increase the signal-to-noise ratio. So, if the signals $U_1(t)$ and $U_2(t)$ are an additive mixture of useful signals $q_н(t)$, $q_н(t-\Delta t)$ and interference $\xi(t)$ acting simultaneously on both electrodes, they can be represented as

$$U_1(t) = q_{\text{н}}(t) + \xi(t);$$
$$U_2(t) = q_{\text{н}}(t - \Delta t) + \xi(t),$$

where Δt is the time equal to the transport delay when moving the label from the first electrode to the second.

The difference signal at the output of the differential amplifier will correspond to the expression

$$\Delta U(t) = q_H(t) - q_H(t - \Delta t),$$

from which it can be seen that the interference ξ(t) is subtracted and does not affect the formation of an informative pulse [4].

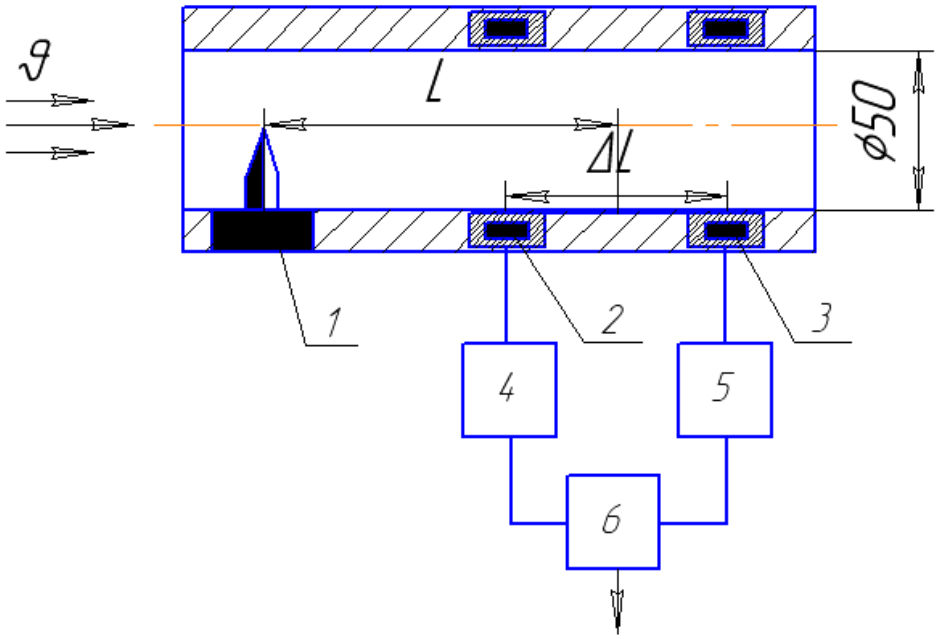

Figure 5. Diagram of the differential ion label recorder

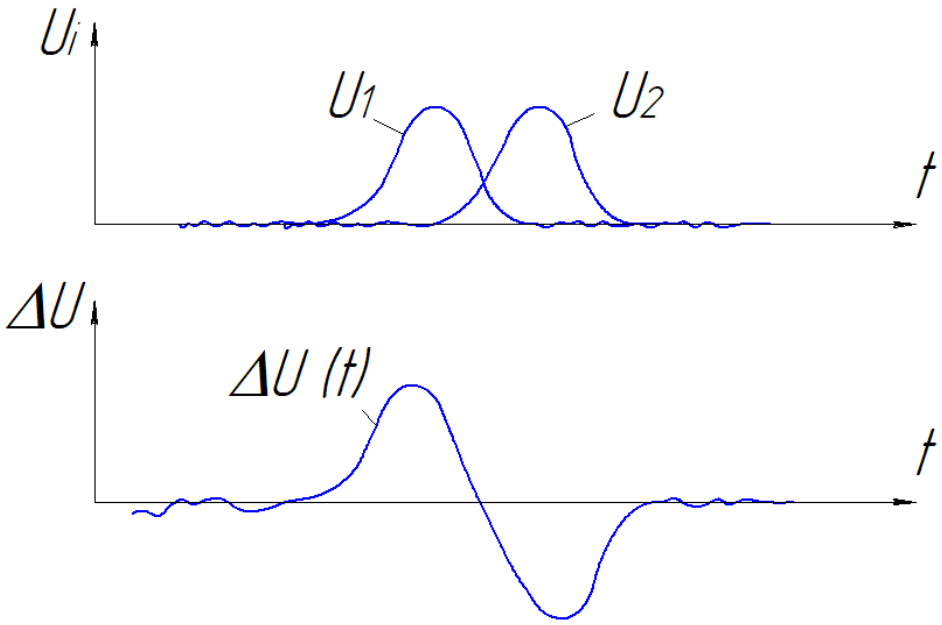

Figure 6. Diagram of the operation of the differential ion label recorder

In this article, the options for implementing an ion-label air flow meter for use in supply and exhaust ventilation systems were considered. An analysis of the block diagram, a description of the work, and requirements for functional nodes were carried out.

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УДК 621.331

ANALYSIS OF THE TRANSFER OF URBAN PUBLIC TRANSPORT TO MODERN ELECTRIC MODELS

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Abstract. One of the main goals of new energy policy in Russia is a course towards deep electrification of the entire economy and social sector of the country. This determines the need to transfer urban public transport to modern electric models. The overview of the use of electric public transport in Russia and abroad is presented in the article. A comparative analysis of the bus, trolleybus and electric bus both from an environmental and technical point of view is made.

Keywords: electric transport, urban infrastructure, electric buses, public urban transport.

АНАЛИЗ ПЕРЕВОДА ГОРОДСКОГО ОБЩЕСТВЕННОГО ТРАНСПОРТА НА СОВРЕМЕННЫЕ ЭЛЕКТРОМОДЕЛИ

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Аннотация. Одной из главных целей новой энергетической политики в России является курс на глубокую электрификацию всей экономики и социального сектора страны. Это предопределяет необходимость перевода городского общественного транспорта на современные электромодели. В статье произведен обзор применения электрического общественного транспорта в России и за рубежом. Выполнен сравнительный анализ автобуса, троллейбуса и электробуса как с экологической, так и с технической точки зрения.

Ключевые слова: электротранспорт, городская инфраструктура, электробусы, общественный городской транспорт.

By 2018, electric buses, which until recently were not taken seriously by anyone, turned out to be the very lever with which you can turn the world of urban transport and drastically influence the development of the oil industry.

One of the most significant trends in the development of the transport industry now is the popularization and mass launch of electric vehicles. The modern level and speed of technology development make it possible to create and mass-produce not only passenger electric vehicles, but also electric public transport, promising not only economically, but also environmentally. Many countries of the world have been conducting research in the field of ecological public transport for almost 20 years, offering their own options or modifying existing ones [1].

Of course, switching to electric transport will significantly reduce the demand for fuel. Diesel-powered buses consume 30 times more fuel than passenger cars, and the introduction of electric buses will have a much greater impact on the energy sector than all cars produced by Tesla, Toyota and other companies combined.

According to calculations by Bloomberg New Energy Finance (hereinafter – Bloomberg), every thousand electric buses will displace about 500 barrels of diesel fuel per day from the market. Considering the most powerful modernization in the People's Republic of China (when 1.9 thousand electric buses were produced in a week, and the same number of them were disposed of), diesel fuel consumption began to decline sharply. As can be seen from Figure 1, as a result of the release of Chinese electric buses, fuel consumption has decreased by almost 37 % over the past 3 years. Therefore, the introduction of an electric bus into the urban public transport fleet is growing all over the world.

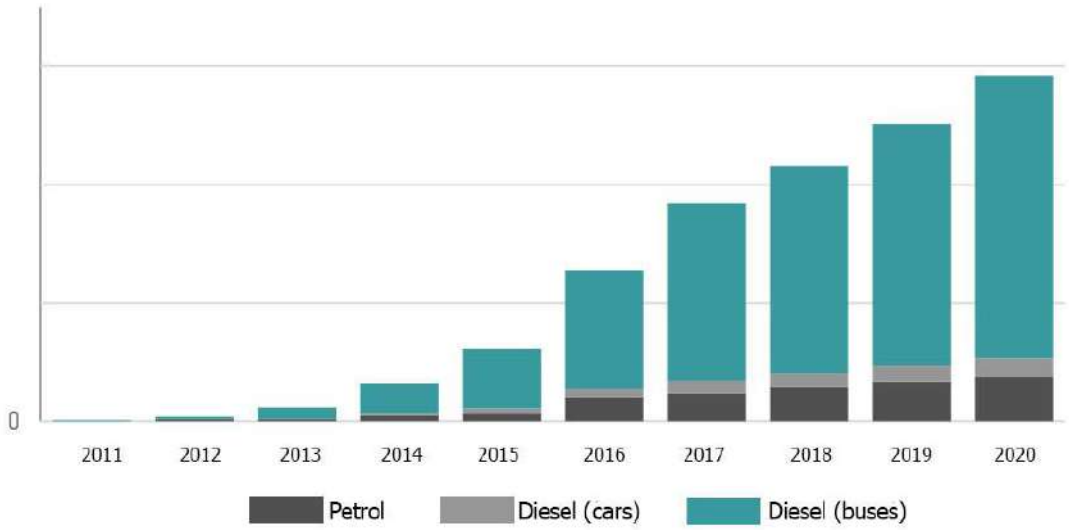


Figure 1. The volume of fuel consumption reduced as a result of the use of electric bus mln bbls/day

The pressure of environmental organizations and international obligations does not weaken, so the purchase of electric buses will be extremely profitable for various countries [2]. The authorities of large cities around the world have been trying to solve the problem of air pollution for a long time. At the

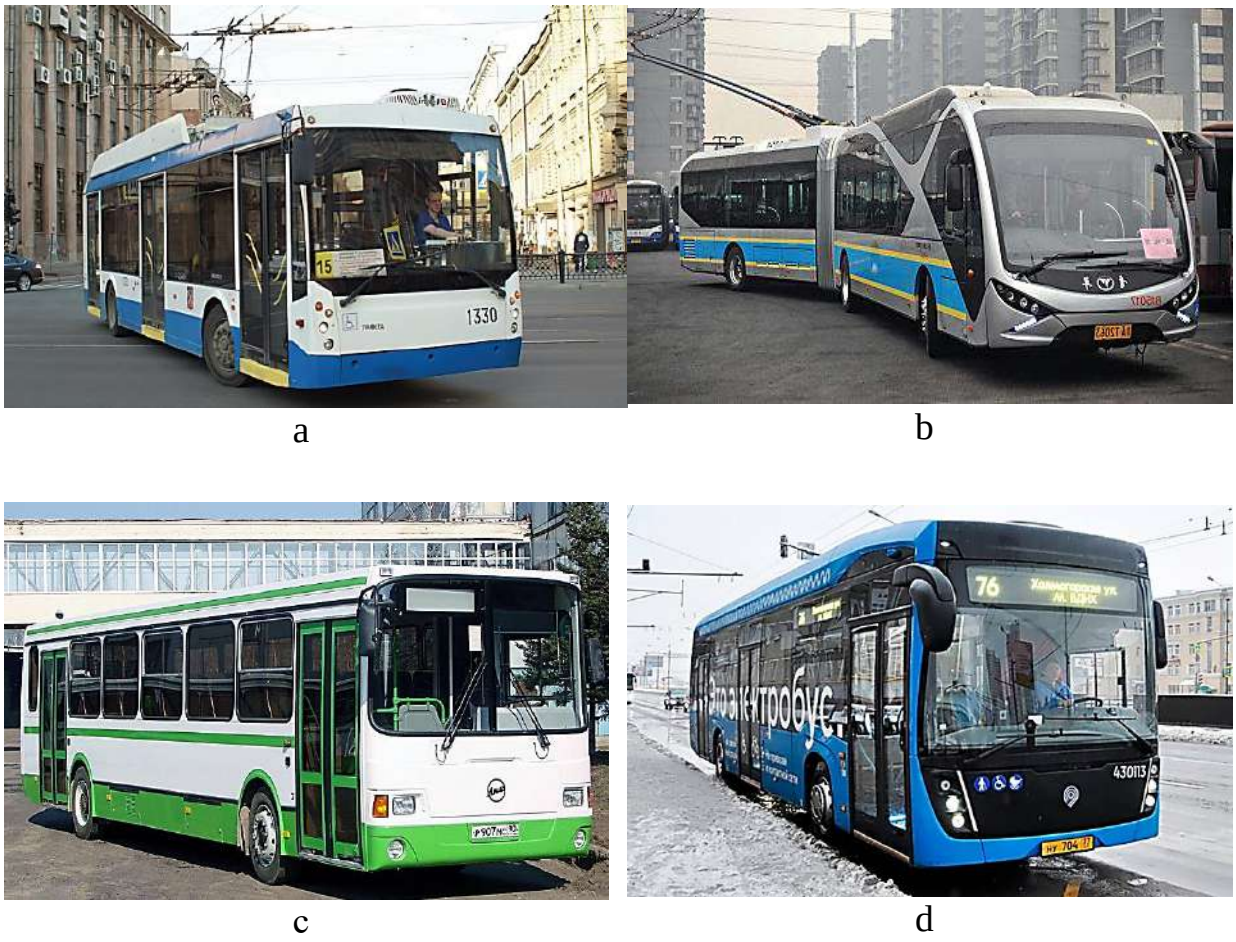
beginning of 2020, electric buses plied the streets of 816 cities in 51 countries. In 2020 alone, more electric buses were registered than in the period from 2012 to 2019.

In 2020, 5.1 % of city buses registered in Western Europe and Poland were battery-powered electric buses. Electric bus registrations increased by 48 % between 2017 and 2019. The municipalities of Paris and Amsterdam also announced the transfer of the entire bus fleet to electricity in the next decade. And in Western Europe and Poland, 2020 was a record year in terms of switching to zero-emission buses. In Western Europe, during the COVID-19 pandemic, the market for battery-powered electric buses increased by 22 %. As of the end of 2021, more than 8.500 electric buses were in operation in Europe.

However, today approximately 98 % of electric buses in the world are used in Chinese cities. In China, the share of electric buses in the public transport fleet is 17 %. In other countries, the staffing of ecological public electric transport is less than 1 %. So, according to a report by the Bloomberg research organization, in 2020 the global fleet of electric buses numbered almost 500.000 cars. Of these, approximately 490.000 are located in China only.

In the cities of the Russian Federation (in St. Petersburg, Kazan, Yekaterinburg, Perm, Rostov-on-Don, etc.), “green” routes began to appear relatively recently. For example, in the Moscow region, the electric bus KAMAZ-6282 has been tested in the Odintsovo branch of Mostransavto since 2018. The company calculated that due to the rarer maintenance, the absence of a number of consumables (fuel, oils, filters, etc.), the operating costs of this machine (in fact, this is only electricity payment) are several times less than the fuel costs for a diesel city bus. However, it should be noted that the cost of an electric bus is three times more expensive than its diesel counterpart and amounts to 25 million rubles, which makes it less attractive from an investment point of view. In addition, in the cold season, up to 80 % of battery charging is spent on heating and interior lighting, reducing the already small power reserve [3].

The growth of the share of electric buses in Russia is hampered by a shortage of semiconductors. But by the end of 2022, the problem should be solved. However, manufacturers may face another obstacle – rising prices for lithium, the main element for traction batteries. After all, the battery is still the most expensive component of cars, accounting for about a third of its cost. In 2023-2024, the intensive introduction of updated models into the fleet is expected (Figure 2).



a b

c d

Figure 2. Appearance of urban public transport:
a – trolleybus, b – trolleybus powered by lithium-ion batteries, c – diesel bus,
d – electric bus

Nevertheless, to solve environmental problems, Moscow plans to purchase 900 electric buses by 2024, and by the end of 2025 to bring 2,500 such vehicles to urban routes. All of them will be equipped with fast charging technology, as well as equipped with modern lithium-polymer batteries, thanks to which electric buses will be able to travel up to 320 km on a single charge. In addition, the charging infrastructure is actively developing in Moscow: there are more than 250 charging points in the city, next year it is planned to integrate 300 new charging stations into the charging infrastructure.

Since May 2016, Moscow has been gradually abandoning the classic trolleybus, and in 2020 it completely closed all its routes and trolleybus fleets. The reason was the electric bus, as it, unlike the trolleybus, is maneuverable and independent of the bus contact network, and is also environmentally friendly.

In comparison with trolleybuses, electric buses have a number of disadvantages:

– significantly more expensive to maintain;

– the resource of electric buses is limited by a very short resource of batteries or supercapacitors;

– lower machine productivity, as part of the working time should be spent on recharging batteries or supercapacitors;

– in winter, considering the heating of the interior, the power consumption increases sharply (about 2 times), a diesel engine is used for heating, i.e. all the disadvantages of the bus (vibration, noise, exhaust emissions into the external environment) are preserved;

– in low temperature conditions, the battery electrolyte should not freeze – that is why the technical solutions for electric buses that are supposed to be used in Moscow include diesel battery heaters, which also reduce the efficiency of cars compared to trolleybuses, which can start moving at any temperature without warming up;

– batteries must be disposed of at the end of their service life, this requires an additional program with appropriate financial support [4].

– However, these disadvantages are not so significant compared to the problems of a trolleybus and a diesel bus. The convenience and environmental friendliness of the electric bus make its use more efficient. For clarity of comparison, the advantages and disadvantages of buses, trolleybuses and electric buses are summarized in Table 1.

Table 1 − Comparison of the characteristics of urban public transport

№	Characteristic	Diesel bus	Trolleybus	Electric bus
1	Mobility	High	Moderate	High
2	Ability to avoid unexpected obstacles	Has	Has the ability to drive autonomously	Has
3	Environmental Safety	Low	High	Moderate
4	Noisiness	High	Low	Moderate, with non-operating diesel sources - low
5	Vibration	High	Low	
6	Performance	High	High	Moderate (decreases due to the need for recharging)

Despite the obvious advantages of electric buses, their production companies are not standing still, trying to come up with new, more advanced models, both with increased capacity (from 40 to 90 passengers) and using

composites that simultaneously reduce the weight of the bus by several tons and reduce its dimensions by 2-3 meters. This allows the electric bus to be more maneuverable and makes it possible to travel on routes inaccessible to buses with a large turning radius.

