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ANALYSIS OF DIRECTIONS DIGITAL TECHNOLOGIES ARE INTRODUCED INTO INDUSTRIAL COMPLEX

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In the last decade, advanced digital technologies have been actively introduced into the industrial complex leading to increased efficiency of enterprises through changes in their internal business processes, as well as modernization of all production facilities. Further active adoption of digital technologies and their practical application in national industrial companies will open even greater opportunities and economic benefits. As a result, the use of digital technologies in complex solutions will change the business environment, as well as increase competition for all industry enterprises. According to most experts, the scale of this transformation requires a systemic targeted vision of digitalization at the industry level. In the new conditions of development and digital transformation of the industrial complex, enterprises must face new challenges, develop internal business processes, focusing on new factors affecting the functioning and improvement of production. At this stage, this is possible thanks to the use of digital technologies, as well as the active development of new products of the industrial sector of the economy, which have completely new functions. This process will be possible in case of involvement of all participants of industrial transformation and digitization of all production processes. The transition to the digital platform of the industrial complex implies the transition of vertical and horizontal relationships between producer companies and customers, contractors, transport companies to digital format. Thus, a single digital industrial space will create a monitoring tool for the industrial complex of the Russian Federation, which will allow to react and make management decisions quickly. A digital space of this type will help national enterprises to become faster, more flexible and more competitive in both domestic and international markets. This study describes the modern technological way of digital economy. The authors analyzed digital transformation of domestic industrial enterprises in modern conditions and identified the main directions of introduction of digital technologies into the industrial complex.

Keywords: igitalization, industrial complex, industrial economy, industry 4.0, digital economy

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АНАЛИЗ НАПРАВЛЕНИЙ ВНЕДРЕНИЯ ЦИФРОВЫХ ТЕХНОЛОГИЙ В ПРОМЫШЛЕННЫЙ КОМПЛЕКС

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В последнее десятилетие происходит активное внедрение передовых цифровых технологий в отрасли промышленного комплекса, что ведет за собой повышение эффективности деятельности предприятий посредством изменений их внутренних бизнес-процессов, а также модернизации всех производственных мощностей. Дальнейшее активное освоение цифровых технологий и их практическое применение в деятельности отраслевых национальных компаний откроет еще большие возможности и экономические выгоды. Как следствие, использование

цифровых технологий в комплексных решениях приведет к изменению бизнес-среды, а также к повышению конкуренции для всех отраслевых предприятий. По мнению большинства специалистов, масштаб данной трансформации требует системного целевого видения цифровизации на уровне отрасли. В новых условиях развития и цифровой трансформации промышленного комплекса предприятия вынуждены отвечать новым вызовам, развивать внутренние бизнес-процессы, ориентируясь на новые факторы, влияющие на функционирование и совершенствование производства. На данном этапе это возможно благодаря применению цифровых технологий, а также активной разработке новых продуктов промышленного сектора экономики, обладающих абсолютно новыми функциями. Данный процесс будет возможен в случае вовлечения всех участников промышленной трансформации и оцифровывания всех производственных процессов. Переход на цифровую платформу промышленного комплекса подразумевает переход вертикальных и горизонтальных связей компаний-производителей с заказчиками, подрядчиками, транспортными компаниями в цифровой формат. Таким образом, единое цифровое промышленное пространство создаст инструмент мониторинга за промышленным комплексом РФ, что даст возможность быстро реагировать и принимать управленческие решения. Цифровое пространство такого типа позволит стать национальным предприятиям более быстрыми, гибкими и конкурентоспособными как на отечественном, так и международном рынках. В настоящем исследовании дана характеристика современного технологического уклада цифровой экономики. Проведен анализ цифровой трансформации отечественных промышленных предприятий в современных условиях. Выявлены основные направления внедрения цифровых технологий в промышленный комплекс.

Ключевые слова: цифровизация, промышленный комплекс, экономика промышленности, индустрия 4.0, цифровая экономика

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Introduction

Regarding digitalization, attention should be paid not to the ev is characterized by parameters significantly different from the economy of the previous, industrial, technological paradigmolution of the term, but to the phenomenon it describes. For several decades it was nd later artificial resources at the disposal of a person into useful types of them, capable of meeting the person's needs, as well as the nature of relations of people in the process of their joint production activity. Leading Russian and foreign scientists and researchers devote a significant amount of research, both theoretical and applied, to this process.

