

Leading Digital Technologies in the Industrial Safety Management

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Abstract The development of the modern digital economy predetermines the necessity for the effective use of technologies in enterprise management, ensuring labor protection and the safety of technological processes in manufacturing. The aim of the current study is to identify the peculiarities of industrial enterprise management in the context of digitalization and the formation of an algorithm for implementing the digital transformation of the enterprise. The article covers the importance of the introduction of modern technologies in the management of industrial safety, in order to improve economic and social indicators. Also, the necessity of digital transformation of industrial enterprises based on the active use of SMAC technologies is justified, the basis for building a "digital enterprise" is determined. Today, there is a tendency for large industrial enterprises to develop their own innovation centers involved in the development of platform solutions.

Keywords: *digital technologies, industrial safety management, leadership, digital economy*

1 Introduction

In the modern society, new economic processes are rapidly forming, connected with the extension of information technologies in all spheres of human life. The introduction of a system of effective management of available resources at industrial enterprises, which is based on innovative technologies and methods for optimizing business processes, allows getting a significant competitive advantage (Amelin and Shchetinina 2018). Digital technologies are an important management toolkit that allows continuous improvement of existing processes in the enterprise and their effective optimization.

In 2016, the shift of the Russian economy to a fundamentally new level, based on digital and cross-cutting technologies was announced (Arenkov and Smirnov 2018; or Arenkov and Bichun 2018). Based on this message, in 2017, a large-scale development of the economy of a new technological generation was launched- the so-called "Digital Economy of the Russian Federation" concept (Government of the Russian Federation 2018).

Digital transformation is already successfully implemented by industrial enterprises in many countries around the world, the result of which is the formation of digital companies. For example, such programs as "Digital Europe 2020", Germany – "Industry 4.0", China – "Internet plus", are being successfully used today.

The pace of the digital economy development is accelerating every year, as shown by research conducted by McKinsey & Company specialists. According to their estimates, from 80 to 100% of world industry will use the technologies of the industrial Internet of things by 2025. The reason is that industry is the main generator of innovation in the modern world (McKinsey Global Institute 2017).

The success of developed countries is based on a combination of technological processes with digital technologies, which contributes to the growing perfect competition. Where a new industry is being formed, science rises, thanks to which the scientific and technical potential is accumulated for the development of the competitive positions of states, in particular, the well-being of citizens is raised and national security is formed.

Thence, digital technologies are necessary for the growth of industrial efficiency, and in some sectors, they become the basis of production strategies. In general, all this means that the study of new paradigms and guidelines for enterprise management in the development of the digital economy and the spread of the new industrial revolution should be given the highest priority, since those countries that cannot respond to modern challenges run the risk of remaining on the sidelines of world progress, losing their competitive advantage.

The introduction of new information systems at industrial enterprises forces a reorganization of activities based on modern digitalization technologies. It leads directly to the emergence of risks, since the implementation of projects that are already finished and developed without taking into account the characteristics of a particular enterprise may fail. Already implemented and existing methods and tools often do not allow reducing risks, as well as solving the problems of transformation of business processes of enterprises at various stages. In this regard, the methodology of building a complex system of activity of the enterprise is of current importance.

Innovative theories and management methodology are the basis for the sustainable functioning of an industrial enterprise. The management, process organizers and employees involved in the implementation of business processes in the enterprise need to maintain the level of efficiency and results achieved through the

implementation of the process approach. The field of industrial safety and labor protection is strictly regulated and rule-based, therefore, innovations should be aimed more at a preventive action.

2. Literature review

Particular attention to the study of the problems of the development of the digital economy, as well as transformational processes in industry, was given by Russian and foreign authors (Ansoff et al. 2019; Apalkova and Tsyganov 2016; Doyle and Stern et al. 2006; or Drucker 2001).

Researchers Yashin, Kulagova, Malova and Sukhanova (Yashin et al. 2018) in their works they noted that in the modern conditions of the digital economy, the development of an industrial safety strategy is necessary. The formation of an effective management system is reduced to the development of a strategy based on the principle of the relationship between risk and resources spent to ensure industrial safety. The authors developed a set of criteria and indicators for the industrial safety management system.

Zegzhda, Vasiliev, Poltavtseva, Kefeli and Borovkov (Zegzhda et al. 2018) devoted their work to considering the features of the fourth industrial revolution, the digital transformation of production management. The authors investigated current threats to digital production, their features and impacts. Researchers concluded that to build a digital production information security management module, a monitoring technology base is needed.