Based on the conducted research on the development of transport infrastructure in Russia, a number of European countries and China, it was revealed that the public electric transport market can have a positive impact on the development of urban infrastructure. When transferring urban public transport to modern electric vehicles, it is necessary to rely on Russian realities: the specifics of roads, climate, and the degree of congestion.

It is worth noting that at the moment the domestic infrastructure for electric vehicles and urban electric transport is extremely weak, but projects to introduce ecological transport in Russian cities can have a great impact on changing the appearance of the country's transport system.

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УДК 621.311.22

EFFICIENT WAYS TO PRODUCE HYDROGEN

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Abstract. The use of hydrogen as the main fuel or as an additive to fuel gas, is currently seen as the main tool to reduce the carbon footprint. This paper considers ways of hydrogen production. It is shown that the most environmentally friendly is the production of hydrogen by electrolysis.

Keywords: hydrogen, natural gas, alternative fuels, improved efficiency.

ЭФФЕКТИВНЫЕ СПОСОБЫ ПОЛУЧЕНИЯ ВОДОРОДА

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Аннотация. Использование водорода в качестве основного топлива или добавки к топливному газу в настоящее время воспринимается как основной инструмент снижения углеродного следа. В данной статье рассматриваются способы получения водорода. Показано, что наиболее экологически чистым является производство водорода методом электролиза.

Ключевые слова: водород, природный газ, альтернативные виды топлива, повышение эффективности.

The European Union is currently trying to minimize carbon footprint in the energy sector. On July 8, 2020, the EU signed hydrogen strategy, which includes the transition from the use of natural gas to hydrogen [1]. The use of hydrogen is a promising [1]. The use of hydrogen is very promising and can be used as the main and reserve fuel fuel for power boilers of gas and steam at the moment. There is a great potential for transition from gas fuel to hydrogen fuel. This is caused by high energy characteristics of hydrogen [2; 3].

Table 1 – Comparison of methane and hydrogen parameters

Parameter	Hydrogen	Methane
Specific heat of combustion, MJ/kg	140…120	50
Boiling point, K	20,28	111,42
Density under normal conditions, kg/m^3	0,08987	0,6682

Today most industrial companies are focused on improving energy efficiency and decarbonizing their production. Energy efficiency can be achieved by applying new technologies and the replacement of energy equipment. In order to minimize minimization of harmful emissions from energy production, it is necessary to:

- Reduce the amount of carbon in exhaust gases of gas turbines and power boilers;
- Control of carbon formed after the combustion of organic fuel fossil fuel;
- Carbon sequestration and use in the production of useful products;
- Use hydrogen and CO2, CO to create synthesis gases.

An alternative to hydrocarbon fuels (natural gas, kerosene) can be hydrogen. Currently, there are several ways of hydrogen production. The most promising methods are gasification of coal, electrolysis of water, steam conversion of natural gas.

The above-mentioned methods differ in environmental friendliness of production of production and the cost of produced gas.

According to the production method, hydrogen is divided into blue (blue), green and gray.

The figure shows a block diagram of hydrogen production by conversion, gasification and plasma pyrolysis.

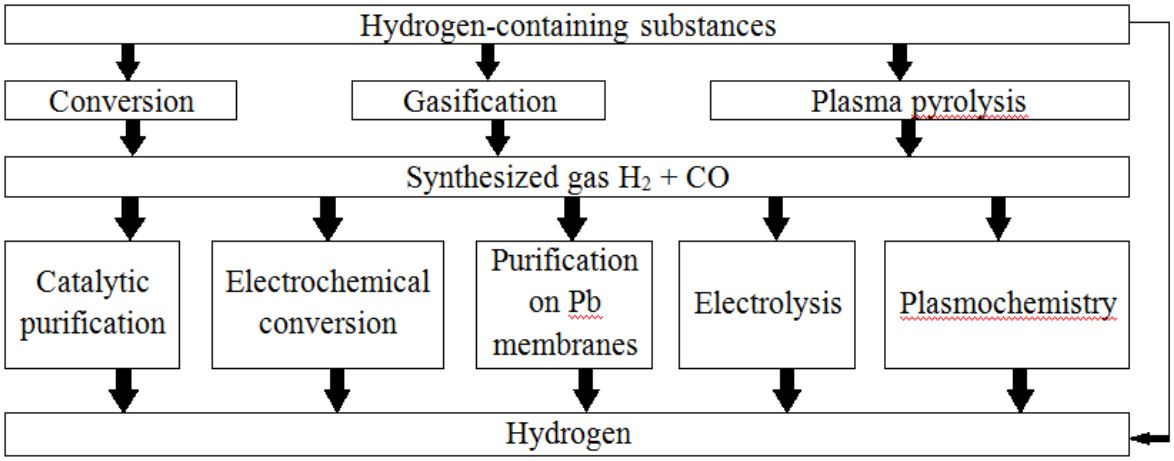

Figure 1. Block diagram of hydrogen production by conversion, gasification and plasma pyrolysis

“Gray” refers to hydrogen produced from fossil hydrocarbons, such as oil, natural gas, and coal. When it is extracted, it is not cleaned of impurities, so its energy performance lowers than that of natural gas. Producing this hydrogen uses a lot of fuel and is therefore less environmentally friendly because production releases a lot of additional CO, CO_2 and NO_x. And these vary depending on the fuel.

However, it is worth noting that this type of hydrogen is the cheapest in production.

“Blue” hydrogen is not much different from “gray” hydrogen. It is the same extracted from natural fossils. The only and important difference is the presence of an additional installation, which allows capturing carbon dioxide from exhaust gases. This system is called “CCS” and stands for “carbon capture storage” [4]. It should be noted that the presence of “CCS” significantly purifies the final product, but makes its production more expensive. It should be noted, that neither “blue” nor even less “gray” hydrogen are uncompromisingly clean fuels. Because even in the case of “blue” hydrogen, in the production process, there is CO, CO_2 and NO_x.

“Green” hydrogen is the cleanest, according to the production method. At the moment there are two main directions of “green” hydrogen production: from biomass and by means of electrolysis of water.

The most environmentally friendly way to produce hydrogen today is electrolysis of water. This method does not emit CO, CO_2 and NO_x, but it is the most expensive way of hydrogen production. This, according to PJSC Gazprom data, to produce 1 cubic meter of hydrogen by methane pyrolysis only 0.7...3.3 kWh, and by electrolysis − 2.5...8 kWh, i. e. almost three times more.

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SECURITY PRINCIPLES OF QUANTUM COMMUNICATIONS

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Abstract. Data transmission technologies are constantly evolving. Now, when we are waiting for the fifth generation of mobile communications, one can hear more and more about quantum communications. Quantum communication is a breakthrough technology in the field of communication, and it is especially distinguished by the almost absolute security in the transmission of information. In this article, I reviewed the principles that ensure the security of quantum communications, and noted their shortcomings.

Keywords: quantum network, cryptography, quantum teleportation, entanglement, communications

ПРИНЦИПЫ БЕЗОПАСНОСТИ КВАНТОВОЙ СВЯЗИ

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Аннотация. Технологии передачи данных непрерывно развиваются. Сейчас, когда мы ожидаем пятое поколение мобильной связи, все чаще можно слышать о квантовых коммуникациях. Квантовая связь является прорывной технологией в сфере связи, и особенно ее выделяет практически абсолютная безопасность при передаче информации. В этой статье мы рассмотрели принципы, обеспечивающие защищенность квантовых коммуникаций, и отметили их недостатки.

Ключевые слова: квантовая сеть, криптография, квантовая телепортация, запутанность, коммуникации.

Now there are many methods of data encryption necessary to protect the transmitted information. They all work according to the same scheme – before

being sent, the data is encrypted according to certain rules, and then the recipient decrypts it using an encryption key that acts as an instruction for decryption.

In modern systems, the key is transmitted along with the encrypted message over one channel, and it is encrypted in accordance with either some algorithm, or using asymmetric cryptographic algorithms with a public and private key. In both cases, the calculation is that decryption without knowing the keys will take too long and require large computing power. One of the most common methods is the use of public key cryptography. It is based on the use of one-way functions – such functions where x from y is quite easy to calculate, but y from x is impossible under current conditions. However, in the end, the protection of such algorithms is not absolute – even the most complex functions can theoretically be calculated.

Quantum communication is one of the options for solving this problem. The use of the laws of quantum physics [1; 2] makes it possible to make the transmission itself impossible for hacking and wiretapping. Quantum communications are based on two principles – quantum teleportation and quantum entanglement [3]. Quantum teleportation is the transmission of a quantum state over a distance using an entangled pair separated in space and a communication channel, in which the state of a quantum system is destroyed during measurement and recreated at the receiving point.

It is necessary to explain what an entangled pair is. Quantum entanglement is a phenomenon in which the quantum states of two or more systems become dependent on each other. For example, when changing the parameter of one element of the system, these changes will affect the other, and vice versa. The quantum state of individual subsystems cannot be written without considering other subsystems, and the state of a global system cannot be represented as a linear combination of subsystems. At the same time, the phenomenon of quantum entanglement persists regardless of the distance between systems.

Quantum teleportation occurs as follows: the sender has particle A, which is in an arbitrary quantum state, and he wants to transfer this state to the recipient, that is, particle B in the same quantum state as particle A. An entangled pair of particles C and B is born. One particle (B) is sent to the recipient, the other (C) to the sender. The sender measures the states of the system of particles A and B, while the entanglement is destroyed, and the particle B takes on a certain quantum state. It remains to transfer the measurement result of the system AB to the sender, and he, knowing the state of the system AB and particle B entangled with C, can restore the initial state of particle A. At the same time, it is impossible to intercept the data - if you try to measure the state of a particle from an entangled pair, this will destroy their entanglement.

This is how quantum communication works. The data is encoded in the states of a photon, which, in accordance with the laws of quantum mechanics, change irreversibly when trying to measure. For quantum communication, you can use any object that can be in two different quantum states, but due to the spread of fiber optic networks, photons are most often used. For quantum communication, data is encoded in single photon states, such as polarization or phase. Opposite values are taken as 1 and 0, respectively.

For example, I will give the BB84 protocol. Let us call the recipient Bob and the sender Alice. Polarized photons are used to transmit information. Alice polarizes photons in two different bases – at an angle of 0 and 90 degrees, or 45 and 135 degrees, and she chooses the bases randomly each time. Bob then receives photons and measures their states, also choosing bases randomly. After that, Alice tells Bob the set of used bases over an open channel, Bob discards the bases that did not match and tells Alice which data did not pass. Despite this, Alice and Bob have a key – the same sequence of zeros and ones. When trying to intercept information, it is necessary to measure the polarization of photons, which will change its value, which will lead to an error. In the case of the BB84 protocol, the allowable error rate due to various reasons is 11 percent, if it is higher, then the channel is considered to be listening.

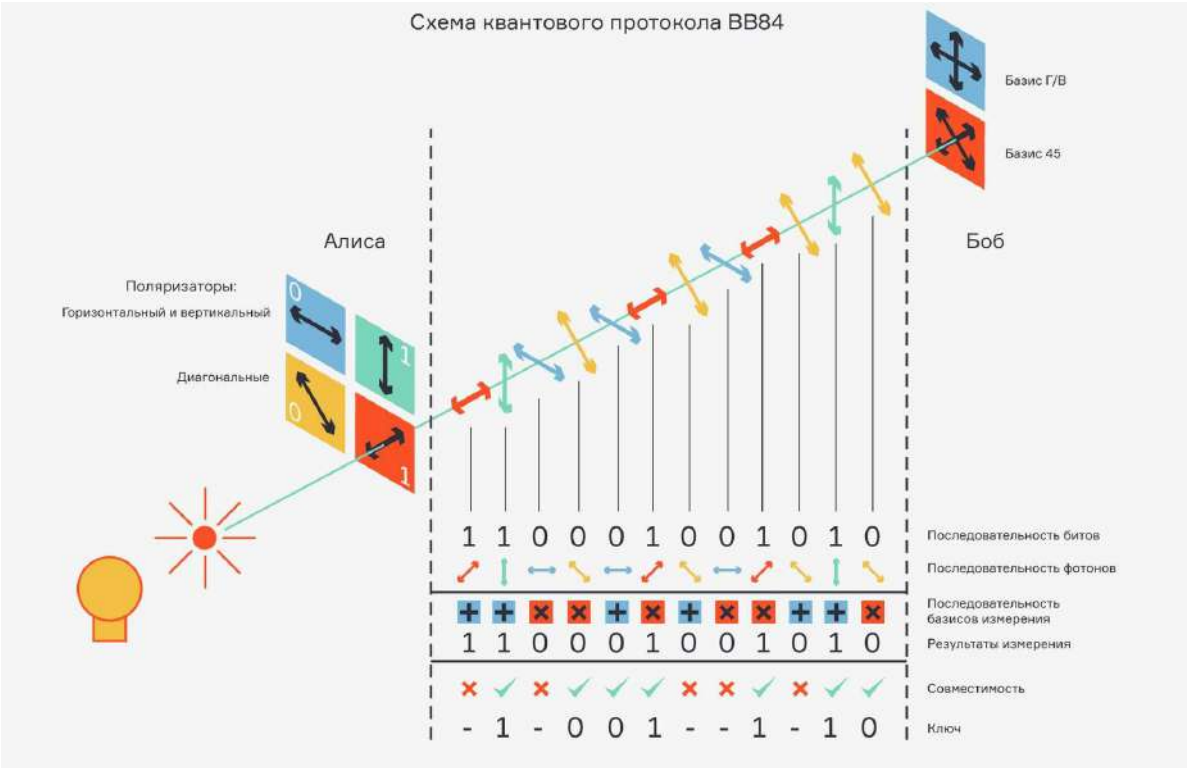

Figure 1. Scheme of the BB84 protocol

There are other protocols that somehow increase the efficiency of data transmission using quantum communication, but only the E91 protocol uses the

phenomenon of quantum entanglement (because creating entangled pairs of photons is a non-trivial task).

The shortcomings of quantum cryptography are inherent in the essence of the physical processes that provide quantum communication. The first and most serious is the transmission distance. Data loss in a fiber optic cable increases exponentially with length. At the same time, if an ordinary signal can be repeated or amplified, this is impossible in the case of quantum communication. The receiver must receive the original photon without any modification. Therefore, the existing quantum networks mainly provide secure communication over distances of tens of kilometers, and their speed does not exceed one bit per second.

The solution to this problem can be the creation of trusted nodes that will receive, read and repeat the data further, or the use of satellites, since photon losses in space are small compared to optical fiber.

Also, the development of quantum communication is hindered by the availability of cheap photon receivers and transmitters, in connection with which developers have to find a compromise between speed, radiation uniformity and signal frequency.

In addition, despite the seeming impossibility of hacking, current systems have vulnerabilities. For example, ID Quantique's quantum communications system was hacked by blinding a photon detector with strong laser pulses. However, despite the presence of vulnerabilities, the use of quantum communication greatly narrows the range of opportunities for attackers due to the hardware qualification.

Quantum communication systems have many shortcomings, but it remains one of the most promising areas for the development of global communications.

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SUPERCONDUCTOR APPLICATIONS IN SPACE

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Abstract. Superconductors are widely used in many areas of everyday life, from MRI machines to high-speed trains. The basics of physics of low-temperature and high-temperature superconductors are presented. The working principle of superconducting foam, method of its creation, operating conditions and effective application in the space industry are described.

Keywords: superconductor, space plants, chemical elements, foam, compounds.

ПРИМЕНЕНИЕ СВЕРХПРОВОДНИКОВ В КОСМОСЕ

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Аннотация. Сверхпроводники широко используются во многих областях повседневной жизни, начиная от аппаратов МРТ и до высокоскоростных поездов. В статье представлены основы физики низкотемпературных и высокотемпературных сверхпроводников. Описан принцип работы сверхпроводящей пены, метод ее создания, условия эксплуатации и эффективное применение в космической отрасли.

Ключевые слова: сверхпроводник, космические установки, химические элементы, пена, соединения.

In many areas of daily life, from MRI machines to high-speed trains, where magnets are used to lift trains off the rails and reduce friction, a superconductor - a superconducting material, i.e. a state of matter in which there is no electrical resistance and no magnetic fields pass through it, while the electric current in the superconductor can be maintained indefinitely.

Superconductors are divided into two main categories: low-temperature superconductors (LTSC), also known as conventional superconductors, and high-temperature superconductors (HTSC), or unconventional superconductors.

NTSP can be described by the Bardeen-Cooper-Schriffer superconductivity theory to explain how electrons form Cooper pairs, while HTSP use other microscopic methods to achieve zero resistance [1].

The discovery of so-called high-temperature superconductors greatly advanced research. The original superconductors required temperatures at the level of absolute zero, and these can only be achieved by cooling the materials with an expensive cooling gas, such as liquid helium. But high-temperature superconductors (namely relatively high-temperature, not absolutely high-temperature) can be cooled with liquid nitrogen, which is 10 times cheaper to produce. Many applications that were not economically viable suddenly became much more practical when high-temperature superconductors were discovered, but other certain conditions, such as high pressure, low material brittleness, and small size, are also needed to use superconductors. To meet these conditions, superconductors were made in the form of foam (Figure 1) [2].

Figure 1. An example of superconducting foam

E. Reddy and J. Schmitz in 2002 made a prototype foam with a strong and stable magnetic field. It can be used to produce superconductors of almost any size, which will be light and strong. The low weight and small amount of materials required significantly reduce the cost of this product, and the small size of the required substance significantly reduces its price. The porous structure makes it possible to cool the foam quickly, which is very important for superconductors.

