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ИНОСТРАННЫЙ ЯЗЫК
АВТОМАТИЗАЦИЯ ТЕХНОЛОГИЧЕСКИХ ПРОЦЕССОВ И ПРОИЗВОДСТВ
(АВТОМАТИЗАЦИЯ ТЕХНОЛОГИЧЕСКИХ ПРОЦЕССОВ И ПРОИЗВОДСТВ В ГОРНОЙ ПРОМЫШЛЕННОСТИ, АВТОМАТИЗАЦИЯ ТЕХНОЛОГИЧЕСКИХ ПРОЦЕССОВ И ПРОИЗВОДСТВ В МЕТАЛЛУРГИЧЕСКОЙ ПРОМЫШЛЕННОСТИ)

Методические указания к самостоятельной работе

для студентов специальности 15.03.04

FOREIGN LANGUAGE
AUTOMATION OF TECHNOLOGICAL PROCESSES AND PRODUCTION
(AUTOMATION OF TECHNOLOGICAL PROCESSES AND PRODUCTION IN METALLURGICAL INDUSTRY, AUTOMATION OF TECHNOLOGICAL PROCESSES AND PRODUCTION IN MINING INDUSTRY)

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ИНОСТРАННЫЙ ЯЗЫК. Автоматизация технологических процессов и производств (Автоматизация технологических процессов и производств в металлургической промышленности, Автоматизация технологических процессов и производств в горной промышленности): Методические указания к самостоятельной работе. / Санкт-Петербургский горный университет. Сост. *Э.Р.Скорнякова.* СПб, 2022. 32 с.

Методические указания предназначены для студентов направления подготовки 15.03.04 Автоматизация технологических процессов и производств (Автоматизация технологических процессов и производств в металлургической промышленности, Автоматизация технологических процессов и производств в горной промышленности). Предлагаемый материал направлен на совершенствование навыков профессионально-ориентированного чтения студентов на английском языке. Методические указания к самостоятельной работе включают тексты на языке оригинала, специально разработанные упражнения и задания, способствующие развитию речевой, языковой, социокультурной и информационной компетенций студентов, необходимых для общения в сфере профессиональных интересов.

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ПРЕДИСЛОВИЕ

Данные методические указания предназначены для учебно-методического сопровождения курса английского языка для студентов неязыковых вузов, обучающихся по направлению подготовки 15.03.04 «Автоматизация технологических процессов и производств (Автоматизация технологических процессов и производств в металлургической промышленности, Автоматизация технологических процессов и производств в горной промышленности)». Методические указания составлены в соответствии с учебной программой по дисциплине «Иностранный язык» для формирования иноязычной профессиональной компетенции будущих специалистов. В методические указания включены аутентичные тексты, в которых освещаются основные процессы автоматизации в металлургической и горной промышленности.

Изучение материала преследует цель развития навыков и умений просмотрового и изучающего чтения текстов по направлению подготовки, а также их перевода на русский язык с последующим использованием полученной информации для речевой практики; овладение студентами иноязычной коммуникативно-речевой компетенцией, позволяющей будущему специалисту осуществлять профессиональную коммуникацию; формирование активного словарного запаса, который включает наиболее употребительные английский термины и выражения по теме «Automation of technological processes and production (Automation of technological processes and production in metallurgical industry, Automation of technological processes and production in mining industry)».

UNIT 1. BASICS OF AUTOMATION

1.1. Read and translate the text "What is Automation?"

Automation, application of machines to tasks once performed by human beings or, increasingly, to tasks that would otherwise be impossible. Although the term mechanization is often used to refer to the simple replacement of human labour by machines, automation generally implies the integration of machines into a self-governing system. Automation has revolutionized those areas in which it has been introduced, and there is scarcely an aspect of modern life that has been unaffected by it.

In general usage, automation can be defined as a technology concerned with performing a process by means of programmed commands combined with automatic feedback control to ensure proper execution of the instructions. The resulting system is capable of operating without human intervention. The development of this technology has become increasingly dependent on the use of computers and computer-related technologies. Consequently, automated systems have become increasingly sophisticated and complex. Advanced systems represent a level of capability and performance that surpass in many ways the abilities of humans to accomplish the same activities.

Automation technology has matured to a point where a number of other technologies have developed from it and have achieved a recognition and status of their own. Robotics is one of these technologies; it is a specialized branch of automation in which the automated machine possesses certain anthropomorphic, or humanlike, characteristics. The most typical humanlike characteristic of a modern industrial robot is its powered mechanical arm. The robot's arm can be programmed to move through a sequence of motions to perform useful tasks, such as loading and unloading parts at a production machine or making a sequence of spot-welds on the sheet-metal parts of an automobile body during assembly. As these examples suggest, industrial robots are typically used to replace human workers in factory operations.

The technology of automation has evolved from the related field of mechanization, which had its beginnings in the Industrial Revolution. Mechanization refers to the replacement of human (or animal) power with mechanical power of some form. The driving force behind mechanization has been humankind's propensity to create tools and mechanical devices.

The developments have provided the three basic building blocks of automation: (1) a source of power to perform some action, (2) feedback controls, and (3) machine programming [18].

1.2. Discuss the information from the text "Early developments of Automation" with a partner.

The first tools made of stone represented prehistoric man's attempts to direct his own physical strength under the control of human intelligence.

