Industrial Technologies in the Context of Digital Transformation

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Abstract. Justified in the article is the demand for automation of technological processes at industrial enterprises in Russia. This article identifies the possibilities of using artificial intelligence and implementing smart manufacturing in the industry. Successful practices of IoT technologies at foreign enterprises are analyzed. The priorities of the leading Russian industrial companies in the field of digitalization have been revealed: expanding the use of cloud technologies; predictive analysis; IaaS services (virtual data centers and storage systems); supervisory control and data acquisition (SCADA) etc.

Targets for priority manufacturing technologies within the federal project Digital Technologies have been identified: mathematical modelling, Smart design and PLM (product lifecycle management), Smart Manufacturing, manipulators and manipulation technologies; the technology of building a comprehensive architecture and strategy for the use of smart manufacturing has been specified. Smart Design provides the implementation of the concept of digital smart manufacturing through Digital Twin technology based on mathematical models of different levels of complexity and adequacy. Smart Manufacturing involves the preparation and implementation of a production process with minimal human participation based on PLM-system data, operational management of technological processes, production, and enterprise. Manipulation technologies include mathematical modelling techniques for robotic systems and the development of appropriate software.

The main possibilities of forming the smart potential of industrial production have been revealed: productivity growth and improved product quality; ensuring the reliability and quality of decision-making; infrastructure security guarantees.

Results: 1. The practical need to use artificial intelligence and to implement actively smart manufacturing at Russian enterprises is justified. 2. The targets for the period up to 2024 on the main technological trends of the development of smart productions in Russia are specified. 3. Opportunities for the formation of smart potential and its strategic use for the development of industrial production are identified.

Keywords: Automation · Industrial enterprise · Artificial intelligence · IoT technology · Digital technologies · Digital design · Mathematical modelling · Smart manufacturing · Manipulators · Manipulation technologies · Architecture

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1 Introduction

The unprecedented development of information technologies and communication devices, existing global trends in virtualization of production force modern companies to radically change their own production processes in order to maintain a competitive position in the market, facing new challenges. Production management in the standard version today does not allow one to keep the profitability of the business at the desired level.

The new stage in the development of production systems is aimed at combining people, machines, information and value chains into a single network. The concept of smart manufacturing and smart factories, injecting new dynamism into labor productivity, provides new opportunities to improve the efficiency of production companies.

2 Background and Methodology

The methodology includes a combination of quantitative and qualitative approaches, systematic and comparative analysis.

The papers of Russian and foreign scientists and specialists on digitalization of industrial production (Abdrasilo 2019); (Bakarov 2018); (Girdiuk 2018); (Grabchak 2018); (Korovin 2018); (Filin 2018); (Khokhlova 2017) and on the assimilation of smart technologies (Baur and Vi 2019); (Brynjolfson 2017); (Waldhausen and Ahvenainen 2018); (Fedotova 2019); (Tupchienko 2018); (Lu et al. 2020); (Winkelhaus and Grosse 2020) served as the theoretical basis of the article.

The purpose of this paper is to identify technological innovations and strategic opportunities that are on trend and that are aimed at using the smart potential for the development of Russian industrial production in the context of digital transformation.

Scientific value: high-tech technological innovations, non-standard solutions and modern tools for managing production systems are systematized; targets for the main technological trends in the development of smart industries are specified; directions for the development of the smart potential of the Russian industry are justified.

Practical value:

– strategic opportunities for using smart potential for the development of Russian industrial production in the context of digital transformation are identified;
– scientific and research findings might be useful to the management of industrial companies in determining technological trends of the development of smart manufacturing.

3 Discussion and Results

Many innovations in industrial production are constantly being introduced around the world to maximize its modernization and automation. The global development of smart manufacturing is due to its advantages. Smart manufacturing provides better connectivity between industrial capacities and automates technological processes as much as
possible. Besides, this technology gives manufacturers some virtually unlimited opportunities to improve their activity (Bayneva 2019).