Scientists from Japan and Germany, including a researcher from the Krasnoyarsk Scientific Center SB RAS, described the production of large samples of superconducting foam, which can give a stable, uniform and sufficiently strong magnetic field [3]. This allows the foam, despite the fact that it has large dimensions, to show approximately the same properties that conventional superconductors have. Due to the above, the superconductor made

in the form of foam can be effectively used in outer space and in space installations (satellites, rockets, etc.).

In order to obtain superconducting foam, it is necessary to create a polyurethane structure with pores. It is impregnated with the chemical elements that superconducting materials have: yttrium, barium, copper and oxides. First of all, they are soaked in polyvinyl alcohol (at home − PVA glue). After saturation, the resulting foam is annealed until the polyurethane is completely burned out. After that, there remains a compound that is close to a superconductor in its properties, but it is not yet a superconductor. Finally, the superconductor (superconducting crystal) is placed in the center of the resulting structure, after which it is finally heated.

Low weight of materials is important for spacecraft, and the resulting foam is unusually light. 90 % of the foam are pores, and only 10% are the conductor itself, so it is 10 times lighter than a conventional superconducting material [4]. Such foam can be used in satellites, or in the docking of spacecraft, because the superconductor has an external magnetic field, with the help of which control, you can make the control of docking, docking or repulsion. Two other devices deserve special attention – superconducting accelerometer and superconducting gravimeter [5]. The accelerometer is being developed as a sensor for gravitational-wave antennas. The predicted sensitivity is impressive, and the device can also be used for inertial navigation. The gravimeter is a working device that is already contributing to ground-based research. An attractive feature of this device is its very low drift, making it the only gravimeter capable of low-frequency measurements. It would be especially interesting to observe changes in the gravitational field of the Moon and other planets, since the normal human-generated earth noises. do not cause any interference. A superconducting gravimeter would allow such observations to be made at the lowest possible frequency.

Obviously, in the future, studying samples of the obtained foam, which combines existing approaches of modeling the mechanical properties of the foam metal with modeling the flow of superconducting current. Thus, superconducting foams may in the future generate large magnetic fields in space experiments.

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УДК 620.91

EVALUATION OF THE LIFE CYCLE OF SOLAR POWER PLANTS

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Abstract. The purpose of this work is to assess the life cycle of solar power plants. Methods of assessment, methods of disposal of spent elements and their impact on the environment are also considered in the paper.

Keywords: solar energy, electricity, economy, problems, disadvantages, batteries.

ОЦЕНКА ЖИЗНЕННОГО ЦИКЛА СОЛНЕЧНЫХ ЭНЕРГОУСТАНОВОК

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Аннотация. Целью данной работы является оценка жизненного цикла солнечных энергоустановок. Также в работе рассмотрены способы оценки, способы утилизации отработавших элементов и их влияние на окружающую среду**.**

Ключевые слова: солнечная энергетика, электроэнергия, экономика, проблемы, минусы, аккумуляторы.

Solar energy plays a special role in the total volume of renewable energy sources, on the example of which we will make an assessment of the life cycle.

The life cycle of existing and newly built power plants, including solar ones, is determined not only from the point of view of energy, but also ecology.

Currently, there is a tendency of intensive growth in the introduction of capacities of newly built solar power plants. For example, in 2004 their total capacity was 1.4 GW, and after 6 years, in 2010 it increased more than 16 times and amounted to 22.7 GW. In accordance with forecasts [1], this growth will

continue, and by 2030 it will reach 1,480 GW of installed capacity, and 4,600 GW by 2050.

Taking into account this trend, it is necessary and important to make an assessment of the life cycle of both existing and new photovoltaic plants.

The Intergovernmental Panel on Climate Change assessed the emissions of major greenhouse gases (CO2, CP4, N2O, etc.) and concluded that their increased content in the Earth's atmosphere leads to an increase in the average annual temperature of the planet, which leads to serious natural disasters (typhoons, droughts, flooding of territories as a result of increased precipitation, etc.). However, it is quite difficult to quantify these emissions, because they are visually invisible.

One of the ways to calculate and determine the main emissions in order to take further measures to reduce them is to assess the life cycle of a photoelectronic converter.

When calculating the life cycle, it is necessary to take into account a wide range of variables, which complicates obtaining accurate and reliable results. The study and analysis of the studied factor consists of the following stages (Figure 1):

1. Determination of the purpose and scope of the survey.
2. Analysis of the survey.
3. Environmental impact assessment.
4. Interpretation.
5. Conclusions and recommendations.

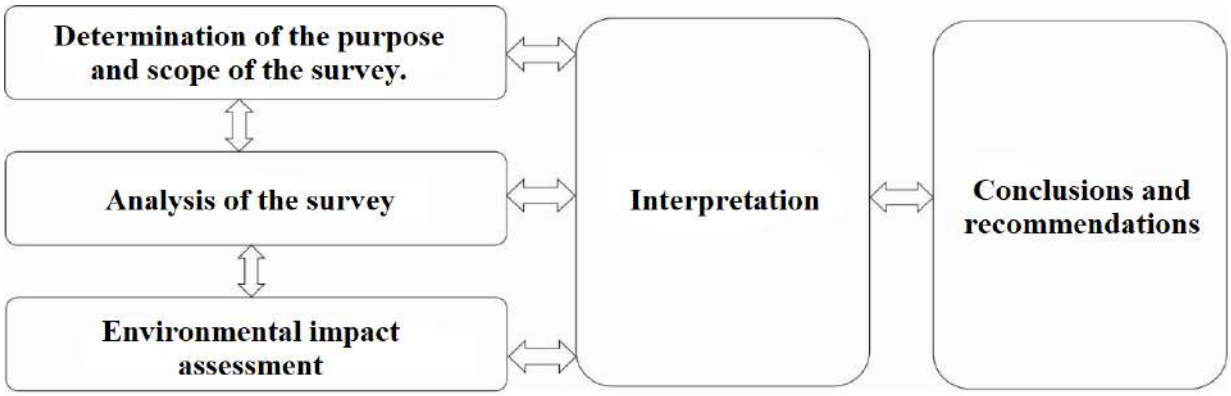

Figure 1. Stages of life cycle research

The life cycle of a solar power plant is regulated by ISO 14040 and ISO 14044 standards [2] and includes the period from the development of primary energy until the decommissioning of a solar power plant and the disposal of its components and equipment (Figure 2). The period of primary energy development (fuel extraction stage) for solar power plants is not considered, because, production electric energy is not used during the conversion of solar radiation at a solar power plant.

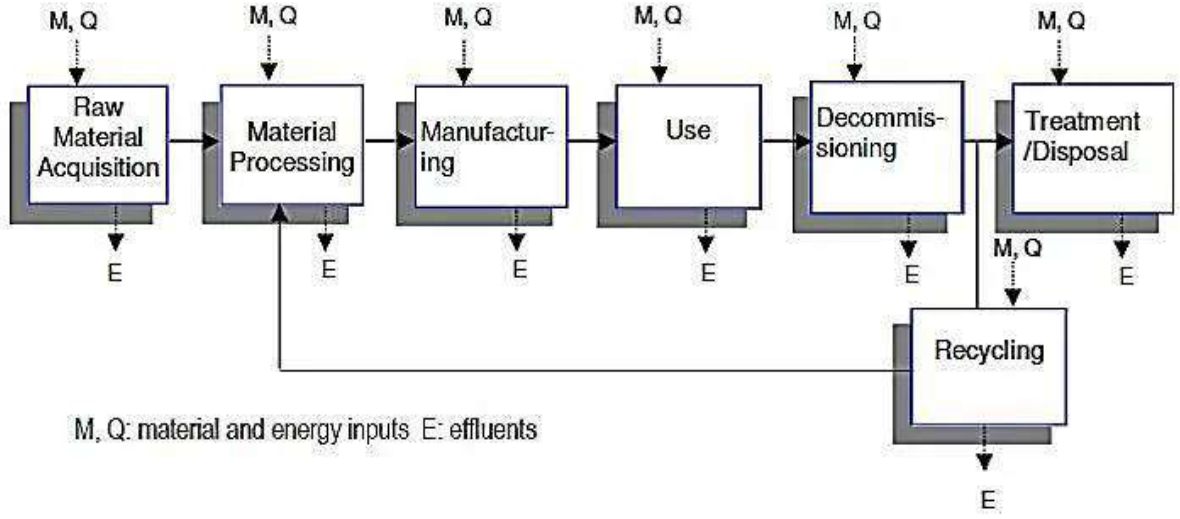

Figure 2. Structure of the life cycle of solar power plants

An important stage of the life cycle of a solar power plant, which must be taken into account, is the construction of plants for processing primary raw materials and the production of solar modules. Further, the life cycle includes consideration of the preparation of territories for the placement of solar panels, their transportation to this territory, installation of modules and auxiliary equipment, adjustment of the production process and energy generation. The completion of the life cycle is determined by the stage of decommissioning of the solar power plant.

When using silicon technologies, a large amount of energy is spent on the purification and processing of metallurgical silicon (Si) to a purity class of more than 99.999999 % (solar gradation).

Thin-film technologies for the production of solar modules based on CdTe, A-Si and ClGS require less energy. This is explained by the fact that the thickness of the active zone of solar energy conversion in solar cells is about 100 times less than the thickness of the same zone in silicon solar cells. In addition, metals such as cadmium or tellurium, necessary for the production of solar modules, are obtained mainly as co-products in the processes of smelting copper or other components. [3].

Accounting for energy costs at the first stage of solar power plants currently in operation is practically impossible, since most of them were put into operation using early stages of silicon production technologies.

Another important indicator of the efficiency of photovoltaic power plants, by which all heat and electricity production technologies are compared, is the intensity of CO2 emissions. However, with regard to solar power plants, this indicator will be minimal or somewhat conditional, since the production of

electricity on them is not associated with greenhouse gas emissions into the atmosphere. In this sense, the use of photovoltaic plants to solve environmental issues will be the most justified and promising.

For existing solar power plants, the life cycle duration is quite difficult to estimate. As a rule, for such stations, according to the International Energy Agency, the average duration is 30 years.

With an increase in the service life, the efficiency of photovoltaic cells begins to decrease, and after about 30 years, the question of their replacement or disposal will seriously arise. Such a problem began to seriously affect after 2020, when the volume of waste from the use of solar modules amounted to about 132750 tons. [4]. This, first of all, will be observed in Germany, which in previous years was a leader in the introduction of solar energy capacities. For it, the number of solar modules to be disposed of may amount to more than 42 thousand tons per year. About 90 % of the waste from the modules is glass, the processing of the remaining components – cables and semiconductor materials also require serious costs.

To date, there are no legislative and regulatory documents on the disposal of waste from the production of solar modules and electrical equipment. Therefore, it is required not only the adoption of urgent legislative acts and regulatory measures for the decommissioning of solar energy equipment, but also the creation of additional enterprises for the disposal of such elements and equipment.

It should be taken into account that such measures will create additional greenhouse gas emissions into the atmosphere and this fact has yet to be assessed when determining the life cycle of a solar power plant.

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УДК 332.055.4

COMPARATIVE ANALYSIS OF THE DYNAMICS OF OSH REGION DEVELOPMENT IN THE ASPECT OF DIGITALIZATION OF THE ECONOMY

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Abstract. The article examines the features of the digitalization process of the Osh region of the Kyrgyz Republic based on the generalization of the scientific provisions of the theory of regional economy. The study made it possible to identify bottlenecks for the eGffective digitalization of the Osh region's economy. Analyzing the current situation through this prism will allow building long-term plans for the region of Kyrgyzstan and seeing the picture in perspective.

Keywords: digital economy, digital platform, information and communication technologies, Osh region, regional economy.

СРАВНИТЕЛЬНЫЙ АНАЛИЗ ДИНАМИКИ РАЗВИТИЯ ОШСКОГО РЕГИОНА В АСПЕКТЕ ЦИФРОВИЗАЦИИ ЭКОНОМИКИ

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Аннотация. В статье исследованы особенности процесса цифровизации Ошской области Кыргызской Республики на основе обобщения научных положений теории региональной экономики. Исследование позволило определить узкие места для эффективного процесса цифровизации экономики Ошской области. Анализ текущей ситуации процесса цифровизации через данную призму позволит выстроить долгосрочные планы для региона Кыргызстана и увидеть картину в перспективе.

Ключевые слова: цифровая экономика, информационно-коммуникативные технологии, Ошская область, цифровая платформа, цифровизация.

Digitalization is a global process that characterizes a new era. Currently, digitalization is one of the global trends, and the practice of introducing new digital technologies is gaining more and more momentum.

It should be noted that the content of the concept of “digitalization” has evolved from the “interaction of people and machines” to the transformation of almost all spheres of human activity into a new digital world. Currently,

digitalization includes such components as the economy platform, the economy of shared consumption and gigonomics in the totality of information and communication technologies (ICT), software, services and business processes [1, p. 220].

Today, the process of digitalization in Kyrgyzstan is experiencing great difficulties. This is evidenced by complaints and discontent on the part of citizens due to bureaucracy in obtaining public services. Special attention is paid to the formation of a policy focused on the structural restructuring of the economy of the region of the Kyrgyz Republic based on the introduction of high-tech technologies and digitalization. Which allows us to revive the importance of industrial sectors as the foundation for solving strategic tasks for the modernization of the country [2, p. 88].

It is obvious that the effectiveness of digitalization is determined by the active investment policy of the region [3, p. 333]. The implementation of such a policy involves analyzing the current state of sectoral development and technological readiness of economic entities in the region, in particular Osh and Osh region of the Kyrgyz Republic, to meet the requirements of the digital age [4, p. 350].

In the economic literature devoted to the development of the productive forces of territorial systems and the study of factors directly or indirectly affecting their spatial location, as well as the patterns of transformational processes, new paradigms of regional governance in the era of digitalization are highlighted. Such features are associated primarily with the change of technological patterns in production and management, forming new relationships between the elements of the economic system of the regions, changing the institutional environment of the subject of the country and its constituent municipalities [5, p. 152].

The purpose of this study: based on the theoretical postulates of the regional economy, to analyze the current trends and specifics of the development of the Osh macroregion of the Kyrgyz Republic and, including the city of Osh, in the aspects of digitalization of the territorial space of the country.

The work is carried out on the bases of generalization of theoretical positions, collection, processing and interpretation of statistical data, as well as their graphical visualization, allowing to formulate conclusions about the subject of research. Despite the significant fragmentation and blurring of the key concepts of digitalization, as well as the process nature of the formation of individual categories, the author is considered it appropriate to carry out a selection of parametric data, collectively capable of giving a systematic view of the development of the region's economy in the era of digitalization. Predictive analytics methods were used for data processing, which made it possible, based on the structuring of data with different metrics, to visualize current trends and specifics of the development of the Osh region.

The development of the digitalization process in the city of Osh and the Osh region is catching up with the city of Bishkek, but it is better than in other regions and settlements of the Kyrgyz Republic. The main hindering factor for

the growth of ICT in the region is the low level of understanding in the private and public sector of the role of digitalization. Even with Internet access, as well as the lack of practical skills and understanding of step-by-step instructions for including advanced technologies in strategic plans, the creation of departments, the compilation of functional responsibilities and the introduction of IT specialists in organizations.

To date, specialists who are trained in IT professions do not know where they could get a job after completing the courses, do not find jobs by profession in the region and are forced to undergo internal migration to the city of Bishkek or go abroad**.** Thanks to the openness of data, new projects in this area are emerging, such as at the municipal level, the Osh City Hall uses its own website and the OshCity application to interact with the population, respond to the needs of the population through a cartographic service http://www.map.oshcity.kg.

In the future, the Osh City Hall plans to initiate the introduction of building information modeling and construction Business Information Management (BIM), which will allow better management of the city's housing. To date, the first seminars on the use of BIM using the LIRA- computer-aided design (CAD) software package are being held in Bishkek.

A large amount of data has generated a whole concept of Big Data, because of which data science and business intelligence are based. The Internet of Things and social media are recognized as classic sources of big data, it is also believed that big data can originate from internal information of enterprises and organizations (generated in information environments, but not previously preserved and analyzed). The Internet of Things includes all telemetry devices connected to the Internet, including CCTV cameras. The Safe City project is one of the main generators of big data in Kyrgyzstan, whose potential is not fully used for decision-making. In addition to government data, there are also private ones. Telecom operators and commercial banks have the most structured data. Commercial and public use of depersonalized aggregated data would open up great opportunities for evidence-based decision-making.

There are no data centers in Osh that would provide data storage and processing services. However, there is evidence that telecom operators and Internet service providers have space to host client servers, and financial institutions have their own server rooms.

Local enterprises providing cloud storage, hosting and software services as a SaaS, IaaS, PaaS service have not been noticed in the Osh region. Most organizations use their own spaces to store small amounts of data.

Companies from Osh use the services of Bishkek companies or foreign hosting sites such as Google Drive, Yandex Disk, Mail.ru Cloud, Amazon AWS, Digital Ocean in the implementation of export-oriented projects. In Osh, Internet service providers have not yet started providing IP video surveillance and data storage services “in the cloud”, the demand for which is starting to grow in Kyrgyzstan [6, p. 25].

According to the National Statistical Committee, the share of production in the city of Osh and the Osh region in 2021 was only 6 % [7, p. 15]. According

to UNIDO, the potential for industrial development of the Osh region is “the expansion of the food industry (vegetables and fruits, milk and meat) and the creation of regional logistics centers, the expansion of the production of construction materials, the development of the extractive industry and the further development of coal reserves”. For the period from 2018 to 2023, the financing and launch of projects for 25 million US dollars in the city of Osh and 1.5 billion US dollars in the Osh region are planned. The growth is mainly expected due to the construction of a section of the Kyrgyzstan-China gas pipeline.

To stimulate these areas, the Kyrgyz-Russian Development Fund provides concessional financing directly or through intermediary banks or takes an equity participation in the company.

In the light industry of Kyrgyzstan, textile companies use CAB systems used for modeling, designing and preparing for the production of clothing and footwear. The factories are equipped with the latest equipment, but there are not enough qualified specialists. Educational institutions of the city of Osh can cover this niche in the southern region of Kyrgyzstan.