The next extension was the development of powered machines that did not require human strength to operate. Examples of these machines include waterwheels, windmills, and simple steam-driven devices. More than 2,000 years ago the Chinese developed trip-hammers powered by flowing water and waterwheels. The early Greeks experimented with simple reaction motors powered by steam. Windmills, with mechanisms for automatically turning the sails, were developed during the Middle Ages in Europe and the Middle East. The steam engine represented a major advance in the development of powered machines and marked the beginning of the Industrial Revolution. During the two centuries since the introduction of the Watt steam engine, powered engines and machines have been devised that obtain their energy from steam, electricity, and chemical, mechanical, and nuclear sources.

Each new development in the history of powered machines has brought with it an increased requirement for control devices to harness the power of the machine. The earliest steam engines required a person to open and close the valves, first to admit steam into the piston chamber and then to exhaust it. Later a slide valve mechanism was devised to automatically accomplish these functions. The only need of the human operator was then to regulate the amount of steam that controlled the engine's speed and power. This requirement for human attention in the operation of the steam engine was eliminated by the flying-ball governor. Invented by James Watt in England, this device consisted of a weighted ball on a hinged arm, mechanically coupled to the output shaft of the engine.

A common example of a feedback control system is the thermostat used in modern buildings to control room temperature. In this device, a decrease in room temperature causes an electrical switch to close, thus turning on the heating unit. As room temperature rises, the switch opens and the heat supply is turned off. The thermostat can be set to turn on the heating unit at any particular set point.

Another important development in the history of automation was the Jacquard loom, which demonstrated the concept of a programmable machine. About 1801 the French inventor Joseph-Marie Jacquard devised an automatic loom capable of producing complex patterns in textiles by controlling the motions of many shuttles of different coloured threads. The selection of the different patterns was determined by a program contained in steel cards in which holes were punched. These cards were the ancestors of the paper cards and tapes that control modern automatic machines. The concept of programming a machine was further developed later in the 19th century when Charles Babbage, an English mathematician, proposed a complex, mechanical "analytical engine" that could perform arithmetic and data processing. Although Babbage was never able to complete it, this device was the precursor of the modern digital computer [18].

1.3. Read the text "Modern developments of Automation", find out more information about the facts described in the text.

A number of significant developments in various fields have occurred during the 20th century: the digital computer, improvements in data-storage technology and software to write computer programs, advances in sensor technology, and the derivation of a mathematical control theory. All these developments have contributed to progress in automation technology.

Development of the electronic digital computer (the ENIAC [Electronic Numerical Integrator and Computer] in 1946 and UNIVAC I [Universal Automatic Computer] in 1951) has permitted the control function in automation to become much more sophisticated and the associated calculations to be executed much faster than previously possible. The development of integrated circuits in the 1960s propelled a trend toward miniaturization in computer technology that has led to machines that are much smaller and less expensive than their predecessors yet are capable of performing calculations at much greater speeds. This trend is represented today by the microprocessor, a miniature multicircuited device capable of performing all the logic and arithmetic functions of a large digital computer.

Advances in sensor technology have provided a vast array of measuring devices that can be used as components in automatic feedback control systems. These devices include highly sensitive electromechanical probes, scanning laser beams, electrical field techniques, and machine vision. Some of these sensor systems require computer technology for their implementation. Machine vision, for example, requires the processing of enormous amounts of data that can be accomplished only by high-speed digital computers. This technology is proving to be a versatile sensory capability for various industrial tasks, such as part identification, quality inspection, and robot guidance.

Finally, there has evolved since World War II a highly advanced mathematical theory of control systems. The theory includes traditional negative feedback control, optimal control, adaptive control, and artificial intelligence. Traditional feedback control theory makes use of linear ordinary differential equations to analyze problems, as in Watt's flying-ball governor. Although most processes are more complex than the flying-ball governor, they still obey the same laws of physics that are described by differential equations. Optimal control theory and adaptive control theory are concerned with the problem of defining an appropriate index of performance for the process of interest and then operating it in such a manner as to optimize its performance.

Artificial intelligence is an advanced field of computer science in which the computer is programmed to exhibit characteristics commonly associated with human intelligence. These characteristics include the capacity for learning, understanding language, reasoning, solving problems, rendering expert diagnoses, and similar mental capabilities. Developments in artificial intelligence are expected to provide robots and other "intelligent" machines with the ability to communicate with humans and to accept very high-level instructions rather than the detailed step-by-step programming statements typically required of today's programmable machines [18].

II. Study the following words and expressions:

human labour – человеческий труд;
self-governing system **-** самоуправляемая система;
perform a process – выполнить/осуществить процесс;
programmed commands – запрограммированные команды;
automatic feedback control – автоматическое регулирование с обратной связью;
proper execution **–** должное/надлежащее исполнение;
robotics **–** робототехника, робототехнические средства;
spot-weld **–** точечная сварка, точечный шов;
sheet metal **–** листовая сталь, металлический лист;
automobile body – автомобильный кузов;
assembly – сборка частей; комплект инструментов;
driving force – движущая сила;
machine programming – создание машинного кода, машинное программирование;
waterwheel **–** водяное колесо;
windmill – ветряная мельница;
steam-driven **–** с паровым двигателем;
trip-hammer – падающий свайный молот, механический молот; ***valve*** **-** клапан;
piston chamber **–** полость цилиндра, поршневая камера;
flying-ball governor – центробежный регулятор с шаровыми грузами;
hinged arm – коромысло, подвижный хобот, качающийся рычаг;
output shaft **-** выходной/выводной вал;
Jacquard loom – ткацкий станок Жаккарда (с автоматическим управлением с помощью перфокарт);
shuttle **-** ткацкий челнок, деталь с возвратно-поступательным движением;
thread – нитка, нить; цепочка команд;
data processing – обработка информации; precursor – предшественник, прототип;
ENIAC – ЭНИАК, электронный цифровой интегратор и калькулятор;
UNIVAC **-** универсальный автоматический компьютер УНИВАК;
integrated circuit – интегральная микросхема;

implementation **–** реализация, внедрение.