Some more forward-thinking manufacturers who have implemented IoT technologies are already taking some advantages of these systems. Only 11% of manufacturers have implemented an IoT strategy in their production processes. Moreover, about half of them are still trying to make sense of basic IoT definitions and strategies (Fig. 1).

The introduction of key promising technologies is integral to smart manufacturing approach. This process involves using an ever-growing number of smart devices to improve the quality of information processing, efficiency, security, and data retention. The strategy for using cloud computing, mobility, and data analysis is also implied here.

One can see individual initiatives all over the world, and most of them relate to the implementation of IoT technologies.

The Bosch plant in Blaichach manufactures ABS/ESP safety systems for cars. Within the framework of the Industry 4.0 project, the applied products and technologies allowed to double labor productivity in a few years without physically expanding the space and equipment, only by increasing efficiency (Moiseev 2019).

Smart manufacturing technologies at the Mitsubishi Electric plant in Nagoya increased the speed of the equipment by almost 190%, while reducing the expenditure of production by more than 60%.

The AMRC plant in Sheffield (UK) uses the most advanced technological achievements: industrial robots, flexible automation, and new-generation human-machine interfaces.

Thanks to the use of new monitoring technologies at the Intel Fab32 factory in Arizona, it was possible to achieve an unprecedented sterility of the environment in
which microprocessors are manufactured. The air in the premises at the enterprise is a thousand times cleaner than in the operating theatre.

The enterprises use various technologies to increase production enhancement and reduce costs.

According to a collaborative study done by National Agency for Financial Studies (NAFI) and SberCloud, 77% of large and about 42% of small and medium-sized enterprises are ready to switch to cloud technologies today. 34% of companies plan to increase their IT budgets. In every fifth company, expanding the use of cloud technologies is among the priorities.

For example, SB SberCloud. Advanced allows one to deploy IT infrastructure of any complexity. This service provides work with big data clusters, cloud containerization management, automatic deployment, scaling, and application management.

The driver of the current changes is COVID-19. There are rules to ensure the safety of employees, and their violation entails imposing heavy fines on the company. There are many solutions on the IT market that can be implemented right now and thus automate control over the possible spread of infection in the enterprise. All of them are based on the use of a video surveillance system and processing of the received data.

Firstly, one of the solutions is contactless access control based on employee face recognition. Secondly, an automatic identification of the first circle of contacts of a sick employee, the blacklisting of sick employees in order to ensure their compliance with the 14-day quarantine. Thirdly, the identification of the concentration of people. Fourthly, the control of wearing masks. And, fifthly, the detecting of employees with a high temperature.

Predictive analysis is one of the most popular technologies for large enterprises. For example, the organization of an effective MRO strategy based on predictive analysis reduces the cost of maintaining the main production assets by 30–40%. However, there are few successful projects in this area. The main reason is the lack of competencies. There are a lot of companies involved in forecasting, but most of them use too general and abstract mathematical models (Baynev and Fedosin 2019).

Another problem is that enterprises have data, but the quality of this data is rather questionable. Getting data from the Computer-Aided Process Control System is the easiest way, but this represents only 10–15% of the necessary information. Another source of data is a mobile MRO. The most reliable information comes from portable devices or stationary diagnostic systems. One also need to remember about information originating from the EAM systems (MRO activities undertaken, directories, etc.). Unfortunately, most enterprises today have a so-called digital zoo, where data from different systems are not integrated or arrive in a single storage with a long delay.

The Safe Plant software platform can be utilized to accumulate primary data. The ability to analyze data either manually based on big data technologies, or through artificial intelligence is implemented on the platform. After processing, the data is transmitted to the enterprise management system for making management solutions.

The Biocad company’s chat bot Botanique allows to control the efficiency of the use of equipment and all actions of service personnel, respond to emergency situations in time, quickly access the necessary information and digitize data from analog equipment (Bayneva 2019). The system is built on a microservice architecture, meaning that its upgrade is very fast and unnoticeable for users.
For instance, the company uses more than 9,000 units of non-digitized equipment, and one never knows how it is applied. Now employees use their mobile device to read the QR code of the equipment and tell the chat bot what they are going to do. Thus, it turned out that 30% of the equipment is actually idle, and the company’s management has a real opportunity to optimize its use.