In general, according to observations and expert assessment, there is no systematic interaction between representatives of industry associations and the IT sector in the Osh region.

On the one hand, companies may not realize the value and role of information technology in stimulating sales, promoting trademarks, increasing the competitiveness of the enterprise through the optimization of work processes, digitalization of working moments. It seems that for decision makers it is necessary to explain what search engine optimization, social media marketing, copywriter, companies still consider specialists with skills in working with digital media as a separate profession. This is confirmed by the job vacancies at the “PC Operator”. Company executives consider the role of IT highly, but do not realize how to use the full potential of the Internet in the business environment for the purposes of the enterprise.

On the other hand, the cost of the proposed foreign IT solutions is high, and suitable solutions for the price group and functionality are not represented on the local market or are not created by local companies, developers.

Payment systems are an important component for the development of the digital economy. The development of such systems makes it possible to make indicators measurable. In the Osh region and the city of Osh, all payment systems, bankcards and electronic wallets available in the Kyrgyz Republic are functioning. In proportion, the cards used in the region account for 15.7 % of all in circulation. The most popular bankcards are Elcard, Golden Crown, and Visa.

According to the data of the National Statistical Committee on 2020 (see Figure 1), 2 119 ICT companies that are registered as individual entrepreneurs operate in the Osh region. The dynamics in the number of medium and large enterprises over the three observed years remains relatively unchanged. However, there is an increase in the number of individual entrepreneurs and small enterprises in the field of ICT.

From the 2,119 ICT companies in Osh, 87 % are individual entrepreneurs, small enterprises 9 %, medium-sized 2 % and large 3 % of enterprises. Large and medium-sized enterprises in the region include regional and district branches of telecom operators, Internet service providers.

After analyzing the profiles of companies, it was found that integrators of foreign IT solutions are very popular; in particular, solutions for accounting and automation of enterprises of the Russian company 1C. The most well-known 1C products are the management and accounting program “1C: Enterprise”, CRM systems “1C-Bitrix” and “Megaplan”. Local companies Service Kg, OsOO Dos and Reverse Group carry out the integration of solutions. They offer employment for 1C programmers and training courses. The clients of these companies are trading enterprises, the service sector, manufacturing enterprises, pharmaceuticals, and tourism and budget organizations.

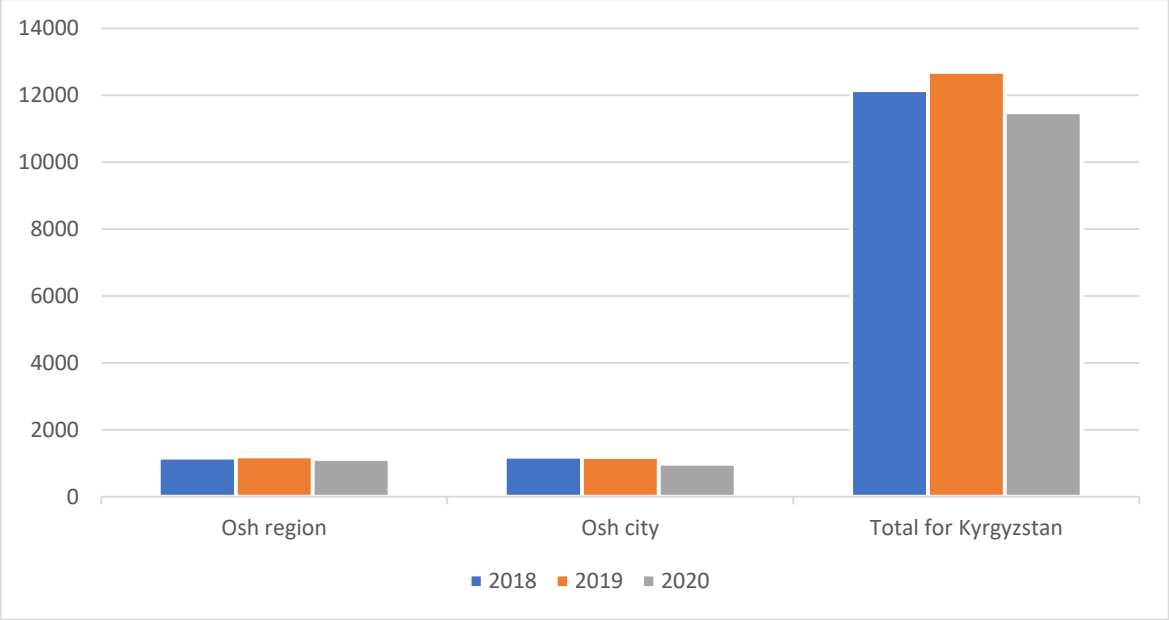

Figure 1. Analysis of the dynamics of ICT enterprises of the Osh region

The computer service of enterprises and organizations is characterized by the presence of local area networks (LAN), Internet access, e-mail and Web sites.

In 2020, more than half of the local area networks available in the region (52 %) operated at state-owned enterprises, organizations and institutions.

Table 1 – Analysis of economic indicators of ICT development of enterprises and business entities in the Osh region and the city of Osh for 2019-2020

Digitalization indicators	**Years**	
	2019	**2020**
Number of enterprises and organizations using ICT (units)	2 400	2 119
Number of employees at enterprises and organizations using ICT (people)	88 336	86 651
Number of specialists of enterprises and organizations engaged in ICT (people)	3 191	2 365
Salary fund of employees of enterprises and organizations using ICT (thousand USD)	156,814	168,659
Salary fund of specialists of enterprises and organizations engaged in ICT (million USD)	4,624	11,662
Total costs of enterprises and organizations, using ICT (millions USD) *including for the development and use of ICT (millions USD)*	392,815 3,0	444,296 3,36
Availability of personal computers in enterprises and organizations (units)	31 525	32 400
Number of personal computers purchased (during the year, units)	2 752	1 734
Local area networks (units)	1 626	1 779
Specialized software tools (units)	646	745
Availability of e-mail (units)	1 313	1 447
Number of Internet access points (units)	2 782	2 862
Availability of own Web site (units), *including those providing on-line services*	144 62	164 67
Number of websites with Kyrgyz language content (units)	40	45
Number of plastic cards in circulation (units)	469 211	556 112
Number of ATM (ATMs) (units)	254	295
Number of POS terminals (units)	1 001	1 059

More than 50 % of Internet access points were owned by economic entities with a state form of ownership, of which 30 % were used to work in ADSL mode and on dedicated lines.

As can be seen from Table 1, Osh lacks a sufficient number of specialists in the field of network administration, management of high-load networks, administration of data centers, cloud technology management, and so on. Local companies do not have sufficient expertise and organizational structure to attract foreign investment and create enterprises in the field of telecommunications solutions. At the same time, the growth of digital television and the consumption

of highly loaded content in the form of videos creates the need for data storage services close to customers.

The assessment of the regional SWOT analysis is carried out according to the criteria of geography, economy, infrastructure; skills (see Table 2).

Table 2 – SWOT analysis on digitalization of the Osh region

Strength: ➢ The rapidly growing young population of the region ➢ Presence of trunk lines ➢ Internet service providers ➢ Availability of educational infrastructure ➢ Geographical location ➢ Accessibility of school education and high level of literacy	Weakness: ➢ Weak regional ICT infrastructure ➢ Lack of skills and personnel to build ICT infrastructure ➢ Low level of understanding and demand for IT among businesses and government agencies ➢ The level of training staff is low ➢ Low level of cooperation between business and the academic world in creating new solutions, conducting research
Opportunities: ➢ Positioning as a regional educational hub for the Fergana Valley ➢ Availability of funds for the implementation of DCASA - 50 million USD ➢ The state as a platform opens up opportunities for local companies ➢ Growing domestic demand for IT specialists and companies from the Hi-Tech Park (Bishkek) ➢ The growing need for digital skills of the state ➢ Support of donors of the digital agenda of the state ➢ The global trend in automation and robotics may arouse interest in professions in the IT sector	Threats: ➢ The pace of digitalization of the economy and the need for ICT specialists can be extremely slow ➢ The presence of regular power outages can be an obstacle to the adaptation of technologies and the use of digital platforms ➢ Stratification of society - IT skills are understood and accessible only to educated families, migrant children remain out of the field of access ➢ Decrease in the overall competitiveness of key sectors of the region's economy

Among the strengths of the region is the most dynamic growth of the young population in the republic. According to the National Statistical Committee, the highest rates of natural growth are observed in the city of Osh and the Osh region. Thus, the region has significant labor resources.

From a geographical point of view, Osh region is a transit territory connecting China and Uzbekistan and further the Middle East. With this in mind, the region can become a transit territory for fiber-optic backbone connections, as well as, if there is an infrastructure, a center for data processing and providing cloud solutions for the entire region.

The city of Osh has a good educational infrastructure compared to the entire Fergana Valley. Taking into account the indicators of digital development of the neighboring republics of the Ferghana Valley, when carrying out reforms in the higher education sector, Osh can become a forge of ICT specialists of the entire region.

At the same time, it is necessary to highlight weaknesses that have a significant impact on the attractiveness of the region. The ICT infrastructure is poorly developed, many public as well as private business processes are not digitized. Data is stored on unorganized computer networks or local server systems. However, cloud solutions, corporate e-mail solutions, electronic document management, accounting and data analysis systems are poorly distributed.

From the point of view of external factors, favorable opportunities have now developed for the intensive introduction of information and communication technologies and the construction of a strong foundation for the digitalization of the national economy.

The main opportunity is to actively involve the government in digitalization projects and promote the practical implementation of the projects “Open Data”, “Digital CASA”, the System of interdepartmental electronic interaction “Tunduk”, “Sanariptic Aimak” (Digital Region) for the next three years.

Stimulating the deployment of GPON-based (Gigabit Passive Optical Network) infrastructure, as well as launching a regional traffic exchange point and localization of cache servers, would allow overcoming the intra-regional digital gap between Osh and Bishkek within two years.

All of the above measures can make a tangible economic contribution to the development of the Osh region. Based on limited data and available research, it can be assumed that the creation of 5,000 new jobs in the IT sector of the ICT market alone, with an average sectoral salary of $600, can create an economy of $1.8 billion in wages annually in the foreseeable future. In addition, indirect jobs can be created with an economic multiplier of 2 to 3 billion USD with an average salary of 200 USD in the Osh region and the city of Osh. With the average share of wages in the structure of ICT enterprises at 60 %, it can be assumed that the revenue of enterprises in the field of IT can grow to $100 million per year. Thus, the results of efforts aimed at developing the ICT sector of the Osh region can give an increase in the GDP (Gross domestic product) of the Kyrgyz Republic by 1.25 % of the GDP figures for 2018. In other words, the contribution of ICT to GDP growth in absolute terms can be up to 20 % with the growth rates of 2019/2020. However, the calculation of economic benefits requires a more detailed assessment and accounting of all econometric parameters.

Future trends imply that all economies will be digitized and further competition will go on specializations. In this regard, over the next five years, industry advantages and further specializations should be developed products and solutions that could be internationally competitive in their niche. This goal

also implies tangible investments in the ICT component of priority industries to strengthen the competitive advantages of specific city-forming companies.

The analysis of regional development leads to the conclusion that digitalization generates problems of transformation of industrial and social relations, the implementation of new methodological and practical approaches in the management of the subject of the country. Digitalization processes at the regional level are characterized by different dynamics. The regions where the digital environment of interaction between state and industry management bodies and economic entities is effectively formed, as well as developing their own production of ICT tools that meet modern requirements, look the most prosperous. In this connection, the author of this article consider it relevant to conduct further research in the direction of evaluating the effectiveness of digitalization of the productive forces of territorial systems in the form of growth of the main indicators of regional development.

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УДК 620.1

ELEMENTS FROM MATERIALS WITH SHAPE MEMORY IN TECHNICAL DEVICES

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Abstract. The unique characteristics and possibilities of using shape memory alloys, which are referred to as “smart” materials, in devices for various purposes are considered. The importance of modeling the temperature-deformation hysteresis manifested by these materials and the dependence of its parameters on the stress state in which this element of the device operates is noted.

Keywords: smart materials, shape memory effect, thermoelastic martensitic transformations, titanium nickelide, technical devices.

ЭЛЕМЕНТЫ ИЗ МАТЕРИАЛОВ С ПАМЯТЬЮ ФОРМЫ В ТЕХНИЧЕСКИХ УСТРОЙСТВАХ

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Аннотация. Рассмотрены уникальные характеристики и возможности применения сплавов с памятью формы, которые относятся к «умным» материалам, в устройствах различного назначения. Отмечена важность моделирования температурно-деформационного гистерезиса, проявляемого данными материалами, и зависимости его параметров от напряженного состояния, при котором работает данный элемент устройства.

Ключевые слова: умные материалы, эффект памяти формы, термоупругие мартенситные превращения, никелид титана, технические устройства.

At present, new generation structural materials, called intelligent or “smart” materials (SM) are becoming more and more widespread. The registration, executive, computational or control functions inherent in SM create the ability to register external influences, process them and exercise control over them in real time. In this case, the resulting action of the IM can be either an independent restructuring of its structure, or the transfer of data for processing to the control center. Smart materials include materials with a shape memory effect (SME). The shape memory effect is the restoration of the shape of a structural element, which was previously given to it, during the subsequent heating of the element, while it is possible to restore the deformation up to 6-8 %. The shape memory effect is manifested due to phase austenitic-martensitic transitions with a reversible change in the size of crystals of a new phase with a change in temperature or mechanical stress. If the shape recovery of the deformed material is limited, then reactive stresses of 600÷700 MPa occur, while the yield strength of shape memory alloys corresponds to 80 MPa. It is these deformations and forces that are used to create actuators based on modern SM with shape memory. The main characteristics of SM based on SME materials are: sensitivity; switchability; activation; adaptability; memory and recovery; energy intensity; damping.

Owing to their unique properties, SME alloys have found effective application in the production of:

– executive power drives;

– heat engines for converting geothermal, solar and low-quality thermal energy into mechanical energy;

– high-tight detachable and permanent connections of pipelines for various purposes;

– connecting elements of various designs and purposes;

– automatic sensors, valves, switches, fuses, regulators;

– unfolding antennas and masts, power devices such as pullers, jacks, couplers, etc.;

– specialized static loading presses;

– medical technology.

Martensitic transformation is one of the fundamental ways of rearranging the crystal lattice in the absence of diffusion. Martensitic transformations have been found in many crystalline materials: pure metals, numerous alloys, ionic, covalent, and molecular crystals. The martensitic transformations in iron-based alloys have been most thoroughly studied, in particular, in connection with the hardening of steel. Martensitic transformations (often in combination with a diffusion redistribution of components and a change in the atomic order) form the basis of numerous structural transformations, due to which, with the help of

thermal and mechanical treatment, a directed change in the properties of crystalline materials is carried out.

For a long time, inelastic deformation was considered completely irreversible. In the early 60s of the XX century. An extensive class of metallic materials was discovered, in which the elementary act of inelastic deformation is carried out due to a structural transformation. Such materials exhibit inelastic deformation reversibility. The phenomenon of spontaneous shape recovery, the shape memory effect (SME), can be observed both under isothermal conditions and under temperature changes. During thermal cycles, such metallic materials can repeatedly deform reversibly. Shape memory metals include Ti-Ni alloys of equiatomic composition (approximately 50:50 % (at.)), commonly referred to as nitinol or titanium nickelide, nitinol-55 (with iron), titanium nickelide TN-1, TN-1K, VTN -27, titanium alloys VT–16, VT23 (heat treatment according to a special regime, 2-3 times cheaper and 1.5 times lighter than titanium nickelide), titanium-based alloy with 28-34 % manganese and 5-7 % silicon, terfenol (magnetostrictive alloy, dampens vibrations at low frequency vibrations), copper-based alloys such as ternary alloys Cu-Al-Ni and Cu-Zn-Al and binary compositions Fe-Ni, Cu-Al, Co-Ni, Ni-Al [10-11]. Of the large number of SME alloys, titanium nickelide Ti-Ni and cheaper copper-based alloys are the most promising for practical applications.

At high temperatures in the austenitic state, Ti-Ni has a cubic lattice. Upon cooling, the alloy passes into the martensitic phase, in which the lattice cells become beveled parallelepipeds. When heated, the austenite phase is restored, and with it, the original shape of the shape memory alloy product is restored. Shape change is the main feature of martensitic transformation, which is associated with the effect of “memory” of alloys, a necessary but not sufficient condition for the manifestation of “memory”. The free energy of martensite crystals is less than that of the initial phase, which stimulates the development of the martensitic transition. The transition is retarded due to the appearance of the interface between the old and new phases and the increase in free energy. The growing crystals of the martensitic phase deform the surrounding volume, which resists this. An elastic energy arises that prevents further crystal growth. When this energy exceeds the elastic limit, there is an intense deformation of the material in the vicinity of the phase boundary and the growth of crystals stops. In steels, the process takes place almost instantly (individual martensite crystals grow to final sizes). The reverse transition of martensite to austenite (high-temperature phase, diffusionless shear lattice rearrangement is difficult) occurs at high temperatures, when austenite crystals grow in martensite without transition to the original form (atoms do not fall into their original places). In alloys with “memory”, martensitic crystals grow slowly upon cooling, and disappear gradually upon heating, which ensures dynamic

equilibrium between the interface between them and the initial phase. The boundary between the phases behaves similarly if cooling and heating are replaced by the application and removal of the load, respectively – thermoelastic equilibrium of phases in a solid. The collective movement of atoms in a certain direction, accompanied by spontaneous (martensitic) deformation of the material (lattice rearrangement), in which the neighborhood and interatomic bonds of atoms are not violated (it remains possible to return to their previous positions, to their original form), takes place only under certain conditions.