III. Complete the table and make 5 sentences with any of the words from the table.

verb	noun	adjective/participle
implement		
	control	
	automation	
		performed
operation		

IV. Answer the following questions:

1. What do terms “automation” and “mechanization” mean?
2. How can automation be defined?
3. What is implied in Robotics?
4. What are three basic building blocks of automation?
5. What information do you know about the Industrial Revolution?
6. How were steam engines operated?
7. What is a common example of a feedback control system? How does it work?
8. What are Joseph-Marie Jacquard and Charles Babbage famous for?
9. What do abbreviations ENIAC and UNIVAC stand for?
10. Can you describe recent advances in sensor technology?
11. What is a theory of control systems?
12. What are advantages of artificial intelligence?

V. Insert the missing words and expressions:

the Jacquard loom; automation; feedback control theory; the Industrial Revolution; Machine vision; Artificial intelligence; human intelligence; performance; thermostat;

1. ______________________ is an advanced field of computer science in which the computer is programmed to exhibit characteristics commonly associated with _____________________.
2.___________________, for example, requires the processing of enormous amounts of data that can be accomplished only by high-speed digital computers.
3. Advanced systems represent a level of capability and _________________ that surpass in many ways the abilities of humans to accomplish the same activities.
4. Another important development in the history of automation was _______________________, which demonstrated the concept of a programmable machine.
5. Traditional ___________________________ makes use of linear ordinary differential equations to analyze problems, as in Watt's flying-ball governor.
6. A common example of a feedback control system is the ____________ used in modern buildings to control room temperature.
7. The technology of ______________________ has evolved from the related field of mechanization, which had its beginnings in __________________________.

UNIT 2. AUTOMATION IN METALLURGICAL INDUSTRY

I. Analyze excerpts from the articles below. Give a brief summary of each one.

2.1. Computer-integrated control of metallurgical complexes using forecasting simulation

In modern metallurgical production the greater part of products is made in the automated technological complexes (ATC). Since the productive efficiency and, respectively, the production capacity are not the only indicators of the enterprise performance with the computer control integrated, there is a whole series of challenging problems involved in the ATC synthesis. These problems need to be solved at different stages of the ATC life cycle (at planning, strategic planning, current planning, modernizations etc.).

Results of the simulation modeling done for the energy saving control in the "furnaces – hot strip mill" ATC led to implementation of the main components of the software and algorithms package SUET (System Used in Energy-saving Technology). The study of the results of controlling the "furnaces – hot strip mill" ATC with the use of the SUET components allows establishing the quantitative and qualitative relations of the power used and the modes of rolling.

The efficiency of algorithms of the initial adjustment of the energy-saving control and its updating to fit different rolling modes is manifest in higher efficiency of the strip rolling mills and lower metal burn out in slab heating due to shorter heating time; lower energy use in the metal heating and rolling; higher quality of the finished products thanks to metal temperature stabilization at the output of the train [11].

2.2. Improvement of the automated control systems for the development of metallurgy

Over the last decades, Russian metallurgical enterprises are the major suppliers of steel products in the world market. The main advantage that causes the Russian metallurgical enterprises export success is in the fact that the high quality of its products satisfies the world standards requirements. Experts predict high production growth in the Russian metallurgical industry in 2030. The world economy forecast for the following decade assumes two scenarios of sustainable rise in production of the Russian metallurgical companies.

The first scenario is based on the existing enterprises principles and suggests the non-ferrous metals production growth in 2030 is able to be increased by 40%. The second scenario involves the metallurgical industry innovative development that can make possible to increase the production in 2030 by more than 48%. Such programs follow both Russian and international laws in the fields of labour and environmental safety at the metallurgical enterprises. However, there are definitely some challenges on the path of innovative development of the steel industry. They are: facilities and equipment wear and tear high percentage; lack of the necessary number of highly skilled specialists; ore composition heterogeneity, etc.

These factors not only lead to negative economic and technical results but also cause emergencies with serious social and environmental aftereffects. Thus, one of the key tasks of innovative development of the steel industry is to work out intellectual information management systems that improve conditions of labor and environmental safety, both within the enterprise and the surrounding areas. In this light, the aim of our work is the development of smart information systems for improving the metallurgical enterprises Industrial control system (ICS).

Today, the responsibility for the technological processes management has considerably increased and management information systems (MIS) such as SCADA are partially in charge of the production safety. These systems, SCADA trace mode v.6 in particular allows them to be upgraded. This fact in its turn allows us to consider it as the most perspective way to manage in complex automated systems due to the possibility of modernization.

It is discovered by the authors that the principle of openness bases of SCADA Systems, allows to introduce additional modules without significant human and financial costs, designed to solve the following problems: increase the economic and environmental assessment of the enterprise; reduction of the environmental costs; maintenance of the stable operation of equipment and chemical composition of raw materials within the standards; safeguarding of the enterprise high rating on a domestic and international markets. These tasks are proposed to be solved by the Smart Advanced Warning System (AWS) development and its integration into the ICS of the metallurgical enterprise.