The information technological paradigm (IT paradigm):

- the needs of people are not only physiological, but also mainly social, there is freedom of business aa process such as "informatization", which was actively developed in the informational and technological paradigm[1] of the economy. The type of technological paradigm of economy means the technological process of transformation of natural and personal activity;
- global networking, virtual specialization and cooperation determine the nature of economic relations between economic entities;
- the main types of economic resources used are information and intellectual ones;
- the dominant factors of production are intellectual labor and capital, knowledge, and information;
- the magnitude of the division of labor is global.

With the emergence and development of the global Internet and modern information and communication technologies, time and place have ceased to be barriers to doing business anywhere in the world. Information and knowledge have become more mobile than capital and people, allowing the world to learn about the properties of any commodity and influence its demand and supply. The period of active formation of a new technological paradigm characteristic of the information economy (knowledge economy) coincided with the world economic crisis of the beginning of the twenty-first century challenging not only to the

[1] https://en.wikipedia.org/wiki/Technological_paradigm

economies of individual countries, but also to their enterprises. The term "knowledge economy" was first introduced by F. Mahlup, referring to the type of economy in which knowledge production is the source of its growth. Subsequently, "post-capitalist" society", "innovative economy", "information society", "high-tech civilization" became synonymous concepts of "knowledge economics".

At the same time, many developed countries of the world are intensively shaping the new technological paradigm of the digital economy through the development of knowledge-intensive technologies and production, in which information, communication and digital technologies become the main resources for the production of goods and services and at the same time new factors of production. The key difference between digitalization and informatization is that the category of informatization is broader than digitalization, covering information processes of diverse kinds, not just digitized ones.

Thus, digitalization is a modern stage of informatization development, which is characterized by the predominant use of digital technologies of processing, transmission, storage and visualization of information, which is due to the emergence, distribution and increase of economic and physical accessibility of innovative technological and software solutions.

According to foreign authors, digitalization of industrial enterprises within the framework of the fourth industrial revolution will lead to complete automation of most production processes, and, as a result, to an increase in productivity, economic growth and competitiveness of leading countries [14, 17]. Many Russian researchers highlight the special relevance of digital transformation of the national industrial complex, justifying this by the fact that this integrated structure, which is a lot of industrial enterprises, is indeed the environment in which communications between all participants, as well as the provision of production and logistics processes, should be as effective as possible [2, 3, 9].

Research objective

Based on the above, the purpose of the study is to determine the peculiarities and main directions of the introduction of digital technologies into the industrial complex in modern conditions. By industrial complex authors mean such a mutually agreed combination of enterprises in industrial point, at which certain economic effect is achieved due to a convenient selection of enterprises in accordance with natural, economic conditions of the region, with its transport and economic-geographical position.

The objectives of the objective are:

- characterize the modern technological paradigm of the digital economy;
- analyze the transformation of the industrial complex of the Russian Federation in modern conditions;
- identify the main directions of digital technologies introduction to the industrial complex of the Russian Federation.

Research methods

The authors used analysis of domestic and foreign sources on the investigated issues, identification of specific features of the concept.

The active introduction of digital technologies into internal and external business processes of enterprises leads to the emergence of innovative business models that ensure the future competitiveness of any industry. The national industrial sector prioritizes the victory in the global technological race, as well as the formulation of a new reference point for digitalization, which will ensure the connection of the financial and intellectual potential of our country [1].

However, there are different opinions regarding the way the digital transformation of the industrial complex and the sphere of business is carried out. The first strategy, digital transformation of "small things", involves selective optimization of business processes using innovative IT technologies. This concept is based on a flexible approach to modernizing production processes. In order to implement this strategy effectively, production must:

- provide automation of processes with counterparties;

• use cloud services to provide universal access to files and applications from any device connected remotely to the system;

• implement Big Data collection and analytics system;

• engage modernization and optimization of internal organizational structure and business processes.

In order to effectively implement this strategy, Russian managers rely on the analytics of a large amount of data to obtain great results in the shortest possible time. This strategy requires effective use of innovative IT technologies to process, analyze, and store large amounts of data. In addition, this functionality requires information technology professionals to determine where and how the data can be used to maximize benefits in the future.