The article by Zaichenko, Smirnova and Borremans (Zaichenko et al. 2018) substantiates the need for transformation of the management of industrial enterprises, which is based on digital technology. The authors found that the main promising area in industry is the use of unmanned aerial vehicles. Researchers, along with the advantages, identify the main difficulties in introducing robotic technologies in industry.

The work of Kiseleva (2015) is devoted to the study of the digitalization of innovative processes of industrial enterprises. The author substantiates the necessity of using digital technologies to increase production efficiency based on balanced management.

Analytical reports (2017, 2018), statistics of industrial enterprises, studies of international companies (MIT Sloan School of Management 2018) and Capgemini Consulting, information and reference materials of rating agencies, the Federal State Statistics Service (FEDSTAT 2019) formed the information basis of the current research. Legal documents, periodical scientific publications, works and publications of scientists, researchers and specialists, including collections of international and national conferences, Internet materials available in the public domain have been used as well.

3. Research methods

Research methods: system analysis, induction and deduction, comparison, forecasting, structural and functional method. Moreover, general scientific methods of cognition have been used: the method of information retrieval, information collection and processing, generalization, analysis of existing sources on the subject under discussion, analogies, logical methods.

4. Digital technologies in the field of industrial safety and labor protection

YE HSE Technologies system, presented at the international specialized exhibition “Safety and Labor Protection” in December 11, 2018, offers the use of analytics based on the industrial Internet of things to reduce occupational diseases and injuries. With the help of HSE digital technologies, the following items can be carried out: quantitative assessment of industrial safety risks and accident modeling; issuance of work permits; accounting for personal protective equipment; medical examination procedure; waste management; incident investigation.

The main perspective directions of the use of HSE digital technologies are: protective clothing with digital sensors; a mobile application for audits and incident reports; traffic safety monitoring tools (smart sensors for monitoring water and air pollution); learning systems based on virtual reality; drones.

Automation of HSE processes and integration with a production IT system will increase management efficiency, improve performance, reduce risks and reduce costs. As a result, this will ensure: transparency and accessibility of comparable information for the analysis of leading and lagging indicators; monitoring compliance with permits, the implementation of planned activities; increasing efficiency and ensuring a unified approach when conducting inspections and audits, as well as implementation and realization measures; centralizing the analysis of incidents, risks and measures to manage them and increase efficiency; ensuring prompt response to incidents; elimination of duplication of processes/ reports and reduction of labor costs.

Using a mobile application helps to improve the registration of incidents, to connect teams with those responsible for issuing orders. The use of analytics based on the technology of the Internet of things helps to reduce the risks of accidents and equipment shutdowns, which immediately will lead to: an increase in the efficiency of production processes while reducing costs and accident rate; optimization of maintenance work; reducing

unplanned downtime of equipment; reducing the risks of equipment failure and accidents due to the planning of a maintenance strategy based on predictive analysis data; determination of the need for repair / removal / replacement of equipment taking into account the risk (potential damage) of the accident.

Internet of things technologies (sensors embedded in clothes, smart watches, head fasteners) help to manage risks for the sake of staff health, reduce occupational diseases and injuries. For example, based on the analysis of statistics of indicators of the cardiovascular system, respiratory activity, hemodynamics of building a “norm” for each employee, and in the case of a slight deviation from the norm, an automatic notification of the operator occurs. The risk of personal injury due to non-use of personal protective equipment is also reduced.

Solutions using unmanned aerial vehicles can be beneficial in all key production processes in the oil and gas industry. Namely, to reduce the costs of monitoring linear objects, timely detect integrity violations, damage to the supporting structures, reducing the risk of accidents, reducing working hours in dangerous conditions or eliminating the presence of a person.

Mobile communication tools in the HSE system help to improve the safety culture from the level of supervision to the personal commitment of employees. The use of augmented reality technologies will reduce security risks, as well as significantly reduce transaction costs. For example, in case of equipment shutdown, accident or accident investigation, it will be possible in real time to get immediate contact with either a highly specialized expert or company’s representative.

The SAP EHSM system was firstly implemented into large industrial enterprises around Russia in 2017. The main emphasis in the system is placed on the release of the Labor protection module, which is part of the 1C line. A successful example was the reduction in the complexity of working with Audits at the United Metallurgical Company.

World statistics (NAEM association) shows that only 3% of companies have ensured that all work is carried out in only one information system. 58% say that an automated labor protection information system has been implemented on a corporate scale. 85% use acquired professional labor protection system. However, for many functions, most companies do not use professional information technology: tolerance orders 77%, occupational hygiene 75%, hazardous waste management 71%. The main goals of companies planning the introduction of an automated information system are: a centralized data warehouse of 21%, the formation of a management system of 19%, compliance with established requirements of 14%.