During the AWS development process the complex man-machine systems creation experience for other industries, including the transport safety and the glass manufacture, was taken into consideration. AWS allows to evaluate current production situation and to demonstrate effective solutions connected with the impact on the technological situation, including the pre-emergency and emergency ones. The developed AWS has smart properties and provides the substantial improvement of the overall automation of metallurgical enterprises [6].

2.3. Innovations in Monitoring, Control and Design of Laser and Laser-Arc Hybrid Welding Processes

With the rapid development of high power laser, laser welding has been widely used in many fields including manufacturing, metallurgy, automobile, biomedicine, electronics, aerospace etc. Combining the two heat sources of laser and arc for welding can achieve excellent results due to the synergistic effect. Laser welding is a complicated physical and chemical metallurgical process, involving the laser beam and molten pool, keyholes and materials melting, evaporation and multiple physical process. Process monitoring and quality control are important content of research and development in the field of laser welding, which is the premise to obtain fine weld with high quality. Numerical simulation technology (NST) can describe many complex physical phenomena in welding process, which is very important to predict weld forming and quality and clarify the underline mechanism. In this paper, the research progress of process monitoring, quality control and autonomous intelligent design of laser and laser-arc hybrid welding based on numerical simulation were reviewed, and the research hotspots and development trends of laser welding in the future are predicted.

Because of the complexity of the laser welding, it is impossible to obtain the required useful information only by using a single or multiple sensors. However, the information obtained by various sensors may be redundant or even contradictory. So, this requires the sensor “fusion” technology. In order to achieve this goal, neural network is a useful method. At the same time, neural network technology has a great potential in pattern classification and recognition. The neural network has a good learning ability, and the repeatability of laser welding process provides the neural network with learning conditions.

In summary, laser welding has the characteristics of high precision, high efficiency and strong adaptability, and has the advantages of easy automatic control of parameters, good repeatability and reproducibility. It can improve the stability of product quality. Therefore, it has been widely used in many fields. Based on the industry’s demand for automatic and intelligent welding, the research on the monitoring, quality control and monitoring-feedback-parameters adjust integrated control of laser welding process has attracted extensive attention. Various sensors such as inductance, capacitance, acoustic wave, photoelectric and vision are used to realize weld tracking, defect detection and weld forming quality monitoring according to different laser welding processes and requirements through artificial intelligence and computer processing methods; the welding process are adjusted through feedback control, so as to finally realize the automation and intelligence of laser welding process. Although scholars have conducted plenty of research, its application and promotion still face many bottlenecks to be broken through. The main reasons are as follows: on the one hand, the process window of laser welding is narrower than that of traditional arc welding, which is characterized by small weld pool size. Therefore, it is very sensitive to the fluctuation of assembly clearance and equipment state. It is easy to produce defects such as poor fusion, pores, cracks and splashes. On the other hand, the absorption rate of metallic material to laser directly affects the thermal efficiency and stability of welding process. In addition, the laser precision welding of ultra-thin and ultra-fine parts in the fields of electronics, communications and aviation, as well as the automatic intelligent welding of large thickness and large size parts in the fields of electric power, chemical industry and locomotives, has attracted wide attention [10].

Vocabulary

Advanced Warning System (AWS) – усовершенствованная система предупреждения;
enterprise performance – деятельность предприятия, производственные показатели отдельной отрасли;
equipment wear and tear – износ оборудования;
forecasting simulation – моделирование технического прогнозирования;
Industrial control system (ICS) – автоматизированная система управления технологическими процессами; промышленная система управления; автоматизированная система управления;
long-term development – долгосрочное развитие, перспективная разработка;
Management Information system (MIS) – управленческая информационная система;

metallurgical production – металлургическое производство;
satisfy the world standards requirements – удовлетворять (соответствовать) требованиям мировых стандартов;
SCADA – АСУТП (автоматизированная система управления технологическим процессом)
steel product – стальное изделие, стальной материал, металлопрокат;
strip rolling mill – полосовой прокатный стан.

II. Answer the questions.

1. What are indicators of enterprise performance?
2. What are possible scenarios of sustainable rise in production of the Russian metallurgical companies?
3. Can you explain the abbreviations ATC, SUET, ICS, MIS, SCADA, AWS?
4. What is the connection between numerical simulation technology and laser welding?

III. Insert the missing words and expressions:

steel products; laser welding; welding process; metallurgical production; monitoring-feedback-parameters SCADA; automatic control of parameters

1. In modern ___________________________the greater part of products is made in the automated technological complexes (ATC).
2. With the rapid development of high power laser, ______________ has been widely used in many fields including manufacturing, metallurgy, automobile, biomedicine, electronics, aerospace etc.
3. Over the last decades, Russian metallurgical enterprises are the major suppliers of __________________ in the world market.
4. Today, the responsibility for the technological processes management has considerably increased and management information systems (MIS) such as _______________ are partially in charge of the production safety.

5. Numerical simulation technology (NST) can describe many complex physical phenomena in ____________________, which is very important to predict weld forming and quality and clarify the underline mechanism.
6. In summary, laser welding has the characteristics of high precision, high efficiency and strong adaptability, and has the advantages of easy __________________________, good repeatability and reproducibility.
7. Based on the industry's demand for automatic and intelligent welding, the research on the monitoring, quality control and __________________ adjust integrated control of laser welding process has attracted extensive attention.