The German Academy of Sciences and Engineering (acatech) has developed a step-by-step guide on digital transformation of production Industry 4.0. According to this manual, in order to create a "smart industry", it is necessary to implement a process of coordination between physical and computing resources. Accordingly, the second strategy is a step-by-step approach to digital transformation that includes six steps, namely [15]:

1. Regulation of the digital environment, which means establishment of a system of legal regulation of the digital economy based on a flexible approach to each sphere, as well as an introduction of civil turnover on the basis of digital technologies.

2. Information infrastructure, which means creation of a globally competitive infrastructure for the transfer, processing and storage of data, mainly based on domestic developments.

3. Personnel for the digital economy, which presupposes providing training of highly qualified personnel for the digital economy.

4. Information security, which includes ensuring information security on the basis of domestic developments in data transfer, processing and storage, guaranteeing protection of interests of individuals, business and the state.

5. Digital technologies, meaning introduction of "end-to-end" digital technologies mainly based on domestic developments.

6. Digital public administration, meaning introduction of digital technologies and platform solutions in the spheres of public administration and provision of public services, including those for the benefit of the population, small and medium-sized enterprises, including individual entrepreneurs.

For successful development in a digital transformation environment, industrial-scale manufacturers need to have a suitable management strategy and a set of competencies. Thanks to these components, the organization will be able to perceive internal and external changes in its business processes with more flexibility and successfully create innovative business models and products [3]. This way industrial companies will maintain their organizational agility regardless of the scale of production, they will be able to balance the experience gained and gained, the creation and modification of new management strategies. Modern digital technologies enable international corporations to transform their internal business processes as soon as possible, modernize their production facilities, and thereby achieve the most effective results from their activities. The introduction of the latest digital and intelligent technological solutions is one of the key global trends in the development of the national industrial complex at the present stage.

Unified digital industrial space of the Russian Federation

In order to improve the competitiveness of the key sectors of the industrial complex of the Russian Federation, it was necessary to create and use national initiatives. In this regard, 2017 became a landmark year for the development of the industrial complex thanks to the active formation and implementation of a new political direction, namely the transition to the "digital economy". The existing technological structure of the economy has reached the limit of its efficiency and in the future will lose high competitiveness compared to the decisions of the digital economy. The conceptual apparatus of the digital economy is multifaceted and diverse, which is a problem, on the one hand, due to the emergence of different points

of view [4]. However, on the other hand, the resulting phenomenon may be the only solution to the fundamental change of the internal architecture of the economic system and modification of the industrial complex of the Russian Federation.

In order to develop industry, in July 2017, "Digital Economy of the Russian Federation" program was adopted, which defined the main stages of development of the economy of the Russian Federation in conditions of digitalization until 2024 [11]. The program was needed, firstly, to integrate the global process of digitalization into the national economic system, and, secondly, to accelerate this process in an orderly manner. Implementation of this initiative implies approval of the operational plan by the Government of the Russian Federation within every three years with regular updating of the list of activities specified in the program.

The Digital Economy Program emphasizes that digital information is a key factor in production and a resource base in the digital economy. Its analysis will provide the most effective decision-making in all spheres of the national economy. The digital economy will allow to form an innovative information space considering the needs of consumers in obtaining reliable and qualitative information, creation and development of national ICT, formation of an innovative technological basis for economic and social structures of the Russian Federation.

The described model of the digital economy in the initiative program consists of the three interacting components, namely:

- markets and industries of the Russian Federation;
- technology platforms and ICT;
- external environment, contributing to the creation of innovative digital platforms and technologies, and effective interaction of subjects of markets and industries of the Russian Federation.

In addition, the Digital Economy of the Russian Federation program provides for the development of several priority areas that will be in the front line of development in the next few years:

- smart city;
- public administration;
- health care;
- standard regulation;
- digital infrastructure;
- technological reserves;
- education and personnel;
- information security.

The Ministry of Energy of the Russian Federation has formed a departmental project "Digital Energy". Taking into account the priorities identified by the President of the Russian Federation, which were approved in the national program "Digital Economy of the Russian Federation" in 2017, the Digital Energy project planned to create a new targeted approach to the vision of the conceptual apparatus «digitalization of the industrial complex» and its active introduction into Russian industrial production in order to create a new national technological base for its further development and to form proposals to increase the competitiveness of the energy industry.