The “memory” of an individual crystal is not yet the memory of the entire volume of the alloy, which usually has a polycrystalline structure. Individual crystallites (grains) differ in the orientation of crystal lattices. The shift of atoms during martensitic transformation occurs in the lattice along certain planes and directions. Due to the different orientation of the grains, the shifts in each grain proceed in different directions and, despite the significant deformation of individual crystals, the sample as a whole does not experience a noticeable change in shape. It occurs if the crystals are oriented in the same direction. The driving force, which during the martensitic transformation organizes the preferential organization of crystals, is the external load. During the martensitic transformation, the atoms move in the direction of the external load (the sample as a whole undergoes deformation). The process develops until the entire material is deformed in the direction of the force without breaking interatomic bonds and disturbing the neighborhood of atoms. When heated, they return to their original positions, restoring the original shape of the entire volume of the material. The “memory” effect is based on the thermoelastic equilibrium of the phases and the control action of the load. Special thermomechanical processing of alloys creates microstresses in the material, the action of which during martensitic transitions is similar to the action of an external load. When cooled, the alloy spontaneously assumes one shape, when heated, it returns to its original shape (the plate folds into a ring when cooled (Fig. 1), when heated, it unfolds or vice versa (Fig. 2)). Thermoelastic martensitic transformation is accompanied by a reversible change in the shape of austenite crystals, which mainly provides the “memory” of metals.

Figure 1. Plate deformation during cooling under load

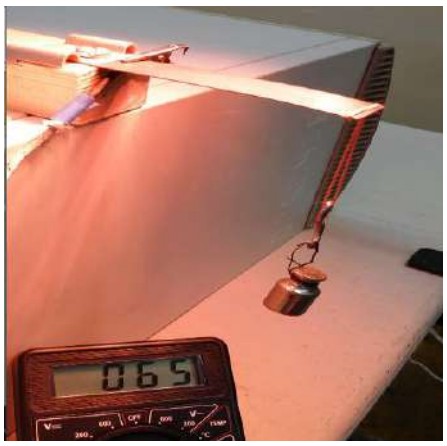

Figure 2. Restoration of deformation of the plate under the counteracting load during heating

However, despite such wide possibilities of SME alloys, today their application is limited only to certain market niches [1]. This is due to the solution of fundamental and applied problems: obtaining and processing high-quality and inexpensive materials; accurate prediction and modeling of their behavior; optimal design; control of microstructure and temperatures of phase transformations; a clear understanding of the effects of hysteresis, phase instability, aging, degradation and fatigue of these alloys [2]. As a rule, shape memory alloys at the manufacturing stage are in the form of a rod, ingot, strip or wire. Then, as a result of complex thermomechanical processing, they are given the necessary shape of an element of a device or structure in the form of a plate, cylinder, spring, or a more complex geometric shape.

Springs made of titanium nickelide, as an alloy characterized by low density and high corrosion resistance, have an advantage over other forms of elements due to a fairly good knowledge of the properties of the material itself and an understanding of the mechanics of the elastic behavior of the spring [3; 4].

Plates made of shape memory alloys can be used in devices, sensors, relays as moving contacts, interface elements, connections, start-ups and movements.

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ENVIRONMENTAL EDUCATION IS THE FOUNDATION OF SUSTAINABLE DEVELOPMENT OF SOCIETY

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Abstract. Education is intended to ensure global consistency of attitude and rules of life for different cultures and social groups. Thus, it is a necessary condition of existence and survival in the face of increasing international integration. Now the content of education should ensure the development of resilient information-ecological society with high humanistic, technological, and environmental culture. This requires well-educated people, with new patterns of thinking and behavior.

Keywords: sustainable development, rent relations, humanitarian and ecological culture.

ЭКОЛОГИЧЕСКОЕ ОБРАЗОВАНИЕ – ОСНОВА УСТОЙЧИВОГО РАЗВИТИЯ ОБЩЕСТВА

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Аннотация. Образование призвано обеспечить глобальную согласованность взглядов и правил жизни для разных культур и социальных групп. Таким образом, это необходимое условие существования и выживания в условиях растущей международной интеграции. Теперь содержание образования должно обеспечивать развитие устойчивого информационно-экологического общества с высокой гуманистической, технологической и экологической культурой. Для этого нужны хорошо образованные люди с новыми моделями мышления и поведения.

Ключевые слова: устойчивое развитие, рентные отношения, гуманитарная и экологическая культура.

In the process of development, human society develops various economic needs. First, the needs include vital goods, which are the basis of human existence. Awareness of the problem of limited natural resources, and, above all, human resources, form the living environment. Qualitative and quantitative

characteristics of the current state of natural resources and the environment are directly dependent on the economic human activity, on what goals are pursued within the framework of this activity. The economic interest of the people directed on accumulation and current consumption of material goods, not taking into account the capabilities and the state of the environment, has led to the emergence of environmental needs.

Thus, the emergence of environmental needs is is directly dependent on economic needs. The emergence of new standards of economic needs, a change in the direction of socio-economic development is an essential prerequisite for the solution of all the growing environmental needs. Natural resources involved in production activities, act at the same time as organically ecosystem elements. By economic activity, it is necessary to consider that within the natural ecosystems every natural object is operable linked to other elements of the natural complex therefore anthropogenic influence (directly or indirectly) on the individual natural resources leads to a change of the entire ecosystem. It determines the need for an integrated, systematic approach to consideration of object of value relations Nature Management. Confirmation of this are ecological disasters, such as a pipeline break on Lovinskoe oilfield (near Khanty-Mansiysk), the accident in the Gulf of Mexico, the Fukushima accident.

Bearers of the relationship of sustainable Nature Management as an integral part of sustainable development, is not only and not so much the individual types of resources, as the ecosystem as a single entity. And then, from the standpoint of satisfaction ecological and resource needs, the relations arising in the process of reproduction of any ecosystem become a priority, fundamental, and transform basic, purely economic interests of the Nature Management in the ecological and economic.

Thus, the economic development of humanity displays a new level of rent relations and their relations have become a fundamental principle for the preservation of ecological balance and restoration of natural systems, and then the relationship for the use and consumption of natural resources.

The concept of ecological rent as an economic category reflects a complex set of new valuable relations developing on the satisfaction of environmental needs of society. The environmental effect as a result of the sustainable production of ecosystems that provide decent living conditions in a particular area, and the ecological balance of the area, is a carrier of ecological rent. The emergence of ecological rent (specific additional income) related to the possibility of minimizing public expenditures to meet environmental and economic needs. As a result, ecological rent is the center of interests of present and future generations. In value terms, the environmental effect is a saving on future costs associated with the reproduction environment-forming functions of ecosystems. These savings will be greater the longer the period of their natural reproduction is.

The concept of sustainable economic development demanded research of the ecological rent. From the perspective of Ukrainian economist OO Veklich possible to allocate such directions of research in this category:

- From the standpoint of the production process ecological rent expresses the economic value of the environmental benefits of different qualities, properties, and their condition as a natural factor of the labor activity.
- Socio-economic aspects of ecological rent is a form of implementation of specific economic relations on the acquisition, ownership, disposal, use different quality of environmental resources and the proceeds of their use among their owner (the population) and economic entities (resource users).
- To control the reproduction process of the position of the ecological rent legally considered part of the rental windfall, which is created by the consumption of different quality environmental benefits and is used for the relative alignment of intra- and inter-regional differences in the economic conditions of farming of natural resources [1].

Sustainable development is not the goal, but a lifestyle organization, it is not a future state of society, but the way of life at the present time. The concept of a sustainable development defines historical transition from the simple solution of the imminent problems to forecasting of future contradictions and planning of the actions directed to their prevention or at least easing.

The greater the current problems of the state are, the more important its policy of sustainable development is as a method and technology of quick and successful solution of existing problems. When all the forces of the state are spent on solving current problems and not focused on identifying potential new threats, development will remain unsustainable for an infinite period of time. The most dangerous for any country and humankind are global imbalances in international and social relations, the economy and the dynamics of biosphere processes. Environmental problems, both local and global, come to the fore only in the XX century. The ecological crisis of the second half of the XX century temporarily pushed aside other problems of the world community. Therefore, in the concept of sustainable development issues of environmental and social improvement are displayed in the first place.

Solutions of ecological problems include nature conservation, rational use of natural resources and environmental safety. Methods of achieving these goals may be divided into technological, economic and social that are implemented in parallel and largely independently of one another. Economic and technological directions are easier in the sense that they are centralized, from top to bottom, from developers to users, from governments to the population.

Practical implementation of actions to improve the sustainability of the economy, the resolution of environmental problems are linked primarily to the reform of the system of state regulation in sphere of nature management and, in particular, tax system.

Environmental taxes are one of the most important mechanisms for the regulation of negative impact on the environment. At present, environmental taxes in one form or another exist in all developed countries, but in the Russian legislation the ecological function of taxation is currently not so noticeable and does not have a systemic character. In this regard, there are a clear need to continue reforming the tax system, in particular: the replacement of the existing environmental charges for environmental pollution environmental tax; consistent increase in the share of taxes on the use of natural resources potential of total tax revenue; imposition of taxes for the use of environment-forming resources and through this expansion of the base environmental taxation; tax stimulation environmentally friendly production and the limitation of direct and indirect subsidization of environmentally dangerous technologies.

As a result, the reproduction of natural resource price will depend on savings in material production and the need to preserve the natural balance in the environmental field. Given that any natural resource involved in the economic turnover is a part of the natural complex, the environmental component of natural resource assessment is not a supplement to their economic value, and pervades the content of the latter, transforming it into the ecological and economic value. However, the resolution of pressing problems do not change the essence of the processes.

Social direction is more difficult, as it's done “from below”; it involves the active participation of the population, changes in the established standards of behavior, and even traditions. In addition, any technological advances can be reduced to zero imperfection of social relations.

Sustainable human development is impossible without simultaneous strengthening of mutual understanding between people. In place of the archaic forms of primitive struggle for the use of other people's material resources must come cooperation in the way of development of the boundless resources of scientific and technical progress, extracting the total gains from cooperation, joint efforts, exchange of experiences, mutual improvement and mutual assistance. This requires a significant realignment of human inner being, improvement of the system of moral values, developing patience and self-criticism. That is education, education and training has the leading role in resolving this most important task. Education program for sustainable development is a political task for the education system, initiating a upbringing human, integrated into the international community.

The complexity of the world dictates the need to develop the ability to take it with divergent and sometimes conflicting points of view, i.e. from different angles. This task must be detailed, and its solution is provided in the framework of traditional academic disciplines, as well as a specially designed training. So far in the professional environment of teachers this case has not been seriously undertaken, and at the state level does not even discuss the necessary action program.

Therefore, if the rapid development of mankind requires timely conversion and changing the lifestyle of every person, and the community has to predict future conflicts and plan of actions aimed at prevention, the education plays a key role in maintaining the stability at all levels of society. Education is designed to provide global consistency of attitude and life rules of the representatives of different nations and social groups – a necessary condition for the existence and survival in conditions of increasing international integration.

Now, on the threshold of the third millennium, the content of education should ensure the establishment of a sustainable information society with high ecological, humanistic, technological and environmental culture [2]. To do this, obviously, we need new, comprehensively educated people, with other patterns of thought and behavior.

We can say that one of the most important objectives of education is the formation of the necessary complex of knowledge regarding human development, its relationship with the social and natural environments. This should help the individual to know the society at different stages of its history, to comprehend the phenomenon of culture, the conditions of their own existence and the existence of humanity.

Currently there is a global challenge: to carry out the socialization of the individual on the basis of ecological culture of values, i. e. based on environmental education in the broadest sense of the word.

The main mechanism of formation of ecological culture is intended to be a deliberate system of environmental education, covering all parts of pre-school, primary, secondary, higher education, retraining of personnel, propaganda and popularization of scientific knowledge.

Environmental education has been put forward by UNESCO and the United Nations Environment Programme in the category of fixed assets harmonization of interaction between man and nature. The Stockholm Conference on the Environment (1972) adopted a recommendation to establish an international education program in the field of environment. By the beginning of 1975 The program was developed by UNESCO in collaboration with the UN Committee on the Environment (UNEP).

At the UN Conference on Environment and Development (Rio de Janeiro, 1992), it was decided to promote education, public awareness and training activities to make the concept of sustainable development in the spiritual and professional installations humanity.

On December 20, 2002 the UN General Assembly decided to hold a January 1, 2005 the Decade of Education for Sustainable Development. In 2003, in Kiev at the 5th International Ministerial Conference Environment for Europe was approved by the Statement on Education for Sustainable Development and invited all countries to integrate the concept of sustainable development into education programs at all levels. Then, at the meeting of the Committee on Environmental Policy of the European Economic Commission in Vilnus in

2005, it was adopted by the UNECE Strategy for Education for Sustainable Development, which marks the beginning of the decade announced. Strategy essence is that to move from a simple transfer of knowledge and skills necessary for the existence of modern society, a willingness to act and live in a rapidly changing environment, to participate in social development planning, learning to anticipate the consequences of actions taken, including the possible consequences the field of the sustainability of natural ecosystems and social structures [3].

Attention to education at the highest level of international cooperation is due to the exceptional role of the timely preparation of young people for the rapid changes in the world community as a result of scientific and technical progress, the increasing power of humanity and globalization. Balanced development of mankind depends largely on the timely recognition of new dangers and contradictions, their adequate perception of people and solidarity in an effort to defuse tensions objective arising under any threats to human well-being.

Education for sustainable development is a very far-sighted social order, but the education system is highly conservative, that's why it turned out not to be prepared to carry out such tasks. Secondary schools and the highest education form the basis of education; their teaching style remains essentially the same as a hundred years ago. The same objective structure of knowledge transfers; the same strict regulations requiring submission to the initiative of students and teachers to the curriculum, the same methods of learning and knowledge control. Therefore, the classical education system will struggle to fulfill the order, formulated in the Education Strategy for Sustainable Development. It takes not only to complement existing curricula with new disciplines and introduce new sections in existing program disciplines. Interdisciplinary knowledge, reflecting the reality of life's problems, should receive support in the world, clearly divided by boundaries of classical sciences [4].

One of the main directions of development of education is environmental, which is understood as a continuous learning process, aimed at the assimilation of systematic knowledge about the environment and skills of environmental activities, the formation of a common environmental culture.

The main foundation of environmental education should be considered by the international community accepting the human right to a healthy living environment. The quality of the environment determines the health - a basic human right, and the main goal of the development of civilization. Environmental education should therefore not just to penetrate the structure of education, and become one of its most important bases. If literature and history are necessary for the assimilation of the values of spiritual culture, science – the laws of nature, the environmental education is necessary for the formation of a genuine human relationship to nature, determining the permissible nature of

conversion measures, the assimilation of specific socio-natural laws and norms of behavior that allow the continued existence and development of man.

International environmental movement recognizes the education of teachers in the field of environment (environmental education) a priority for improvement of educational systems and recommends that States and Governments to review policies and practices in the field of education in view of the global environmental crisis.

It is necessary to distinguish the environmental education from the greening of the educational system. Although they are related, but in some respects, it is characterized by various phenomena. Environmental education is the direct uptake of environmental knowledge of different nature and level. It defines, in particular, the process of preparation of environmental specialists, but is not limited to this. Greening of the education system is the trend is characteristic of the penetration of ideas, concepts, principles, and approaches of ecology in other disciplines, as well as the preparation of environmentally conscious professionals of various profiles: engineers, doctors, economists, sociologists, etc.

Environmental education in the context of sustainable development concept acquires the status of integrating factor of education in general, defines its strategic goal and leading direction. Secondary goals of environmental education are associated with a certain spiritual, epistemological prerequisites and conditions for the solution of environmental problems.

In the concept of sustainable development an ideal educational system becomes formation of the person possessing a certain internal freedom and independence in their opinions, actions, building their relations with the environment, based on an understanding of its integrity. Freedom in the framework of the environmental need – such must be a person strategy on a boundary of a new civilization. These qualities society has set through the educational system.

Conclusions

Ecology as an expanding area of knowledge has a powerful impact on the education system. It affects, first of all, on the reorientation of secondary education purposes, as well as training and retraining, calling to form a broad view of the world, humanity and nature, on the methods of cognition and activities influence the development of value orientations of universal human nature, as opposed to the traditional consumer.

Environmental subjects are part of the “global education” of man, the basis of his understanding of the relationship between the individual, society and nature on a planetary scale.

A large proportion of environmental education should be given to the social environment, which is directly involved in the search for patterns of sustainable development “society-nature” system.

Realization of ideas of environmental education and greening education suggest a new interpretation of traditional subjects and the introduction of new disciplines, helping to uncover a holistic view on the relationship of man and nature.

Improving the education system at the present stage becomes a civilization problem. There is no doubt that to cope with this task will be the country's leaders in the world community, and a result of improving the foundations of education will significantly strengthen mankind, contributing to its balanced development.

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УДК 004.94

MODEL OF THE CUSTOMS PROCESS “CUSTOMS CONTROL OF GOODS IMPORTED INTO THE TERRITORY OF THE EEU BY AIR TRANSPORT”

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Abstract. The paper presents a model of the customs control procedure on imported goods, built in the ELMA BPM modeling environment. The features of using this software product for modeling customs processes are considered.

Keywords: software, simulation modeling, declaration, release, modeling, customs processes, customs control, ELMA BPM.

МОДЕЛЬ ТАМОЖЕННОГО ПРОЦЕССА «ТАМОЖЕННЫЙ КОНТРОЛЬ ТОВАРОВ, ВВОЗИМЫХ НА ТЕРРИТОРИЮ ЕАЭС ВОЗДУШНЫМ ВИДОМ ТРАНСПОРТА»

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Аннотация. В статье рассмотрено программное средство имитационного моделирования ELMA BPM. Рассмотрена возможность применения данного программного продукта как способа моделирования таможенных процессов, в частности, процесса таможенного контроля товаров при ввозе.

Ключевые слова: программное обеспечение, имитационное моделирование, декларирование, выпуск, моделирование, таможенные процессы, таможенный контроль, ELMA BPM.