IV. Find further information about automation processes in metallurgical industry, make a presentation, share information with your group mates.

UNIT 3. AUTOMATION IN MINING INDUSTRY

I. Analyze excerpts from the articles below. Give a brief summary of each one.

3.1. Concept of shield-data-based horizon control (SDHC) for longwall coal mining automation

Coal is an important fossil fuel and will also be for the next decades. Thus, there have been several approaches and researches in longwall coal mining automation which are mainly focused on the shearer as the executing machine. In addition approaches of coal interface detection have to be taken into account for horizon control to reach autonomous shearer guidance. The shield-data-based horizon control is an alternative control approach which integrates data from the roof support as input and feedback to reach an automatic cutting drum height adjustment with the aim to follow the seam trend, generate a defined face opening and keep it.

A longwall coal mining workface is a complex system. Fundamental analyses based on a simulation model make the system behavior of a longwall workface visible. Therefore, the cut contour and the seam trend are considered. Regarding the simulation results for the non-controlled system it is obvious that the system does not reach a stable rest position without a recurring override by an operator or another control concept. Therefore the SDHC is introduced as an approach for longwall coal mining horizon control. The control objectives are the generation of a desired face opening as well as the tracking of the seam trend. Thus the SDHC approach integrates the roof support for data acquisition but did not need the memory cut as almost all other horizon control methods. The schematic of the SDHC control algorithm and test results for different conditions are shown. The experiments have shown promising results referring to the control aims. The defined face opening is generated and kept, the controlled system follows changing seam trends and the system behavior is stabilized. The next steps in the development of an autonomous horizon control by using SDHC is the application in an underground mine [9].

3.2. Future automation systems in context of process systems and minerals engineering

The mining industry is confronted with a number of technological challenges along the entire production value chain. There is a need for innovative production solutions to bring the next digital generation to the raw material field. Industry 4.0, Industrial Internet of Things (IIoT), Cloud Computing and Artificial Intelligence (AI) are today the mega trends in the field of process automation.

Autonomous driving has been one of the most important technology drivers for digital transformation in mining industry. Mining industry involves heavy equipment which must be also reliable and operational. IoT sensors provide maintenance data for analysis at the edge of the computing platform enabling a closer focus on operation. As the technology becomes more widespread, it will allow mining companies to consider the installation of mine operation centers for monitor their mines, automated vehicles and performance remotely. IIoT platforms will offer great opportunities to build these centers using the latest technology.

The digital twin is a digital replica of a mineral processing equipment, process or the whole plant. At the heart of the digital twin is a model that represents the attributes and operation of the system. A digital twin usually also includes artificial intelligence in its self-learning. Most of the digital twin services in mining and mining engineering are today based on steady state models of unit processes and equipment [8].

3.3. Deep learning in mining and mineral processing operations

Digitalization of the manufacturing industries is growing rapidly in what is often referred to as the 4th Industrial Revolution or Industry 4.0, and in this respect the mining industry is no exception. Massive quantities of data drive these developments. The knowledge derived from these data is obtained by means of machine learning, which has been evolving in the broader field of artificial intelligence, since the mid-20th century.

Deep learning, a subset of machine learning, has achieved significant breakthroughs in a range of applications in recent years. Unlike many other machine learning methods, deep learning naturally takes advantage of automatically discovering features and patterns from data combined with modeling structures capable of capturing highly complex behavior.

Broadly speaking, these deep learning architectures can be categorized as unsupervised, supervised and hybrid methods. Unsupervised methods are typically used for feature extraction and can be combined with supervised methods designed for regression or classification problems to yield hybrid methods. Some examples of these hybrid approaches include pretraining of convolutional neural networks with deep autoencoders or deep multilayer perceptrons with deep belief networks.

While digitalization of the mining industry is advancing in many ways, the industry tends to adopt technology, rather than leading in its development. Insight into future development can therefore be gained from recent developments in manufacturing. In this area, some novel machine learning methodologies closely tied to deep learning are emerging. This includes deep reinforcement learning and adversarial learning [7].

II. Match the left and the right.

1. Roof support	a) глубокое обучение с подкреплением
2. Cutting drum	b) Промышленный Интернет вещей

3. System behaviour	c) метод машинного обучения
4. Work face	d) виртуальный макет, виртуальная копия
5. Production value	e) стоимость продукции, объем производства
6. Cloud Computing	f) вычисления при помощи интернет-ресурсов, обработка облачных данных
7. Maintenance data	g) эксплуатационные данные, параметры технического обслуживания
8. Digital twin	h) крепление кровли, поддержание кровли
9. Deep reinforcement learning	i) состязательное обучение (метод глубокого обучения двух противоборствующих нейронных сетей)
10. Adversarial learning	j) фрезерный барабан

III. Answer the questions.

1. What are approaches and researches in longwall coal mining automation?
2. What is a shield-data-based horizon control?
3. Describe the SDCH approach.
4. What are Industry 4.0, Industrial Internet of Things (IIoT), Cloud Computing and Artificial Intelligence (AI)?
5. What is specific about the digital twin?

IV. Find further information about automation processes in mining industry, make a presentation, share information with your group mates.

UNIT 4. Translation Challenge (from English into Russian).

4.1. What is RPA?

RPA is a generic tool to create specialized agents (i.e. bots) which can monitor users' interactions with GUI elements while performing a task in order to replicate it.