Analysis of Russian experience of transformation of industrial complex in conditions of digitalization

Currently, the Russian Federation is actively working on the introduction of digital technologies in all leading sectors of the economy, special attention is paid to the so-called digitalization of the industrial complex of the Russian Federation. For example, one of the largest producers of aluminum and alumina, RUSAL, introduces innovative information technologies into its production, covering all stages of the production process. In conditions of intense competition, digital technologies become the most important advantage in the Russian market and allow companies to maintain a leading position in their industry, while moving to a qualitatively new level of development.

For RUSAL, the digital transformation is as follows. First, innovative technologies are used, which allow to perform measurements of different types with the help of special probes and sensors, which track, for

example, different technical parameters of a specific production process. The data transfer technologies, corporate information systems, as well as production control systems, the so-called MES systems are both wired and wireless.

As a part of RUSAL's digital transformation of production processes, the entire range of operational information related to technological, production and other processes will be available online at all levels of business process management. In addition, the real-time mode allows for feedback when making any management decision immediately. Digital technologies are used not only in the production processes of the company, but also in the work with clients. A client can place his order in a special app and monitor all stages of its execution in real time.

Thus, it can be said that the conditional strategy of the end-to-end digitalization of RUSAL company includes three directions, namely:

- improvement and full-scale deployment of technical probes, sensors and the equipment operating them in production;
- implementation of MES-systems in production;
- implementation and improvement of corporate systems [7].

In 2018, RUSAL already had a corporate accounting system, or ERP-system, but now the issue of further development was acute. Thus, the management of the company proposed the launch of a mobile app for clients, as well as a supply chain management system that would allow to track the order at each stage of its implementation.

In addition, together with Yandex Data Factory RUSAL launched several projects focused on machine learning and artificial intelligence at some enterprises of the Aluminum Division [13]. AI technologies will be effective when processing large amounts of data, which in turn leads to the identification of certain patterns. In the future, RUSAL intends to bring all technological, repair, commercial, logistics, economic, marketing and other production processes into a single system possible to manage from anywhere in the world. It will become a reality when RUSAL ensures uniformity of all the data of plants, which can be processed, compared and received online.

Such a large-scale campaign of digital transformation requires investment of tens, if not hundreds of millions of dollars. Even with the decline in computer prices, this process is clearly not cheap, as it involves an innovative restructuring of the architecture and hierarchy of the system, as well as the introduction of the latest software and MES systems. Each stage of end-to-end digitalization entails new investments. Each conditional technical sensor installed requires a device transmitting information from it, and consequently another device to receive these data arrays. In addition to powerful stations and data stores, tens and hundreds of thousands of mobile devices, various interfaces, mobile applications, etc., are needed. All this requires certain financial investments, which, if collected, represent substantial amounts.

However, if the company does not digitally transform production, its competitors will do so, thus reducing the cost of their products by several percent. The company itself will not be competitive and will lose its leading position in the market. Therefore, from the point of view of business, these financial costs will be justified, the economic effect of investments in digital transformation of production will pay off quite quickly due to improvement of technological processes, reduction of delivery time of products, improvement of client services, etc.

With the further rapid development of IT technologies, the issue of human participation in all stages of production is acute. For the next 10-15 years, RUSAL intends to adhere to the strategy, in which an AI system will act as an advisor, but the personnel will make the final management decisions. The components which need human interaction in the company internal processes are work with the clients, suppliers, employees, development of human capital. Despite the introduction of digital technologies in all these areas to improve the quality of service and facilitate access to information, as well as reduce the time spent on routine operations, strategic management of production and the company requires human intervention.

The digital transformation of production raises the following question: will there be a need for new specialists? After all, in the future many employees will need additional skills, knowledge of data processing, programming, IT technologies. For example, Yandex Data Factory, with which RUSAL cooperates, employs representatives of a new specialty Data Scientist. These are specialists in the field of building neural network algorithms, which also have an idea of machine learning, etc. Of course, over time and with the development of digital technologies new professions will appear, but not all specialists will have to master the field of artificial intelligence or programming directly.

Traditional specialties will undoubtedly change over time because digital technologies will focus specialists more on causal relationships in production processes. Competence centers will appear, where specialists will remotely monitor all stages of production and remotely regulate the deviations.