A modern application is developing to rethinking old business organizations, developing business processes using new technologies. A business process is a self-connected set of activities of an enterprise, the completion of which is the creation of products or services that are transferred to the consumer. The BMP system is based on the implementation of the management process. This software is intended for workflows regulation,

information management and interfacing between software components and users (Figure 1).

Figure 1. Structure of a BPM system

The ELMA BPM business process management system is positioned as the leading software product on the Russian software market. The system is designed to describe interactions at all levels and stages of the process [1]. ELMA complies with BPM platform standards and implements the functions shown in Figure 2.

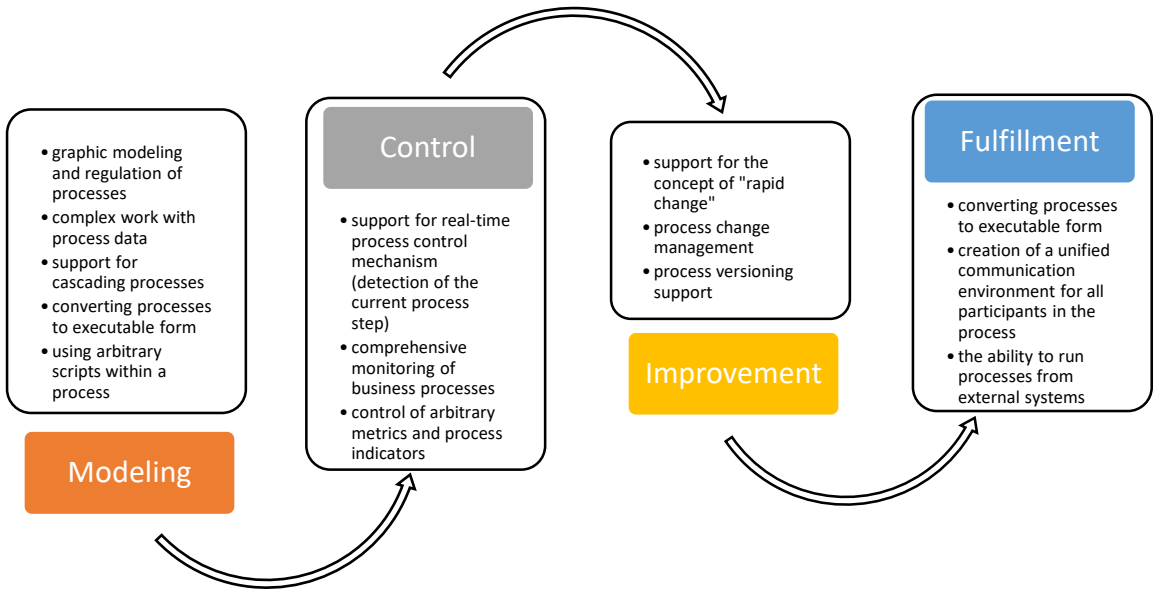

Figure 2. Main functions of the ELMA BPM system

Figure 3 highlights the key advantages of the Russian software tool ELMA BPM over analogues.

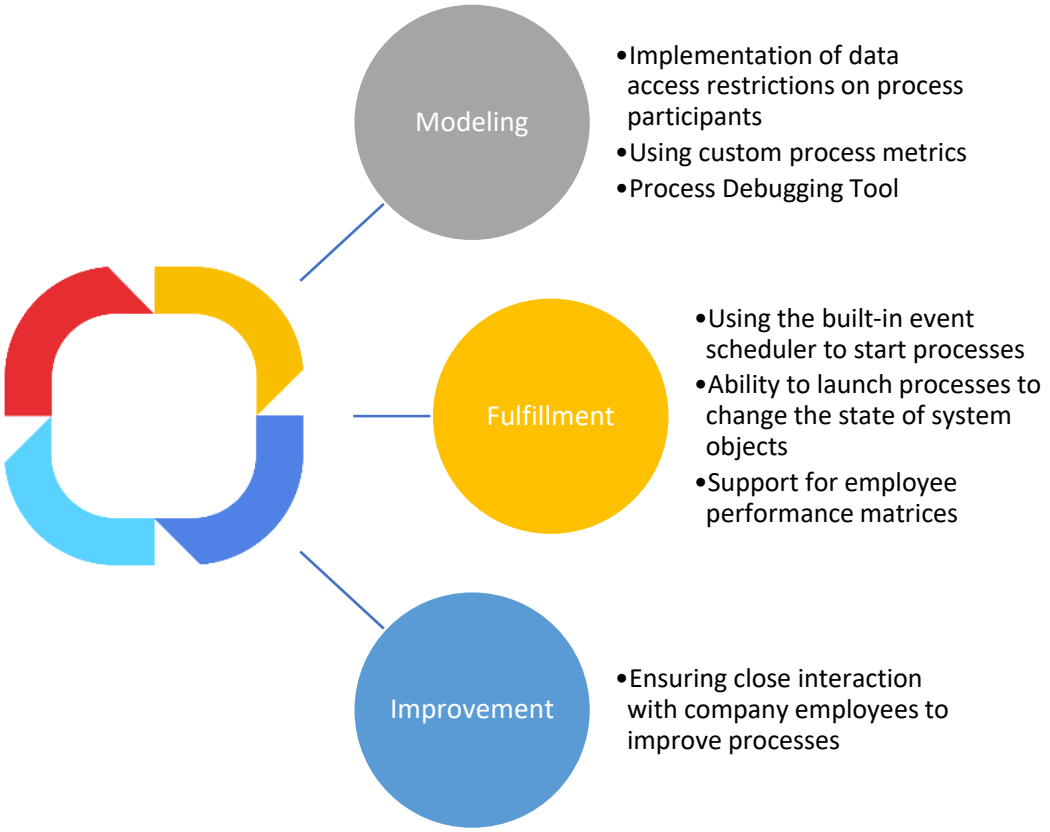

Figure 3. Advantages of the ELMA BPM system

The ELMA BPM system is aimed at simplifying and increasing the speed of modeling, controlling and improving business processes. Figure 4 shows the capabilities of the ELMA system.

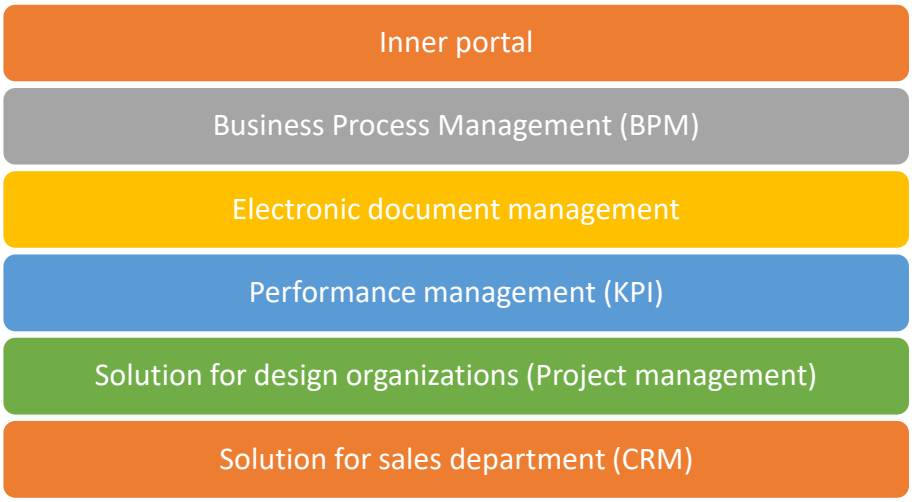

Figure 4. Features of the ELMA system

Thanks to the ability to reflect labor costs, system users can control the amount of working time required to complete any stage of a business process (Figure 5).

Figure 5. Labor cost structure

In the ELMA BPM architecture 3 contours are present (Figure 6).

Figure 6. Three contours of ELMA BPM architecture

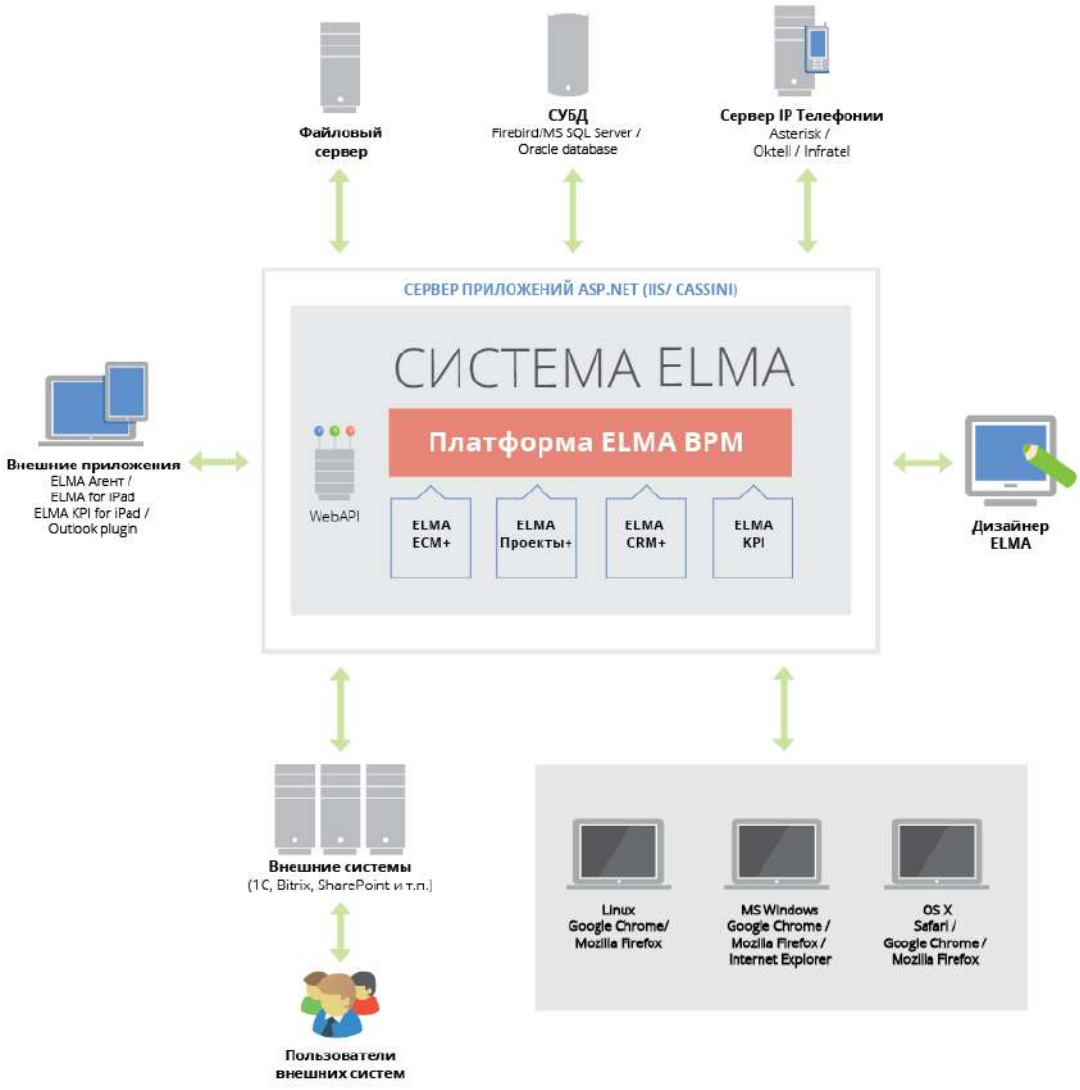

Figure 7. ELMA BPM architecture [1]

Creating a model in the ELMA system consists of the steps shown in Figure 8.

Figure 8. Stages of model creation in ELMA BPM

Customs procedures and the mechanism of managing customs processes itself have a number of difficulties, since the participants in customs procedures are involved in a large number of interrelated processes. The use of the process approach in customs activities allows you to get a number of advantages. To optimize and control the process described in the paper, customs officials can use ELMA as a universal software tool designed for simulation [2].

A simplified model of the customs process "Customs control of goods imported into the territory of the Russian Federation by air transport" is in Figure 9.

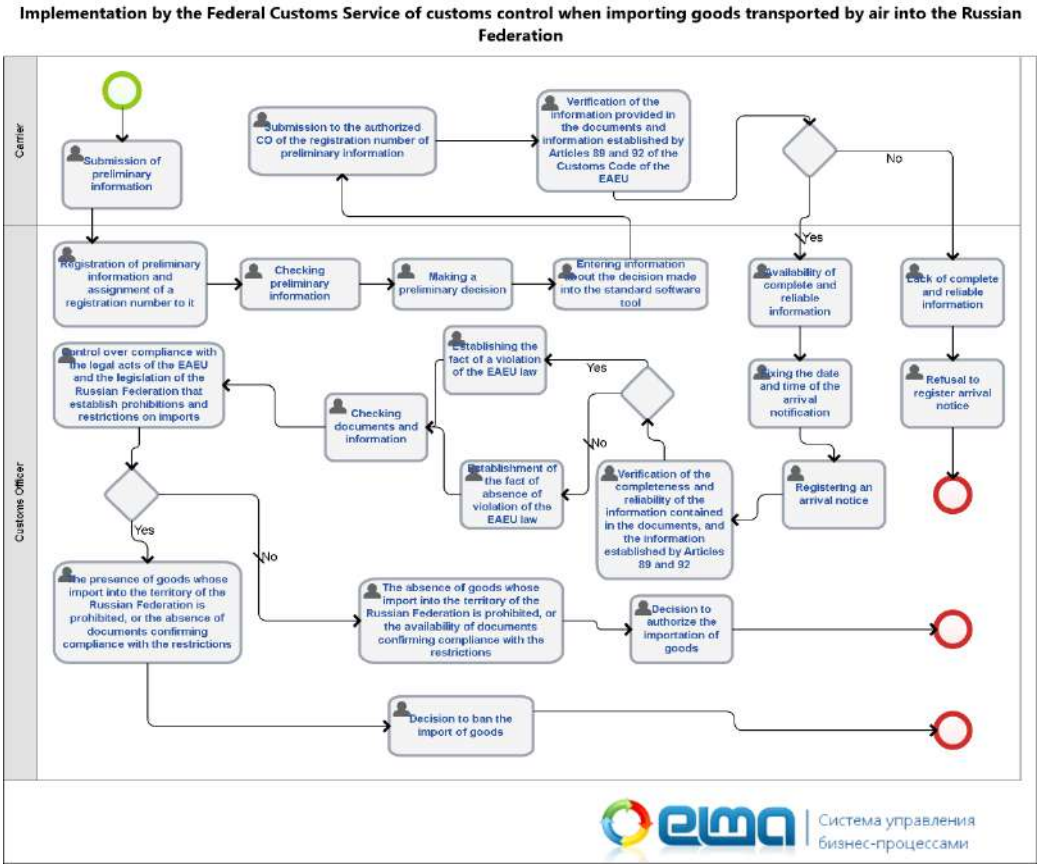

Figure 9. Model of the simplified customs process "Customs control of goods imported into the territory of the Russian Federation by air transport"

The participant of foreign economic activity to the authorized body carries out submission of preliminary information [3]. The ELMA system sends a notification to the carrier that the task has been completed. Next, a process task is formed – “Registration of preliminary information and assignment of a registration number to it” (Figure 10).

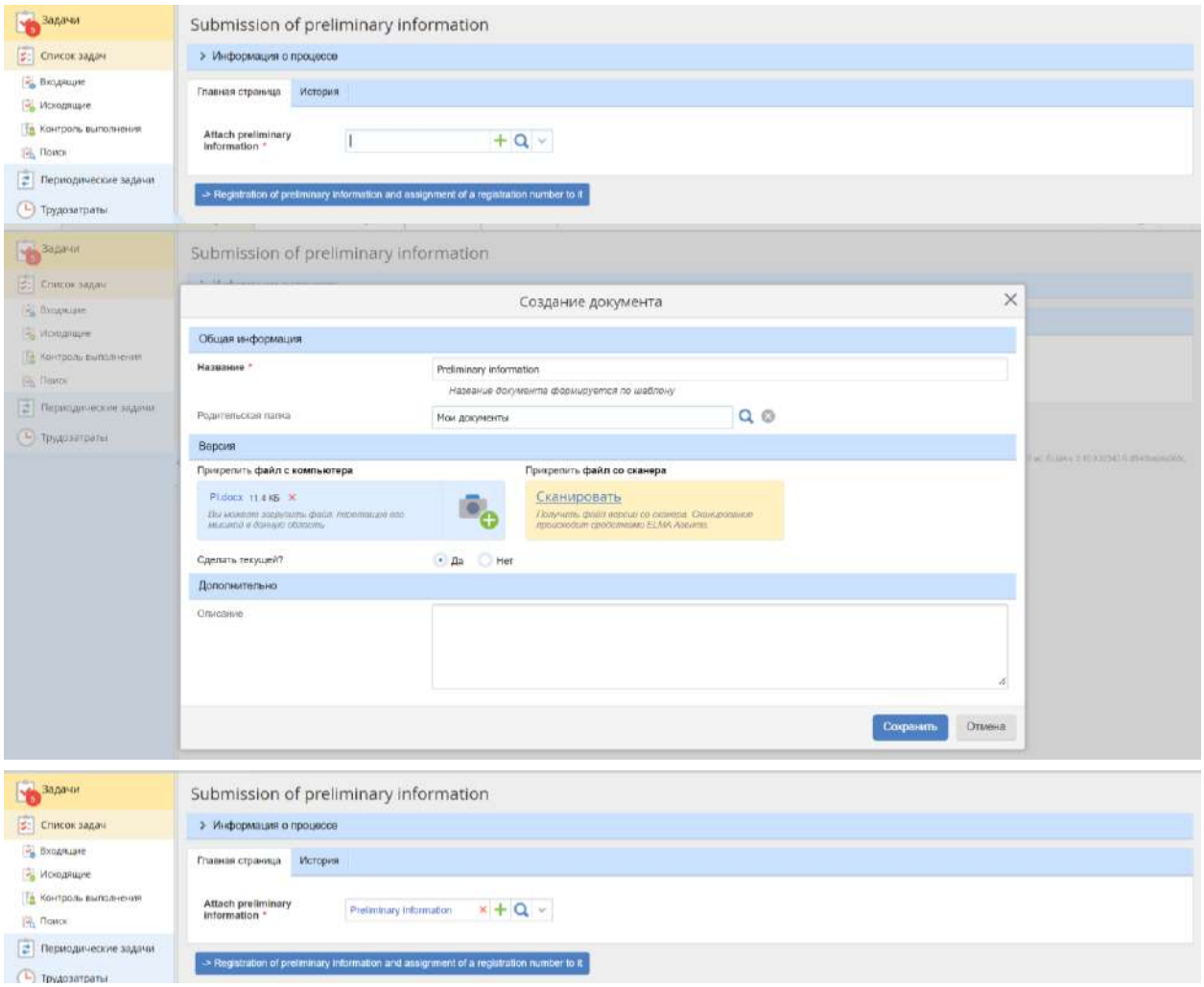

Figure 10. Submission of preliminary information

The next step is to change the area of responsibility. Customs Officer launches the task formed by the FEA participant to assign preliminary information of the registration number. At the end of the whole process, the Customs Officer makes a decision to allow the import of goods into the territory of the Russian Federation (Figure 11).