In Russia, basic IaaS-services (virtual data centers and storage systems) are most needed at industrial enterprises today. This is due to the large number of legacy IT systems that are already in service, operating under different protocols and standards. It is either difficult or impossible to get data from such systems, manage and develop them using cloud PaaS models.

However, the IT infrastructure of large companies generates a huge amount of data that requires both storage and processing. Moreover, enterprises of the same industrial group may be located in different parts of the country, in places where there is often not enough IT capacity and specialists to effectively perform such tasks. Therefore, if we talk about cloud technologies, hybrid clouds are currently the most popular in the industry, when critical data is processed on-site, and IaaS solutions of cloud providers are used for the rest of the volume.

Mass implementation of supervisory control and data acquisition (SCADA), manufacturing execution system (MES), enterprise resource planning systems (ERP) in the near future will require both a larger volume and a larger range of IaaS services, as well as the introduction of PaaS models. Deploying SCADA/MES/ERP systems in the cloud is both cheaper and faster than On-Premise infrastructure.

With the exception of the largest Russian enterprises, relatively few production facilities use a Double Twin technology, a predictive analysis to prevent accidents, an industrial IoT, and Data Science-based solutions. All of these technologies require the full range of cloud services: from IaaS and PaaS to SaaS products, such as applications for personnel working in industry.

The digitalization of industrial production at the beginning of 2020 is characterized by such trends as the transition from a variety of local IT-solutions to common platforms and standards, and the transfer of infrastructure to the cloud. However, the pandemic has shown how important it is to ensure the continuity of production in any, even the most critical conditions. For sure, many industrial groups will think about the increased automation of production, ensuring comprehensive security of personnel, also they will pay more attention to contactless technologies, intelligent cloud video surveillance systems and AI-Analytics of production processes. This approach will not only help one quickly respond to crisis situations, but also predict them, which will ultimately lead to reduced financial losses, increased business efficiency and competitiveness.

The direction of new production technologies includes the following sub-technologies:

- digital design, mathematical modelling and product lifecycle management (Smart Design);
- technologies of smart production (Smart Manufacturing);
- manipulators and manipulation technologies.
The targets for these sub-technologies are defined in the roadmap “New production technologies” (as part of the Federal project “Digital technologies”) (Table 1).

**Table 1.** Targets for sub-technologies such as Smart Design, Smart Manufacturing and Manipulators and Manipulation technologies

| Target                                                                 | 2019 present state | 2021 target state | 2024 target state |
|------------------------------------------------------------------------|--------------------|-------------------|-------------------|
| **Digital design, mathematical modelling, and product lifecycle management (Smart Design)** |                    |                   |                   |
| The number of high-tech enterprises from priority industries that use Double Twin technology and are provided with expert support | 3                  | 15                | 100               |
| The number of high-tech enterprises from priority industries using the developed PLM system | 0                  | 5                 | 25                |
| The number of users of the digital platform for developing Double Twin technology | 250                | 1000              | 2500              |
| The number of applications developed on the full lifecycle platform     | 0                  | 10                | 25                |
| **Smart Manufacturing**                                                 |                    |                   |                   |
| Human participation in the preparation and commissioning of production, % of operations performed | 100%               | 85%               | 65%               |
| MES-system implemented in high-tech enterprises, at least               | –                  | –                 | 1000              |
| The number of industry standards developed by UX                       | 1                  | 2                 | 4                 |
| Equipping with MDC-class systems that provide a real-time data acquisition from equipment in 5 priority industries, % | –                  | 50%               | 70%               |
| The number of medium-sized and large enterprises in manufacturing industries that have passed the digital transformation assessment (received 'digital passports’) and are connected to SIIS (State Industry Information System) services, thousand enterprises | –                  | 5,8               | 14,4              |
| **Manipulators and manipulation technologies**                          |                    |                   |                   |
| Accuracy of material handling by robot manipulators, μm                | 100 μm             | –                 | 10 μm             |
| Speed of delicate manipulation, m/s                                     | 0,1 m/s            | –                 | 1 m/s             |
| Market of industrial robotic systems, bn rubles                        | 8                  | 25                | 30                |
| Share of russian developers of industrial robotics, %                  | 5%                 | 15%               | 30%               |
| The number of robots involved in production, per 10,000 employees      | 4                  | 20                | 40                |