The most popular functions that customers want to see in an automated information system are: report of incidents, accidents, damages – 85%, statistics of incidents, accidents, damages – 79%; analysis of the effectiveness of labor protection and industrial safety – 77%. If we talk about Russia, these are: personal protective equipment, a special assessment of working conditions, medical examinations and production control. The choice is associated with high routine laboriousness and compliance with the law. Russia ranks second after China in the ranking of country risk legislation in the field of labor protection and industrial safety. This is due to the inconsistency, redundancy of legislative acts, outdated norms and the ambiguity of normative practice. Labor protection is one of the least secure functions of the enterprise in terms of information technology.

An analogue of foreign systems is the Safety-360 system, the main advantages of which are special technical solutions aimed at maximum product availability. Here are some of the main technological advantages of the system: own built-in in-memory database; minimum requirements for infrastructure, additional software; ready-made integration interfaces. For example, effective functionality can include automated error checking, analysis of results in the context of classes, factors, employees and positions.

5. Successful digitalization experience in industrial safety management

Russia is already known for a successful experience in implementing digital technologies in industrial safety management. For example, companies such as LLC “Gazprom Neftekhim Salavat”, FOSAGRO, JSC “Rosenergoatom”, and United Motors Corporation were among the first to use the BREALIT industrial safety and labor protection management information system in their activity. This system includes: alcohol testing, video surveillance, geo-and internal positioning, planning and control, risk management, compliance with requirements, training and knowledge testing, smart personal protective equipment, telemetry health. The main results of the implementation of the system include: a decrease in the number of violations identified by regulatory authorities, a decrease in the frequency of violations, a decrease in errors in the planning of certification.

At the All-Russian competition for the best innovative solution in the field of ensuring safe working conditions “Health and Safety”, LLC “Gazprom dobycha Astrakhan” was awarded a gold medal in the nomination “Development and implementation of highly effective labor protection management systems in the organization”. The implemented project for the use of tablet computers during the administrative and production control of Level 1 and 2 is aimed at increasing the efficiency of the process of collecting and consolidating information about non-conformities, monitoring the actual implementation of equipment inspection by personnel, and optimizing the interaction of parties involved in the process of eliminating non-conformances. The advantages of this system are:

replication of the solution to the facilities of PJSC “Gazprom”, integration with other information management systems, the on-line implementation of the project.

Successful testing at Russian enterprises was carried out by the integrated system for ensuring the safety of INDORA operations, the name stands for Isolation of Energy Sources, Outfits-Tolerances, Risk Assessments, Audits. Such enterprises as JSC “JDC – Aviadvigatel”, JSC “Perm Motor Plant “Saturn”, JSC “Klimov”, PJSC “Kuznets” have experimental sites where with the help of additive technologies parts are being manufactured. This allowed to halve the cost of manufacturing and to reduce the manufacturing time by five times.

The enterprises of the military-industrial complex were the first to evaluate the possibilities of introducing the “Industrial Internet of Things (IW)” and actively use it in their activity. Remote maintenance systems and control are included in the package of services of manufacturers of armored vehicles. This allows informing the command of the troops about the need for spare parts, about the condition of equipment and its technical readiness, completed and planned work.

Nowadays the world industry leaders pay special attention towards the concept of economical production, in which labor productivity rises by 30-70%, delivery time decreases, costs are reduced. Large Russian industrial enterprises (PJSC “KAMAZ”, “GAZ Group”, State Atomic Energy Corporation “Rosatom”) have successfully implemented economical production ideas and methods over the past 10-15 years. With the development of economical production methods, it is possible to improve the performance indicators of enterprises, which is relevant in modern conditions of economic transformation.

In the Russian market, the leading position in the field of information technology and management consulting, engineering and system integration for large industrial enterprises is held by the ITPS group of companies. The technology is based on a production monitoring and management system, creating a work plan, optimization depending on the age and health status of the team, monitoring the physical and psycho-emotional state of personnel, managing hazardous work, training (instructing) and testing employees, monitoring and the impact of stress on employees’ activities.

6. Discussion of results

The predominance of high-tech industries is a priority in the development of industrial production. In Russia, new production technologies are emerging, which are understood as technologies and technological processes, equipment used, controlled by personal computers or based on microelectronics and used in the production process of various goods and services.