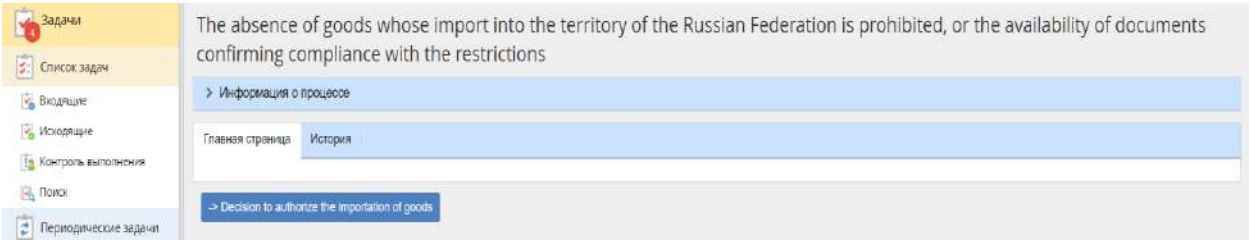

Figure 11. Making a decision on permission to import goods into the territory of the Russian Federation

In case of detection of violations of customs control, officials are liable in accordance with their job descriptions and regulations [4].

Thus, the presented model of the customs process, built using the ELMA BPM software package, is a means of finding ways to optimize the activities of organizations involved in FEA. The development of methods, tools and technologies for improving customs processes at air checkpoints in the context of the above direction can generally speed up the process of customs control at air checkpoints, contributing to the development of foreign economic activity.

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PROSPECTS FOR THE DEVELOPMENT OF MECHANICAL ENGINEERING IN RUSSIA AND ITS IMPACT ON THE ENVIRONMENT

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Abstract. This paper analyzes in detail the prospects for the development of the machine-building complex of the Russian Federation, as well as the impact they will have on the environment during their implementation.

Keywords: machine building complex, production, environment, equipment, technology, industry.

ПЕРСПЕКТИВЫ РАЗВИТИЯ МАШИНОСТРОЕНИЯ В РОССИИ И ЕГО ВЛИЯНИЕ НА ОКРУЖАЮЩУЮ СРЕДУ

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Аннотация. В данной статье подробно анализируются перспективы развития машиностроительного комплекса Российской Федерации, а также влияние, которое они окажут на окружающую среду в ходе их реализации.

Ключевые слова: машиностроительный комплекс, производство, окружающая среда, оборудование, технология, промышленность.

At present in the Russian Federation the growth rate of machine-building production is only increasing every year. Due to the new sanctions, the Russian Federation will have to almost completely cover the shortage of imported products, but for this purpose it is necessary to solve a number of problems. It is possible to distinguish the main problems: 1. low rates of renewal of equipment and output products; 2. the main part of Russian machine-building production was of defense importance, due to what there was a need to renew and focus on development of other industries; 3. low reliability and quality of output products; 4. import dependence of production; 5. downtime of many enterprises.

It is possible to distinguish the following main directions of modernization: improvement of technologies; modernization of technological

base at the enterprises; solution of import substitution processes; attraction of new sources of investment and development of new structural organization of the industry. In this work such directions as the solution of import substitution processes, modernization of the technological base at enterprises and improvement of technologies are discussed in detail.

Table 1 − The industry system of mechanical engineering in Russia [1]

The ICS industry system					
Heavy engineering	Medium Machine Building	General Engineering	Precision Engineering	Production of metal products and blanks	Repair of machinery and equipment

Heavy engineering includes: Railway engineering; shipbuilding; aircraft industry; rocket and space industry; timber industry, etc.

Medium machine building includes tractor building; machine tool building; production of technological equipment for light and food industries.

The general machine building includes such branches as transport machine building; agricultural machine building; production of technological equipment for various industries.

The most important branches of precision engineering: instrumentation, radio and electronic engineering, electrical industry. Products of this industry are computers, lasers, clocks, etc.

Production of metal products and blanks includes: production of knives, cutlery, fittings; production of mass metal products.

One of the most important perspectives is the solution of problems related to import substitution. Due to the recent events in the world, a record number of sanctions have been imposed on the Russian Federation. Sanctions have affected every industry in the Russian economy. In order to avoid shortages in production, it is necessary to introduce innovative technologies and modernize production at an accelerated pace; to increase the rate of domestic production and increase the share of exports of machine-building products.

According to research by RIA-Analytics, today it is possible to single out the top-priority industries in machine-building, which are most dependent on imported products [2]:

1. Tank-building – the share of imports exceeds 90 %;
2. Heavy engineering – imports account for 60-80 %.
3. Machine-tool industry – import share of 90 %;
4. Light industry – import share 70-90 %;
5. Aviation and rocket and space industry – 80 %.

As you can see, the dependence on imported products in many important industries is huge. Russia needs by all means to increase its own production in order to be independent of other countries. But such a decision will have a negative impact on the environment in the country. Several serious negative factors can be identified:

1. Increase in extraction of minerals, which are needed to produce machinery and build plants (rare metals, fiberglass, cement, etc., the extraction and processing of which generates toxic and radioactive waste). Russia is a producing country, but the amount of resources is limited, and the development of new deposits will entail changes in the landscape.

2. Emission of untreated gases containing combustion products, toxic substances and others, which can affect the climate by raising the temperature of the region where the plants are located by a couple of degrees.

3. The withdrawal of large volumes of water needed to run the plant, as well as the discharge of the plant's toxic waste into wastewater.

4. Reduction of biodiversity and mass destruction of rare species of plants and animals.

The implementation of the program of import substitution in mechanical engineering will have a positive impact on the development of all machine-building industries of the Russian Federation by reducing the share of imports, increasing the rate of production of domestic producers with the help of state support [3]. But accelerated development will have a negative impact on the environment.

Another important perspective is the modernization of technological base at enterprises. There are several basic modernization: improvement of technologies; automation of processes; mechanization (reduction of repair costs and downtime, general improvement of organizational resources); ecologization of production (mastering of new wasteless technologies) and energy modernization (reduction of electricity consumption through the use of saving technologies.

As can be seen from Table 2, the share of fully depreciated fixed assets is increasing every year. The main reason for this state is the inability of the vast majority of enterprises to allocate a significant part of the profits received from the results of their economic activities for the purposes of fixed assets renewal. These phenomena can be explained by the lack of investment financial resources for renewal of fixed assets of machine-building enterprises, as well as by saving on the purchase of innovative foreign equipment, due to which the machine-building enterprises of Russia often use the available equipment up to full physical depreciation.

The Russian government is already taking steps to solve these problems, providing financial support, but so far, they have not brought the results that are required. Only by solving these problems and modernizing production will domestic machine building reach the international level.

Table 2 − Indicators of wear and tear and the share of fully depreciated fixed assets of enterprises of the machine-building industry [4]

Name of type of activity	Depreciation of fixed assets, %					Share of fully worn out, %				
	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018
In the manufacturing industry as a whole	46,9	47,7	50,0	48,8	50,6	14,0	15,0	16,2	17,1	18,2
In the production of computer, optical and electronic products	45,3	42,8	43,6	45,3	47,0	17,1	15,2	14,3	14,8	15,3
Electrical equipment manufacturing			52,9	52,7	52,5			18,2	18,6	19,0
By production of machinery and equipment, which are not included in the above groups	44,5	44,4	43,1	45,9	48,7	14,2	14,4	13,2	14,8	16,4
Production of motor vehicles, semi-trailers and trailers	48,7	47,8	50,9	54,2	57,5	18,4	18,1	22,8	24,4	26,0
In the production of other vehicles and equipment	-	-	44,2	47,6	51,0	-	-	12	14,0	16,0

Modernization will affect the environment in different ways. Since on the one hand ecologization of production will reduce the amount of harmful emissions and waste, then on the other hand production of new equipment in large quantities will increase the consumption of useful resources, as well as the equipment itself will be produced on the old, which generates a lot of waste.

The last of the perspectives I have considered is the improvement of technology. The current state of industry in Russia is determined by the low level of demand for new technologies. At the same time the rate of technology development in mechanical engineering outstrips their introduction. Here as reasons should be pointed out the weak use of modern methods of management and marketing at machine-building enterprises. This industry market turned into a financial market, and purchases of imported equipment on foreign loans turned out to be more interesting for domestic business than mastering and purchasing of domestic equipment paid for by a part of own profits.

Table 3 − Differentiation of new technologies in mechanical engineering industries [5]

Industry Sector	Structure, %
Newly created technologies, total	100,0
Production of rocket and space equipment, aircraft construction	15,0
Heavy, energy and transport engineering	17,0
Electrical Industry	1,5
Chemical and petroleum engineering	21,0
Machine tool construction and toolmaking	29,0
Automotive Industry	7,5
Bearing industry	1,5
Tractor and agricultural engineering	1,5
Mechanical engineering for the light, food, and household appliance industries	4,5

Table 3 shows the differentiation of new technologies in the mechanical engineering industries, it shows that in most industries the implementation does not exceed 20 %. This, in turn, negatively affects the quality and quantity of products, as well as a lot of harmful and hazardous waste. The introduction of new technologies will make production more environmentally friendly.

The Russian machine-building complex has a lot of problems which must be solved in order to continue the growth of production. There are enough prospects for development, as well as enough resources and developments for an accelerated pace of development. In turn, such a pace in the near future will have a negative impact on the environment, but then, on the contrary, it will reduce the amount of harmful emissions.

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MOTION CAPTURE TECHOLOGY OVERVIEW

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Abstract. This paper discusses motion capture technology in general. The mechanisms of its functioning are explained including different methods and the problems that can be encountered when working with it are considered. The following part includes areas where this technology has been successfully applied. As a result, we establish the current state of affairs in this industry and outline the development prospects.

Keywords: motion capture, mo-cap, marker-based system, markerless system, three-dimensional models.

ОБЗОР ТЕХНОЛОГИИ ЗАХВАТА ДВИЖЕНИЙ

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Аннотация. В работе рассматривается технология захвата движений в общем. Объясняются механизмы ее работы, в том числе различные методы, и разобраны проблемы, с которыми можно столкнуться при работе. Следующая часть включает в себя области, в которых данная технология успешно применяется. В результате мы устанавливаем текущее положение дел в данной индустрии и выделяем перспективы ее развития.

Ключевые слова: захват движений, мо-кап, маркерная система, безмаркерная система, трехмерные модели.

Motion capture (or mo-cap) is a technology that has become an integral part of the media over the past few decades. Its early prototype is considered to be rotoscopy – a technology used in animation, which consists of redrawing movements frame by frame from a film with actors. The first setups that began to be used in computer graphics in the 1990s were already similar to modern ones. Then light bulbs or reflective elements began to be attached to the actors' joints, and the recording was carried out at different angles. Such systems were very inaccurate due to the small number of cameras and sensors.

Generally speaking, nowadays all mo-cap can be divided in two categories [1, p. 90] depending on the usage of markers: markerless and marker-based technologies. Markerless technology uses object recognition and does not require special equipment on the actor. This type of mo-cap workflow includes recording of multilayered video with many infrared cameras, installed at different angles, video analysis and creating a 3D-model. We believe that markerless systems are more progressive, since machine learning methods are used to set up the recognition of a read image from cameras [2, p. 3339].

Marker-based technology requires special equipment: as a rule, a black suit that will absorb the light, sensors installed on it, and many cameras that will receive and process the signal from the sensors from different angles. This list may vary slightly depending on the chosen method. Data (cloud of floating points) is entered into the computer. The next phase is called *retargeting* – creation of a skeleton; it will be the basis for the future 3D model.

The method of marker-based technology can be optical passive, optical active, magnetic, mechanical, and gyroscopic depending on the type of markers. In the optical passive one, the basis of such a system is a suit with sensors that reflect infrared light from high-frequency strobe lights mounted on the camera. The reflection from the sensor is perceived by the same camera and thus the position of the marker is identified. If the markers are close to each other, errors may occur in the camera lens, because the system does not provide a clear separation of them from each other. Another important issue is that placing them on an actor takes time.

The difference between the previous method and the optical active one is that the sensors can independently send a signal back, because LEDs with integrated processors and radio synchronization are used. The system distinguishes identifiers because each is assigned a unique ID. On the other hand, they are expensive and relatively fragile.

In the magnetic method, the role of markers is performed by magnets; the camera recognizes their positions in space due to magnetic flux distortions. They are expensive, subject to interference (wiring, appliances, etc.), have a relatively small working area and require an additional controller.

As for the mechanical one, with the help of a special skeleton worn by the actor, all movements are tracked with an emphasis on the bends of the joints (knees, elbows, and so on). This device restricts movement and allows a limited set of actions, which does not include complex interactions of several people and other actions that can damage it (falling, fighting, etc.). Also, in this case no facial expressions can be captured.

The gyroscopic one involves the use of small gyroscopes and inertial sensors acting as markers. The difference between this system and the others is that the sensors transmit not only their position in space, but also the angle of inclination relative to a predetermined one. Such systems are expensive and require an additional controller and an additional angle tracking system.

Both technologies (marker-based and markerless) co-exist which means they cannot be fully replaced with one another [3, pp. 5-7]. Markerless

technologies are convenient in two cases: for rapid animation prototyping and for creating multiple cinematics. In other words, it is suitable when there is a lot of animation and there is no task to get a detailed image in every shot. It also does not need a studio with a large amount of expensive equipment and long preliminary preparation; shooting can be done literally at home. The marker-based approach, on the other hand, can get a more detailed and realistic image.

People performing body shoots can only be called mo-cap actors, they are not recognizable due to the nature of their activities, but still occupy an important niche, being able to adapt to any unusual roles. Technical body shoots (stunts, fights, unusual and complex movements) are filmed by stuntmen and specially trained people. Often the body and face of the same model can be played by different people – someone can move more expressively, someone has very clear emotions. As soon as famous cinematographic actors appear, the shooting switches to the whole-body shooting mode where body movements, facial expressions and voice are captured at the same time.

Often, facial motion capture is singled out as a separate area, despite the inextricable connection with the body movements. Markerless and marker-based technologies are also applicable here. In the first case, a 3D model is created in advance. After that, the person begins to move in front of the camera, the machine learning program recognizes the key points on the face and correlates them with the same points on the face of the 3D model. This method allows to animate a character in real time without wasting resources and time on sensors, but it is very inflexible and can read and determine the actor data from a limited number of positions.

A more efficient method involves small markers drawn, glued or taped to the actor's face and a small camera. But the preliminary creation of a 3D model is also necessary. For this, the actor's face is scanned with special devices from different angles, after which, a topographical capture is taken of the actor's range of emotional expressions – a separate version of the same head – effectively creating a model that can recreate every facial movement of an actor. After adjusting the 3D-head, the recording of the scenes themselves can be started. The actor will act with markers placed at exactly the right places and a high-def helmet cam, wirelessly linked to capture devices, which will record the positions of the points. In contrast to the first method, in this way facial expressions can be captured with minimal deviations. This method is used when working with famous theater and film personalities, when the director wants them to be recognizable and the resulting model to be as realistic as possible.

However, a unique technique was presented by the Russian company VirtuSphere. During recording, the actor is inside a large rotating sphere, which consists of sensors. Currently, sensors capture motion in only one direction, so markers are needed to get a more complex and accurate result, but the development of this approach can reduce the cost of motion capture.

In our opinion, animation may encounter certain issues. As progressive as it may sound, creating good animation through motion capture is costly for developers due to the need for modern equipment (cameras, sensors, software)

that may become obsolete in a few years. If an error occurs during the shooting, for example, the sensors would not be calibrated in time and the position of the sensors would be incorrectly entered into the computer. It would be easier to reshoot everything again than to manually correct it through the software.

Another interesting problem that has accompanied the development of motion capture is the *uncanny valley effect* [4, p. 37]. This term describes the natural rejection of a person to things that look like a living person, but something is felt out of place. Initially, it was used in the field of robotics, but with the advent of more realistic models as a result of motion capture, the term began to cover other areas. At the moment, the situation is such that if the team of people working on the animation has enough skills and equipment, this problem can be completely avoided.

Also, earlier, people often paid attention to the fact that the created models had a dead look in their eyes. This detail is connected with another non-obvious complexity: without the use of a good program based on machine learning, eye movements cannot be tracked. Even with it they will not be accurate enough to create a compelling picture. As a rule, individual people manually recreate the movement of the pupils on an already finished model, using a previously recorded video with the performance of an actor.

An unusual problem that is not related to the technical side of the issue is that it is difficult for film actors to get used to the constant wearing of equipment (most often they participate in whole body capture) and perform as usual. Also, there are no costumes, sets, or sometimes even other actors to get into character, so they have to use their imagination to the fullest. It goes without saying, but it is really hard to apply motion capture to animals' natural movements which people can't imitate; most of the time it's impossible to set up all needed markers on them.