There are currently 2 main types of RPA regarding the way they work:

- Rule-based bots which leverage screen scraping to perform pre-built tasks according to if-then rules (e.g. if new email arrives, then download attachment)
- AI-enabled bots, also known as cognitive RPA, which do not necessarily need rules, instead they use AI algorithms (e.g. OCR, NLP, text analytics) to understand process development and replicate it.

What are the benefits of RPA?

Manual processes are inefficient, prone to errors and lead to employee dissatisfaction. According to vendor studies about benefits, leveraging RPA enables businesses to:

- increase speed of / reduce errors in customer-facing processes to increase customer satisfaction (62%)
- allow employees to focus on higher value-added activities improving both business results and employee satisfaction (61%)
- reduce costs of wages and outsourcing (25 – 60%)

What makes RPA different from other automation solutions?

RPA's power lies in its 4 pillars: **Flexibility**: RPA is a great candidate to automate numerous daily jobs as it's been estimated that a typical rule-based process can be 70%-80% automated. For instance, workers receive some input whether it is an email or a system notification. In response, they conduct a rule-based analysis and take an action like making changes on files or programs. An RPA bot is capable of replicating these GUI-based processes.

Ease of integration: RPA bots do not need to be integrated with most software. Thanks to screen scraping and existing integrations, they can input and evaluate the output of almost all Windows applications.

Ease of implementation: RPA can be set up as simple as setting up a macro by recording your actions. There are also low-code and no-code solutions which leverage drag and drop interfaces for setting up automation. The next generation RPA bots, also called cognitive or intelligent automation, take this one step further, learning activities to be automated based on employee's actions.

Cost: Robots are cheaper than humans! Business process outsourcing solutions are no longer economical when those processes can be automated yielding better results and requiring less cost than outsourcing. However, BPO firms also smartly embraced RPA reducing their costs even further. So some BPO solutions can be considered as outsourced RPA solutions and they can be very efficient as they leverage a BPO's economies of scale [12].

4.2. How AI Helps Boost Mining Safety and Profitability

Predictive technologies take the mining world by storm, providing new insights to help them avoid dangerous situations and costly mistakes. The right predictive maintenance software will utilize existing hardware and data captured with minimal impact to operations.

The adoption of digital technology in the heavy-duty industry, such as mining and mineral processing, has taken longer compared to other industries, such as oil and gas. Although both are very intensive users of large assets, there is a widespread idea that mining is naturally a wear industry, where most equipment deteriorates very quickly, and its failures are unpredictable. Therefore, being able to manage frequent shutdowns and the excessive preventive maintenance of critical equipment has, historically, been the standard practice in this industry.

According to the Occupational Safety and Health Administration (OSHA), more than 20 percent of the accidents in the industry occur during unplanned downtime or machine failures. Out of the 80 percent of accidents that happen during normal routine maintenance, many occur due to lack of subject matter expertise, lack of having a preliminary diagnostic before approaching the machine and defective work methods.
Beyond safety, cost is another issue that arises with standard preventive maintenance.

Moving from Preventive to Predictive

Preventative maintenance involves processes and activities that do not treat or address the underlying problem and often prolong or delay the inevitable. This often means additional downtime or replacement costs through early change out of equipment. We have seen many examples of additional preventative maintenance activities that are executed poorly, through incorrect change out and have introduced further issues. This all leads to more work and ultimately increases the safety risk.

Predictive maintenance is a different approach; it employs powerful AI and machine learning to analyze a wide range of factors and variables in production, can determine from that analysis which variables will lead to certain patterns and behaviors of plant equipment, both fixed and mobile equipment. It categorizes asset conditions as into three buckets: normal behaviors, anomaly behaviors or failure patterns. The system can then alert mining companies to failure, well in advance (weeks, even months) of the actual breakdown of the equipment, and it is all based on early warning signs and patterns found in operational data. For example, when the system monitors asset behavior, if it detects something that deviates from normal conditions it will send an alert to staff – this gives staff the opportunity to make appropriate adjustments and plan ahead to better accommodate downtime if the equipment needs to be serviced, shifting production schedules accordingly [13].

4.3. Advantages of CNC Machining Over Traditional Machining

With the development of PCs, numerical systems penetrated almost all industries. Today, CNC machines are popular with most manufacturers across the board for manufacturing and fabricating applications. CNC systems are a significant part of modern machining technologies. CNC is short for Computer Numerical Control, and the machine mechanism and tools are connected to a unique digital control system.

Principles of CNC and Traditional Machining

The Numerical Control system is made up of both software and hardware. The operator works with the software to monitor the machine tools and to create programs. Numerical Control programs are lists of instructions instructing how the machine should work to process parts. The NC hardware reads the program and tells the machine tool how to act.

Advantages of CNC Machining

Worker Safety

The CNC machine operator is safe from any sharp parts behind a protective construction. The operator can see what is going on in the machine tool via the glass. The operator does not necessarily need to go close to the spindle or mill. The operator does not have to come near the cooling fluids. Some fluids are dangerous to human skin, depending on the material.

Economy of Labor

Traditional machine tools needed the operator to pay close attention and move each part of the tool. As a result, each worker could only operate one machine tool. With the CNC, this changed, and most pieces only take about half an hour to process during each setup. The CNC machine tool cuts without help, and the operator does not have to do anything. The tool automatically moves, with the operator just checking for errors in the setup or program. This situation means the operator has free time in between, time that can be used to operate more tools. With one operator with several machine tools, you can save on the costs of hiring more people to work the machines.