Manufacturers need to guarantee that large amounts of data are managed effectively. This concept includes the use of the IoT technology, connecting data collection and analysis systems to cloud systems to improve work with large amounts of data.
necessary for balancing production activities (Baur and Vi 2019). Manufacturers strive to create and implement connected IoT systems to set up smart productions. To achieve this, there are four main areas described below.

*Improving Productivity and Quality.* Quality management and continuous improvement programs can be created as many times as necessary only if they are based on information that is limited or unavailable in real time. In production, the vast majority of equipment leads surveillance and control work in real time. Moreover, these smart devices are actively used to improve the quality of products and search for defects in the production process.

*Improving the Decision-making Process.* The most optimal decision can be made only if one have operational information. However, most manufacturers have old data acquisition and processing systems that need to be updated to the current level of performance.

Manufacturers who have taken steps to modernize and are equipped with better systems for collecting and processing information, get up-to-date information, thanks to which they can analyze their business in more detail, including:

- identification of operational strengths and weaknesses;
- analysis of processes and initiatives to improve planning;
- development and implementation of more advanced production systems;
- development of targeted training programs;
- the establishment of systems of performance management (Girduc 2018).

*Ensuring Safe and Reliable Solutions.* Reaching the level of secure, compatible and reliable solutions is a permanent problem for every manufacturer, and Smart Manufacturing provides new opportunities to work with some of these eternal problems. The most obvious options are to replace outdated and isolated automation systems that have reached their end of life, that are difficult to integrate with other systems, and are no longer supported by manufacturers. However, before starting the upgrade, the manufacturer must determine the requirements for the new smart system based on past experience in such areas as: injury risk for working personnel, equipment downtime, and work interruptions.

*Ensuring Infrastructure Security.* High availability of information, as well as a huge number of connection points, introduces a great risk to the production environment in the form of internal and external threats. Modern cybercriminals attack not only corporate servers, but also some IoT devices, which is more dangerous for industrial systems that have a lower degree of protection.

None of security methodology or technology can provide a 100% guarantee of protection from these threats. To do this, manufacturers must apply a comprehensive, in-depth security approach that establishes security guarantees at different levels to prevent threats on multiple fronts.
4 Results

Smart manufacturing offers virtually unlimited potential, and it all starts with creating a connected industrial IoT system as the basis for achieving better information exchange. Some of the most common questions about establishing industrial IoT technologies are as follows:

What processes of continuous improvement of smart manufacturing can be useful? This will depend on specific operations and business goals. To analyze efficiency, one needs to take into account the overall efficiency of the equipment, downtime, safe working conditions, and energy consumption.

What business transformation process can provide a competitive advantage? System-wide connectivity can help manufacturers better coordinate actions at all levels, allowing for more demand-driven operations. More detailed information about the operation of mechanisms makes it possible for one to improve the processes of equipment maintenance. In addition, an automated data acquisition and reporting can significantly save time compared to manual processing, especially in highly regulated industries.

What organizational changes are needed to promote smart manufacturing? IT/TO convergence is important, and it should occur as part of the workflow. IT and work staff have historically worked separately, but modern conditions require a deeper interaction. Production managers must bridge the gap between IT and the workforce and at the same time provide them with new skills for managing industrial network technologies.

What are the benefits? Monitoring work operations offers significant advantages. Data can be viewed automatically at specified intervals on key indicators and control panels, which significantly improves the process of managing the production process, improves the quality of output products, reduces the amount of consumables, saves labor, and etc. Standardizing data acquisition and reporting can also help compare the performance of different facilities.

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