As we know, motion capture technologies are most used in the creation of films, computer games, advertising, etc. But the entertainment industry is not the only industry using advanced technology.

UNESCO is an organization whose responsibility it is to preserve the cultural heritage of mankind, but all of this is material. Intangible cultural heritage (ICH) is nonphysical intellectual wealth, such as folklore, customs, beliefs, traditions, knowledge, and language. Dance is also included in this list, and what, if not motion capture, helps to capture all the details? For these purposes, active and passive optical sensors are used, depending on the dance; some will be more suitable than others.

By accurately tracking the movements of masters in specific industries, specialists are able to identify patterns that help train new workers and raise their skill level by focusing on nuances. When a mentor cannot explain exactly what the problem is, the data collected by the sensors can provide a clear answer.

In a similar way, technology is used in sports to evaluate current progress, to determine the effectiveness of training based on the data received and to direct efforts to weak areas. Using only markerless technology, it's possible to

obtain neuromuscular data for how athletes use different muscles in the body to identify speed, reaction time, etc. Comparing the data of one person with others, you can find how to specifically correct those shortcomings that already exist and prevent the risk of developing injuries. When recovering from injuries, it can also be used to properly distribute the load and reduce the risk of re-injury.

From this follows the fourth area where motion capture technologies are applied – medicine. Doctors calculate and summarize the main biomechanical parameters, diagnose joint diseases at an early stage, and detect the risk of possible injuries [5, p. 1028]. The growing spread of technology is giving healthcare decision makers access to much more data than was previously possible and, as a result, helping to improve the quality of healthcare.

We believe that motion capture technology has become more accessible to casual users and finds more and more applications in different areas of life, but still remains quite expensive. If the goal is to get a realistic picture, it's impossible to do so without special equipment and experienced specialists. Working with a mo-cap is a long process that requires high-powered equipment. If the task is to make the movements of a 3D model similar to human movements (maybe only in certain aspects: movements of the hands, mouth), a smaller staff can handle this. You can even start learning the basics of this technology from home.

The markerless method has the greatest development prospects since it is becoming potentially possible to shoot without sensors and get the same picture as in shooting with markers. At the moment, the picture that can be obtained by the latter method looks plausible enough for the viewer to confuse it with a photograph. Improvements in the quality of the resulting image will be noticeable mostly by specialists.

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УДК 338.28

MANAGEMENT OF THE ENERGY COMPLEX WITH THE HELP OF GEOINFORMATION SYSTEMS

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Abstract. The aim of the study is to study the areas of application of geographic information systems (GIS) for the energy complex. The directions of application of GIS for the energy complex of Novosibirsk are being studied.

GIS is currently actively used in the energy sector, which increases the efficiency of the use of energy systems and complexes. The data obtained with the use of GIS is used in solving energy problems in the regions.

Keywords: energy, electricity, data, information system, geodata, economic efficiency, infrastructure.

УПРАВЛЕНИЕ ЭНЕРГЕТИЧЕСКИМ КОМПЛЕКСОМ С ПОМОЩЬЮ ГЕОИНФОРМАЦИОННЫХ СИСТЕМ

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Аннотация. Целью исследования является изучение направлений применения геоинформационных систем (ГИС) для энергетического комплекса. Изучаются направления применения ГИС для энергетического комплекса г. Новосибирска. ГИС в настоящее время активно используются в энергетике, что повышает эффективность использования энергетических систем и комплексов. Данные, полученные при применении ГИС, используются при решении энергетических проблем в регионах.

Ключевые слова: энергетика, электроэнергия, данные, информационная система, геоданные, экономическая эффективность, инфраструктура.

The relevance of the topic is due to the high level of energy demand, energy received from various sources. Energy is the engine of the economy, the economic development of regions and the state as a whole. Without energy, electric energy, the development of the economy will stop. Electricity is consumed by various factories and enterprises, equipment, machines and mechanisms.

Further, we will talk about the use of geographic information systems (GIS) in the energy sector. When using geographic information systems (GIS) to solve energy problems, it is possible to use their capabilities for the development of the energy industry. One of the components of the energy industry is binding to a certain territory, the area where equipment, communications, units, electrical networks, etc. are located.

Now there is an opportunity with the help of information systems. Including GIS to improve the efficiency of management in the energy sector. As part of the development of the energy sector, attention is paid to resources that are replenished naturally, the transportation of resources, logistics, while relying on analytical information obtained from various sources, including GIS. The advantage of GIS is the possibility of spatial analysis [1; 2].

GIS increases business efficiency by managing all kinds of data. For example, data on promising sites, customers, competitors and other components of the energy market. By managing this data at all stages, GIS increases the competitiveness of energy enterprises in the market.

Multilateral data management based on GIS eliminates unnecessary duplication of data, guarantees the continuity and sequence of implementation of all phases of planning, allows you to create a structure for fruitful interaction between various departments of energy companies and their partners. Recently, more and more attention has been paid to renewable energy sources, almost all studies and design conclusions in this area are based on spatial geodata and georeferencing. For data analysis, GIS analytical modules can be used.

Various companies that use energy resources conduct their business on a global level. Managing large volumes of information using modern GIS, such as Esri ArcGIS, these systems provide a great opportunity for software to manage data, integrate other platforms.

GIS helps develop efficient methods for extracting energy resources. For example, the production of energy from renewable sources such as hydroelectric power plants, solar installations, etc.

GIS is applied in the exploration and generation process. GIS is an important tool to support the management of all types of facilities and companies in the energy industry. To date, GIS is constantly improving, these platforms are reliable, allow for the control of transportation systems, tracking losses, planning for emergency response, rapid response to overcome the consequences of economic and political changes [3].

Systems allow you to identify fraudsters who are engaged in the theft of energy resources. Various GIS applications that monitor customer service outages to quickly respond to problems, target network problems, use maps to pinpoint specific problematic addresses, organizations, and more.

GIS improves the reliability and economic efficiency of energy companies, monitors customer requests, monitors consumption, manages infrastructure, property, assets of energy companies and their subsidiaries.

Esri is one of the leaders in the GIS market. This company has accumulated extensive experience in solving problems for the energy industry.

To get acquainted with Esri's available materials for studying issues related to geospatial positioning, mapping and GIS, you can go to, for example, the ArcGIS Online cloud resource and search for the word “energy”.

GIS helps companies develop the best methods for extracting natural resources such as oil, coal, gas, etc. It also provides data for the production of energy from renewable sources. GIS helps to reduce the cost of searching, preparing and developing territories where it is possible in the future to extract natural resources and then extract energy.

Applications with GIS capabilities help engineers to quickly review model options for the exploitation of deposits, group and analyze data on the prospects for mining, the scheme of delivery to places of consumption, and solve other engineering problems.

Energy companies have streamlined resource extraction operations by integrating GIS with real-time geospatial surveys, mine planning software and global positioning technology (GPS/GLONASS), geodetic surveys in the laying of electrical grids.

In order to carry out operational geo-surveying with maximum accuracy and correct inaccuracies at the work site, portable computers are used, which also get access to Esri ArcGIS services via the Internet via satellite communications. All data is loaded into the database, the operators see the overall picture of the design of power grids or other utilities.

Let us give a brief description of the energy complex and systems of Novosibirsk. There are four thermal power plants in Novosibirsk. The main problem in their work is ecological, they pollute the environment. Environmental problems caused by energy companies can also be solved with the help of GIS.

GIS tools and methods make it possible to monitor TPP emissions, determine the areas of distribution of pollution, and determine which areas of the city account for the maximum pollution. Solving problems and optimal distribution of landscaping in urban areas to reduce the negative environmental load.

GIS helps to comply with the laws of the Russian Federation in the field of environmental protection. Comply with the norms within the framework of the regulation “Violation of the Rules for the Protection of Atmospheric Air”, which regulates TPP emissions into the environment [4; 5].

GIS will allow avoiding violations of the TPP work cycle and, as a result, enterprises dependent on electricity supplies. All this will reduce the risks of economic losses, normalize the tariff policy, and reduce electricity losses.

Novosibirsk has a hydroelectric power plant on the Ob River in the Sovietsky district of the city. The hydroelectric power plant plays an important role in the energy system of the city of Novosibirsk. The Novosibirsk HPS plays the role of a regulating and mobile source of electricity. It provides coverage for the daily and weekly uneven load of the Novosibirsk energy system, performs the functions of a rotating power reserve for voltage frequency regulation and an emergency power reserve of the energy system, increasing the reliability of the city's energy system. It is also possible to use GIS tools to effectively monitor the operation of hydroelectric power plants.

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POSITION CONTROL TECHNIQUES FOR SERVO DRIVE WITH ELASTIC COUPLING

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Abstract. The paper deals with control technique of electromechanical systems with elastic coupling, in particular, the dual-mass systems. Different ways of controlling systems with slave and modal control are discussed, their advantages and disadvantages are highlighted. The advantage of a system with a full-state feedback controller for a non-rigid system is stressed.

Keywords: electrical drive, elastic coupling, servo drive, cascade control, full-state feedback control.

СПОСОБЫ УПРАВЛЕНИЯ СЛЕДЯЩИМ ЭЛЕКТРОПРИВОДОМ С НЕЖЕСТКОЙ СВЯЗЬЮ

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Аннотация. В работе рассматриваются способы управления электромеханическими системами с нежесткими связями. Обсуждаются различные способы управления систем с подчиненным и модальным регулированием, выделены их достоинства и недостатки. Подчеркивается преимущество системы с модальным регулятором для нежесткой системы.

Ключевые слова: электропривод, нежесткая связь, следящий привод, подчиненное регулирование, модальное управление.

Nowadays, the development of automation is an important task for the global industry. For the high-quality performance of technological operations, in many cases, an accurate positioning system is required: robotic manipulators, machining centers, machine vision systems, lifting mechanisms, etc. In these systems, a servo drive is used [1]. It is an automatic system for position control of an actuator when the position reference changes unpredictable. Ensuring high accuracy of the actuator position is a challenge due to the fact that the mechanical part is not rigid and may contain gaps in the transmissions. But in

many cases, it is possible to use a special adjustable electric drive and eliminate the need for a gearbox. One example of such a drive is a torque-controlled non-contact motor with a vector control system. This motor is a synchronous machine with permanent magnets on the rotor and two- or three-phase windings on the stator, to which sinusoidal voltages are applied. The parameters of these voltages are generated by a vector control system to maintain an angle of 90 degrees between the rotor and stator magnetic fields. This angle allows you to get the maximum value of torque. Use of vector control system allows to consider dynamic properties of brushless motor as very close to properties of direct current brushes motor [2].

However, the use of a specialized drive does not eliminate the elastic properties of the shaft and other mechanical parts. A precise mathematical description of the elastic system is quite a challenge, but in most cases, it is possible to describe such systems as two-mass systems, with the distributed masses considered to be concentrated. The first mass is the motor shaft and the second is the actuator.

Simulation is used to evaluate the performance of the system and to compare different control technique. The motor is described as a direct current brushes motor, the power converter is described as a first-order transfer function, and the mechanical part as a two-mass system.

Model parameters are presented in Table 1. The structural diagram of such a model is shown in Figure 1.

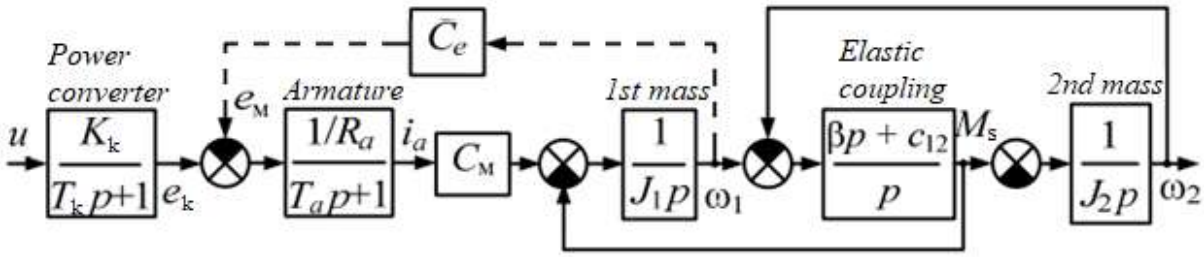

Figure 1. Elastic electromechanical system model

Table 1 – Model parameters

Armature resistance R_a, Om	1.46
Armature time constant T_a, s	0.026
Power converter time constant T_k, s	0.001
Power converter gain K_k	2.7
Armature current I, A	9.1
Motor torque M, Nm	0.81
Motor speed ω_1, rpm	2820
Torsional rigidity c_{12}, Nm/rad	0.215
Motor viscous friction coefficient β, Nm/(rad/s)	0.00405
Motor inertia J_1, kgm^2	0.000335
Load inertia J_2, kgm^2	0.00335

The most common control technique is the cascade control, its essence is to adjust the loops in series, with each successive loop including the previous ones. In electric drive systems with flux-oriented control there are almost always current and speed loops, in tracking systems there is also a position loop. When tuning the current loop, the elasticity in the mechanism can be disregarded as the influence of the counter-electromotive force feedback is negligible. If the influence of elasticity is small, the speed loop can also be tuned as in a rigid system. In this case, the moment of inertia in such a loop is assumed to be equal to the sum of the moments of the first and second masses, and the feedback at the regulator input is the speed of the second mass.

If the influence of elasticity is significant, the described tuning method gives unsatisfactory results [3]. In this case, additional loops can be used: the motor speed loop and the shaft torque loop. All loops are set to modulus optimum. These settings make it possible to achieve good settling time with low overshoot. Parameters of regulators are given in Table 2.

Table 2 – Controller parameters

Control loop	Controller gain	Controller time constant
Current loop	14.25	0.026
Motor speed loop	0.93	-
Shaft torque loop	581.4	-
Actuator speed loop	0.21	-
Position loop	31.25	-

But in this system the motor current limitation has not been taken into account. If the motor current is limited, system will become unstable. Stability can be achieved by using s-shaped rate limiter, which allows to achieve smooth change of motor torque and avoid overloading. The step response for the system with the cascade control are shown in Figure 2. The overshoot is 1.8 %, the settling time is 0.3 s.

The use of a rate limiter has increased the settling time, which may reduce the quality of the tracking system.

Another control technique is full-state feedback control. The full-state feedback controller allows to provide any desired dynamic in the system. This can be achieved by introducing static state feedback.

As the current loop has a very low response time, its influence can be neglected and the current loop can be considered as gain without time constant when tuning the full-state feedback controller. The state variables selected are: velocity of the first mass, elastic torque, velocity and position of the second mass.

The dynamics of the system with a full-state feedback controller is determined by the desired characteristic polynomial. The best results are given by Bessel polynomials [4]. For a 4th order system it has the following form:

$$D_g = s^4 + 3.12\omega_0 s^3 + 4.39\omega_0^2 s^2 + 3.2\omega_0^3 s + \omega_0^4;$$

The value of the geometric mean root ω_0 is taken to be 36.4 rad/s, which is 1.4 times the resonance frequency. The step response for the system with the full-state feedback controller are shown in Figure 2.

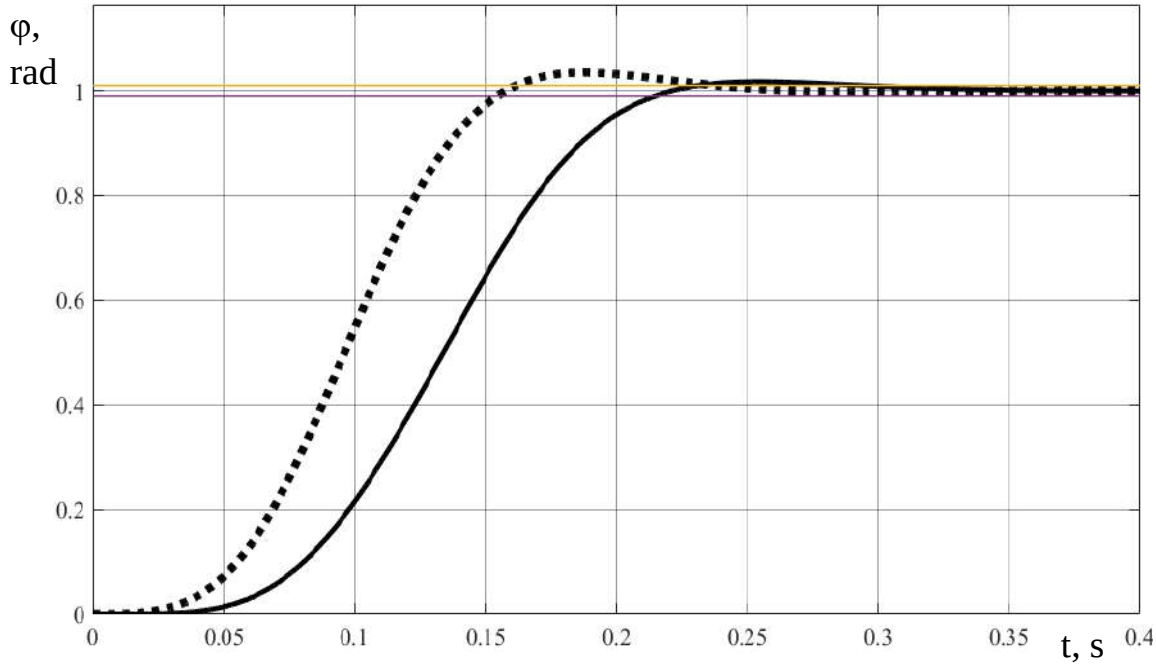

Figure 2. Step response for cascade control (solid line) and full-state feedback control (dotted line)

The overshoot is 3.5 %, the settling time is 0.24 s.

Thus, we can draw the following conclusions: in spite of simplicity of tuning, cascade control is inexpedient at significant influence of elasticity of the mechanism. Transients will be unsatisfactory, rate limiter is required. A better system performance can be achieved by using full-state feedback control. The tuning of the full-state feedback controller is more difficult, but can improve the system performance with a small increase in overshoot.

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МАТЕРИАЛЫ
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Part II

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