Reduced Error in Set-Up

Traditional machine tools rely on the proficiency of the operator in using measuring instruments. Some good workers are capable of setting up parts with a lot of precision, but they are very few. This is why CNC systems employ a special coordinate measuring probe, which is installed into the spindle. The probe touches the fixed part to set its position. The coordinate system zero points are certified so that the setup errors are reduced.

Reduced Test Runs

Traditional machining has a few test parts. The operator must get acquainted with the technology and might miss some things while doing the first part. CNC systems have ways to avoid doing test runs. They use visualization systems that allow the operator to see what will happen after the tool passes are finished.

Conclusion

The traditional machining was tedious and had more possibilities for errors. CNC machining came along to ease the burden of having to do everything manually. The CNC assures you of worker safety, reduces the need to employ more operators as the CNC allows multitasking and myriad other advantages [14].

4.4. Computer Numerical Control (CNC) Machining

For all of the miraculous technologies with which 21st-century cultures are confronted–e.g. smartphones, artificial intelligence, and global positioning systems, to name a few–there is one that flies just under the radar. Computer Numerical Control, or CNC, machining is responsible for major advances in the manufacturing process. Essentially CNC machining involves machine tools performing tasks according to the directions of software programs. So, an activated CNC system can direct, for example, a gear shaper to cut a gear's teeth at a certain pre-set angle or specific speed. In so doing, it increases uniformity and precision with each and every task.

Applications for CNC Machining Services

CNC machines are present in various industries. Milling, for example, is the evacuation of surface materials ranging from highways to blades. The cutting tool itself passes over the surface inflicting multiple small cuts with its spinning teeth. Shaved pieces clump together as chips, making them easier to clear. Depending on the materials encountered, and the scope of the project, the milling tool is set at a particular speed or feed rate. Milling machines cut at varied angles along up to five axes. CNC milling is performed with preset feed rate, angle dimensions, and axes. The job gets done with no, or at most minimal, minimal human intervention.

CNC machining services also improve lathe work. A lathe is used to shape metal (or wood) for a distinct purpose. As the workpiece is secured and continuously rotated on a spindle, the lathe made cuts of defined size, angle, and tapering, whether for shaping large metal cylinders or creating the threads for small screws. Lathes work best for pieces where the symmetry converges at a single axis. The cutting tool then moves from the center to the edge. The geometry of camshafts, gun barrels, and furniture legs make lathe turning optimal for these pieces. With CNC machining, the lathe cutting function operates per G-Code instructions that direct the machine on the location, depth, and area for chipping. 3D Hubs – Get your parts into production in less than 5 minutes [15].

4.5. CMMS for Paperless Mining Operation

How do you bring productivity in the mining operation? According to the McKinsey research, worldwide mining operation are as much as 28% less productive today than a decade ago. To remain competitive in the business being productive is a must.

The paper-based system has come to an end, and it creates an excessive cost that can be saved from an automated system. Moreover, companies are also seeking solutions that are cost saving but easy to deploy and keep competition up front in the market. No doubt a single dollar saving can bring massive difference for the company. CMMS a paperless system can optimize the mining operation. Here is how CMMS can bring the concept of the paperless mining operation.

What is CMMS

CMMS is a Computerized Maintenance Management Software. This software is used to optimize the maintenance of the machine so that your machine never experience sudden shutdown. Some application of CMMS only comes with the desktop version; some even comes with a mobile app and web-based platform which creates an extra layer of flexibility in the usage of the app. CMMS with mobile application brings flexibility, real-time monitoring facility and on time updates that lead to prompt decision making.

CMMS Brings Paperless Work Order Management

Think about, how difficult it is to manage work order using a manual log book. One has to maintain a separate logbook for managing a distinct task. CMMS application eases the whole system. The app brings all the task in one place from where a user can assign work order, send work request, resolve issues and check update and so on. Even some application comes with a mobile app from which a user can manage work orders remotely.

Prompt Decision Making

Stop using a pile of papers, and a CMMS application brings all the information in one place. A mine operation personnel can check updates whenever they want and take decision promptly. In paper-based system decision making used to be lengthy as access to information tend to follow a lengthy process. CMMS makes it easy for all to get access to the recent update of the maintenance.

Digitalize Multiple Site Management

A mine business owner can have multiple fields that need to be managed simultaneously. A system can hardly do it. One has to handle a pile of papers to manage the multiple site's machines, keep track of the maintenance of their devices. CMMS renovate the whole process; this application enables a user to manage their multiple sites from a remote location. You can check all the detail of the machine located in your multiple sites. You can get an update of maintenance, scheduled maintenance, machine performance report, schedule inspection report and so on all from a single application. Moreover, some application comes with a mobile application which enables you to check the update on the go.

Sudden break down of your machine can cause huge loss to your business. Using paper-based system can be tiresome, unproductive and can't give you updates whenever it is needed. Moreover, a paper-based system is prone to human error costly and creates a legacy system. Only an application can make your task efficient, fast and productive [16].

4.6. 5G and the Industrial IoT

At risk of falling further behind the competition, the U.S. is marching full speed ahead in the race for 5G. Earlier this year, the Federal Communications Commission (FCC) voted to accelerate the deployment of 5G networks by eliminating local rules and regulations. Instead of taking months or even years to review a carrier's application to install 5G cells on existing structures, cities and states now have just 60 days to reach a decision. When it comes to new buildings, the timeline is extended by just 30 more days.