Digitalization of industrial enterprises has become an extremely relevant topic in the last few years for several reasons. First, this was due to changes in the competitive environment, in particular, many aluminum manufacturers and other industries are increasingly "going digital". And if earlier digital transformation concerned mainly the sphere of telecommunications, banking, information technologies, now this process affects industrial production [6]. In this sphere there are several simultaneous processes. Thanks to the increased competition and fast development of technologies there is a reduction in cost of the equipment which digitizes production (probes, sensors processing information). In addition, fast development of interesting innovative solutions makes digitalization even more relevant. AI or machine learning technologies allow to achieve such a level of production optimization, which even the most qualified employees are unable to demonstrate simply because their capabilities to process and analyze large amounts of data are not commensurate with AI. Finally, the emergence of innovative and captivating software solutions make digitalization not only a cost-effective, but also an attractive and promising direction.

Features of cyberphysical project "4.0 RU"

The concept of a single digital industrial space in its current form appeared on the margins of the Hannover Messe International Industrial Fair in Hanover in April 2017 [9]. A Russian delegation headed by the Minister of Industry and Trade Denis Manturov visited the German exhibition. The Minister drew attention to an innovative product from Siemens called MindSphere. It's a cloud operating system for the Internet of Things. According to the information on the Siemens website, the cloud operating system MindSphere allows you to connect computers and production equipment to a single digital space. The developers of the revolutionary product argue that the application of this system in production will allow to reduce costs and expenses as much as possible by automatically calculating all economic and logistics processes. In addition, by processing and analyzing a huge amount of data, the MindSphere product allows users to improve the quality of their products to a completely new level.

However, data security issues within the system have not been properly addressed. In this regard, the Russian delegation was invited to further cooperate and sign a partnership agreement on the creation of a national cyberphysical system "4.0 RU" with Kaspersky Lab, not only Russian, but also the world leader in the field of information technologies, which pays special attention to cybersecurity issues in the industrial manufacturing. STAN company management was also present at the Hannover Messe International Industrial Fair. Stan made a strategic decision to join the 4.0 RU project, in which they could offer their own equipment for rolling out the digital platform in practice [10].

A little later, a logistics company Intelma joined the initiative group to create a single digital industrial space of the Russian Federation, which, thanks to the accumulated experience and professional competences of its specialists, takes a leading position in the field of logistics issues. Thus, a working group was formed, responsible for the creation of a single digital space of industry in the Russian Federation, which included recognized high-tech national companies, leaders in the field of production, electronics and information security, namely STAN, Kaspersky Lab, NPP Itelma.

In July 2017, at the exhibition «Innoprom-2017», a prototype of digital production was presented to the President of the Russian Federation, Putin V.V. He launched the production of a fastening element at a STAN machine STT 50-60 in the virtual assembly shop MC-21 of the Irkutsk Aviation Plant. The demonstration model of the cyberphysical project 4.0 RU described a complete production cycle, including all stages: from the company's request to manufacture a specific part to the delivery of the manufactured part by the carrier. The digital approach to the MC-21 starts with the most basic part of the aircraft, namely with a bolt. With the help of animation technologies, the bolt is separated from the engine design and transformed into a schematic image on the screen of the cyberphysical system «4.0 RU».

During the digital part of the design phase, the relative cost indicator is also displayed, which changes when the part parameters change. Note that if you enter an incorrect product parameter, a non-compliance warning appears. At the modeling stage, tools and equipment are selected, and virtual processing of the product takes place in online dialogue mode with the system. Based on the received information about the part and the technology of its manufacture, scanning of databases of enterprises of the Russian Federation for the performance of production of the product is started. By analogy, a selection is made among the logistics partners to deliver the manufactured part to the customer. After pressing START button on the system control panel 4.0. RU starts the process of transition from virtual production to real production, a window with on-line video translation appears to monitor the process of production. When the part is finished, the shipping route of the order by the carrier is displayed on the map. The map shows all the plants that have the necessary capacity to manufacture the part, as well as its cost.

This is what the digital manufacturing process looks like. If these technologies are used by all industrial enterprises of the Russian Federation, all conditions will be created for the creation of a kind of industrial on-line exchange, which will take a certain time. For the effective operation of this system, it is necessary to create a certain infrastructure, the development and construction of which is actively carried out now by the Ministry of Industry and Trade.