The number of fundamentally new developed advanced production technologies by type of economic activity around Russian Federation in 2018 increased by 12% compared to 2017 (as at April 18, 2019).

According to a survey of representatives of Russian companies on the topic of digital transformation, a consulting company in the field of digital strategy and business transformation “KMDA” presented an analytical report in 2018. Respondents from fifteen sectors were selected, including representatives of industrial production (11,4%). Based on the results of the study, the following conclusions were made: 35% of companies pay attention to digitalization and the implementation of the digital transformation strategy; more than 55% are about to show interest and develop a strategy and about 10% are not interested in digital transformation at all. Industrial production can be identified as industry leaders who are in the process of implementing a digital transformation strategy (KMDA 2018).

The concept of managing a modern enterprise involves the use of the following digital technologies: 3D printers, artificial intelligence, robotics, the Internet of things, drones, blockchain innovation, augmented and virtual reality capabilities. Using new concepts will allow enterprises to gain competitive advantage. According to the main characteristics of the technology, they are divided into following groups: input data (drones), data processing (blockchain, artificial intelligence), output data (augmented and virtual reality, robotics, 3D printers).

Changing the industrial production space is the basis of the “Industry 4.0” concept. Today, a digital enterprise involves the use of information technology in each field of activity, which results in a high level competitive advantage. Thanks to digital transformation, an enterprise becomes an organization with “digital mentality”, and the product becomes digital on release.

Traditional IT technologies for automating existing systems and business processes are being replaced by active ones using SMAC – social, mobile, analytical and cloud technologies. Digital enterprises are actively using these technologies to optimize the costs of corporate functions and increase productivity. The use of digital technologies implies a restructuring of the business, which is based on the use of cognitive models, robotics, and artificial intelligence.

According to the results of studies conducted by MIT Sloan School of Management and Capgemini Consulting (2018) in more than 400 large enterprises, it becomes clear that economic indicators directly depend on the introduction of modern methods and technologies. Enterprises in the management of which digital technologies are actively used in management are 26% more profitable than other competitors. Industrial production is in the digital maturity rating, which is starting to build the concept of digital transformation. The

basis of the "digital enterprise" is the active implementation of SMAC technologies. To comply with the laws of the digital world, enterprises will have to build a modern information infrastructure. The basics of creating a digital enterprise are: mobility; sociality; people and knowledge management; business processes.

7. Conclusions

Based on the analysis of world experience in digital transformation of industry, we can conclude that the following concepts are fundamental: Industry 4.0, Economical production, Digital production, Internet in industry, Open production. Over the past five years, the number of device connections has increased, for example, in 2016 this figure was 6.4 billion, and by 2020 it is expected to grow to 20.8 billion. The introduction of modern mobile applications that include advanced functionality is becoming an objective necessity; therefore one of promising mobile technology is the Internet of things.

To optimize safety management processes, industrial enterprises need actively to continue implementing the following items: simulation modeling and augmented reality in the production process; additive manufacturing, 3-D printing and scanning of objects; automated vehicles and drones, sensors and sensors that conduct operational monitoring of the movement of goods and services; use of digital representation on a life cycle; "machine learning" to develop their own decision-making rules in production; robotization and automation of production processes; modern supplies materials.

The main advantage of introducing digital technologies in industrial safety management is the ability to increase production efficiency and the level of staff health, as well as reduce and even eliminate cases of injuries and deaths at work. For example, violation of the presence of employees in hazardous or closed areas by employees or the lack of personal protective equipment using digital technology will be easily identified. On-line information about the types of people's activity, work performed per day and automatic measurement of the duration of operations will help to optimize processes in the production. The information received will make it possible to compose a digital diary or a digital model of a worker.

The need to introduce digital technologies to improve management efficiency in the field of industrial safety and labor protection was recognized by most Russian enterprises. Difficulties arise when it is possible to process biotelemetric data, which is associated with existing restrictions and gaps in the legislation. And this, in turn, causes an additional financial burden on enterprises, so most companies prefer the use of cloud technology.

The management of an industrial enterprise in the digitalization era imposes on the head of the organization the requirements for professional knowledge and skills in the field of both management, personnel management, and in the field of IT technologies. Over the past four years, enterprises that have mastered digital systems have been able to four times reduce the number of incidents. The introduction of digital technologies in the work of industrial enterprises will help to increase labor productivity, shorten life cycles in the production of products, reduce its cost, optimize the process of market entry of modern products and improve product quality. Creation of innovative clusters in order to use common IT solutions and technologies not for certain highly specialized enterprises, but for a wide range of consumers is the main promising area.

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