Above all else, technologies like telematics and robotics will become a much more common sight. From reduced latency to greater automation, see what's in store for the industrial internet of things (IIoT) as new innovations are implemented.

Speed things up

5G is more than just an upgrade. With speeds up to 100 times faster than a 4G LTE connection, 5G networks will revolutionize the IIoT. Often plagued by latency issues, companies limit the number of connected devices they deploy. After all, what good is an IIoT application if data can't be processed in a reasonable timeframe?

The power of 5G resolves issues tied to data transmission. Rather than bringing a network to a halt with too many connected devices, you can use more technologies than ever before. Better yet, improved data processing sets the stage for more valuable insights.

Usher in automation

Automation is on the rise. Among the most important reasons for this sudden surge is the advent of 5G. While robots made their way onto the factory floor years ago, they've only just started to assume greater responsibility. Instead of settling for simple tasks that require minimal data processing, robots are leveraging 5G wireless networks to more efficiently communicate with other machines as well as their human counterparts.

Current networks don't have the bandwidth to keep up with the data requirements of complex tasks. With 5G, however, data gathered by robots can be processed fast enough to avoid the latency issues that often limit automation. Jobs previously reserved for skilled workers can be passed to robots that use available information to improve over time. The speed and reliability of a 5G network can even welcome remote control and monitoring of safety-critical applications [17].

UNIT 5. Translation Challenge (from Russian into English).

5.1. «В основу классификации АСУ могут быть положены различные признаки… Одним из главных признаков является метод управления, по которому АСУ подразделяются на два класса: системы, неприспосабливающиеся к изменяющимся условиям работы объекта управления, и приспосабливающиеся, или адаптивные системы.

Неприспосабливающиеся АСУ – это наиболее простые системы, не изменяющие своей структуры и параметров в процессе управления… Неприспосабливающиеся АСУ подразделяются на три типа: стабилизирующие системы, обеспечивающие поддержание управляемой величины на постоянном заданном значении; программные системы, обеспечивающие изменение управляемой величины по заданной программе изменения задания; следящие системы, обеспечивающие изменение управляемой величины в определенном соотношении с задающим воздействием.

Приспосабливающиеся, или адаптивные, АСУ – это такие системы, в которых параметры управляющих воздействий или алгоритмы управления автоматически и целенаправленно изменяются для осуществления в каком-либо смысле наилучшего ()оптимального_ управления объектом, причем характеристика объекта или внешние воздействия на него могут изменяться заранее непредвиденным образом » [4: 16-18].

5.2. «В большинстве технологических процессов требуется стабилизация давления. Поддержание давления в одних случаях обусловлено технологическим регламентом процесса, в других необходимо для преодоления различных гидравлических сопротивлений.

При понижении давления ухудшаются режимные показатели технологического процесса, при повышении – возникает аварийная ситуация (разгерметизация или даже разрыв аппарата). регулирование давления обычно осуществляется изменением расхода вещества через аппарат на стороне подачи или потребления. Это достигается с помощью регулирующего органа, изменяющего гидравлическое сопротивление в линии подачи или потребления» [2: 69].

5.3. «SCADA-система … разрабатывалась как универсальное, многофункциональное программное обеспечение верхнего уровня АСУТП, позволяющее оперативному персоналу наиболее эффективно управлять технологическим процессом. SCADA – это очень широкое понятие и может относиться как к достаточно простому устройству, реализованному на одном компьютере, так и к сложной, распределенной системе, включающей центр управления, периферийные устройства и систему связи. Применение SCADA-технологий позволяет достичь высокого уровня автоматизации в решении задач разработки систем управления, сбора, обработки, передачи, хранения и отображения информации. В настоящее время SCADA является основным и наиболее перспективным методом автоматизированного управления сложными динамическими системами (процессами)» [3: 82].

5.4. «Применение интегрированной сети беспроводных контролеров и автономных сенсоров – перспективное направление автоматизации технологических процессов литейного производства сплавов из алюминиевых отходов, которое позволяет контролировать процессы, протекающие в мобильных элементах производства. Абонентская система мониторинга параметров технологического процесса литейного производства должна состоять из таких функциональных блоков: измерения, цифровой обработки, коммуникационного и бесперебойного питания.

Существуют 5 вариантов исполнения аппаратной части модулей, которые имеют встроенную антенну, антенный коннектор, усилитель мощности и МШУ для обеспечения большой дальности связи. В каждый из вариантов модулей предварительно запрограммирован сетевой протокол.

В качестве примера можно привести схему производства алюминиевых дисков с целью получения заданного химического состава, оптимальной структуры металла без неметаллических включений и водорода, снятия остаточных напряжений после термообработки, сохранения заданной формы изделий» [1: 101, 104].

5.5. «Все серии электролиза оснащены автоматическими системами управления технологическим процессом (АСУТП), которые помогают обслуживающему персоналу вести контроль и поддержание технологических параметров в заданных пределах. АСУТП имеют разные возможности, но все они контролируют и регулируют рабочее напряжение на электролизере, фиксируют ряд технологических параметров (частота и длительность анодных эффектов, напряжение корпуса).

Рабочее напряжение на электролизерах регулирует система АСУТП в соответствии с заданием, установленным руководством корпуса. Автоматическое регулирование напряжения не производится при выливке металла, перестановку штырей, замене анодов, перетяжке анодной рамы и проведении ремонтных работ на электролизере» [5: 118].

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