Research result

The authors:

• characterized the development of the modern technological way of digital economy in modern conditions;

• analyzed transformation of the industrial complex of the Russian Federation in conditions of digitalization;

• identified the main directions of implementation of digital technologies in Russian industrial enterprises.

Summarizing the above, we would like to note the advantages that the project 4.0 RU will give to the industrial complex of the Russian Federation with effective development. The 4.0 RU cyberphysical system makes it possible to determine the final cost of knowledge-intensive equipment at the design stage by detecting the price of each part of the product [5]. Due to the fact that the design is performed in digital format, it allows to make changes to parameters of parts at each stage, from the design to post-sales service, in online mode, preventing design errors, and as a result, to monitor the change of final cost of the product on the screen.

After that, all enterprises connected to 4.0 RU transmit information to the system about their production capacity, technical characteristics and load. Thus, the customer will be able to determine which enterprise meets the requirements, namely, how long it takes to manufacture the part, the most suitable production facilities in terms of financial optimization, the logistics route of delivery of the finished product to the customer [8]. In addition, the 4.0 RU cyberphysical system will make it possible to reduce the cost of products by increasing the performance of production capacities. This will form the so-called national "producer exchange". The project 4.0 RU on digital transformation of industry of the Russian Federation implies creation of a reliability rating of manufacturers, which will be created based on orders already completed within 4.0 RU.

At the same time, enterprises will be able to offer cooperation to the customer, which will be based on analysis of profitability of production, while focusing on their own priorities and loading production facilities rationally. Thus, the more enterprises are included in the 4.0 RU system, the more efficient its operation will be.

Summary

To summarize the above, it is impossible not to note several advantages that digital technologies give to the industrial complex of the Russian Federation, namely:

- Increased flexibility of production due to dynamic change of technical characteristics of production process. This agility in business process management creates a new competitive advantage and can potentially lead to higher profits.
- Information is integrated of all stages of the product production life cycle, which allows to optimally and comprehensively address the problems of efficient production process, as well as quality of produced products, environmental safety, creation of new business models, etc.

However, on the other hand, the level of dependence of the enterprise on the applied digital technologies in production processes is increasing. As production engages a higher degree of robotics and automation, employees of enterprises are increasingly excluded from making corrective and management decisions, and there are less possibilities of immediate influence on production processes. However, most experts are convinced that soon digitalization of the industrial complex will lead to increased productivity, improvement of product quality, reduction of product cost, increase of effective use of investments and rapid introduction of new products to markets. As a result, we will get increased productivity indicators, improved quality of parts design and production, reduced cost of products, control over effective use of investments, high speed of production of new products.

It is necessary to strive for digital transformation of the whole industrial complex to achieve maximum efficiency. But this process is possible only when the participants of industrial transformation digitize all their production processes. The transition to the process of digitalization of the industrial complex implies the transition of vertical and horizontal relationships between producer companies and customers, contractors, transport companies to digital format.

Thus, a single digital industrial space will create a monitoring tool for the industrial complex of the Russian Federation, as well as for rapid response and management decisions. Such digital space will allow national enterprises to become faster, more flexible and competitive both in the domestic and international markets. Due to the technical and organizational complexity of the formation of such digital platforms, the high risks of their development and successful implementation, the state should play an important role in digitalization of the industrial complex. The importance of state regulation and support of new digital technologies is confirmed by both domestic and foreign experience. In this regard, measures to digitalize the industrial complex should be incorporated into State industrial policy. This will allow to solve problems relevant to the digital economy to accelerate industrial growth, create import-substituting industries, increase labor productivity in industry, etc.

Directions for further research

In the end, the development and introduction of digital technologies has given impetus and continues to stimulate the production of the industrial sector. They help to solve not only important issues of competition and efficient production, but also problems of increasing the efficiency of Russian industrial enterprises and reducing the cost of final products, as nowadays manufacturers are forced to adjust, modify and develop quickly and flexibly. Experience of development and introduction of digital technologies in production processes of industrial enterprises, creation of a single digital industrial space creates prerequisites for creation of new management strategies in modern conditions, as well as a completely new model of industrial production in conditions of digital transformation.

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