

# Innovations in the Design of Production Workshops for the Implementation of Automated Technological Processes

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**Abstract**— The article explores current issues related to the automation of technological processes and the role of automated process control systems (APCS) in the domestic market. It highlights the key advantages of implementing APCS in production processes and outlines the main trends in the development of this field. Innovative solutions in modern workshop design are reviewed, with particular attention given to 3D modeling technologies, modular construction, and the trend toward environmentally efficient workshop designs. The article also analyzes the conditions necessary for designing production workshops to ensure the competent integration of automated technological processes.

**Keywords**— Automation, production workshops, technological processes, efficiency, innovative technologies.

## I. INTRODUCTION

In today's world, the automation of technological processes is a rapidly developing field of scientific innovation. This growth is primarily driven by advancements in innovative technologies and software across various production and industrial sectors, as well as the utilization of technologies that ease human labor. However, to implement the latest technologies in production, it is necessary to move away from traditional approaches to designing production workshops. Modern workshop design fully meets this challenge, making the topic of this research highly relevant.

The goal of this study is to analyze innovations in the design of production workshops.

The article highlights the benefits of the trend toward implementing automated process control systems (APCS), demonstrates the dynamics of the domestic APCS market, and outlines the main challenges facing this industry in Russia. It examines the most in-demand areas and the latest technologies related to automation. The key principles of planning production workshops are identified, and modern design technologies that enhance production efficiency are thoroughly analyzed.

### *The Role of Automated Technological Processes in Production*

Automation of the technological process refers to a set of methods and tools aimed at implementing a system or systems that manage the technological process itself without direct human intervention, leaving the most critical decision-making to humans.

These technologies significantly speed up production processes and improve product quality, minimizing the chances of defects or errors. Automated process control systems (APCS) are an integral component of successful and highly profitable industrial production.

APCS have gained widespread use across a broad range of economic sectors in most countries worldwide. This widespread adoption can be explained by the fact that the global trend of APCS implementation enables:

- Up to 81% reduction in production costs,
- Up to 74% decrease in product cost,
- Up to 39% increase in equipment efficiency and lifespan,
- Up to 56% improvement in product quality,
- Up to 21% reduction in working time losses.

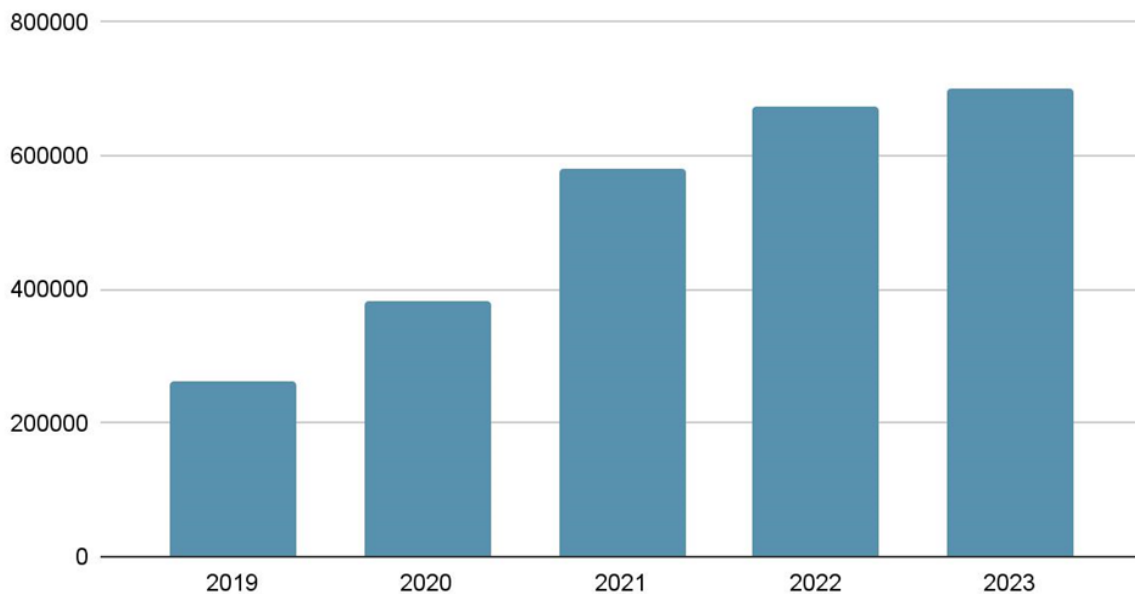
Despite these advantages, only 15.8% of Russian industrial enterprises today have a high level of automation. Meanwhile, 47.4% have a low level of automation, and 36.8% assess their automation level as average.

For decades, industrial automation in Russia relied heavily on close cooperation with foreign companies. This situation destabilized in 2020 due to the pandemic, which caused a shortage of electronic components. The domestic APCS market struggled to cope with significantly extended delivery times for chips. These events underscored the importance of investing in the development of local microelectronic products. In 2022, the APCS market faced a new challenge: key players such as Siemens, Schneider Electric, and ABB left Russia in a short time.

Despite these challenges, the size and growth rate of the automated process control systems market in Russia have steadily increased in recent years, as shown in Fig. 1. This growth underscores the promising future of the APCS industry. It is also worth noting that the development of automation technologies will be focused on the following areas:

1. *Implementation of Artificial Intelligence (AI)*. This technology is used to create autonomous control systems capable of making decisions and executing them without human intervention. AI can also perform tasks such as forecasting and optimizing production processes, managing logistics and inventory, monitoring the technical condition of equipment, identifying issues in its operation, and more.
2. *Use of the Industrial Internet of Things (IIoT)*, which represents a system of connected networks and industrial objects with embedded sensors and software to collect and exchange data, enabling remote control and management in an automated mode.

Fig. 1. Volume and growth rate of the automated process control systems (APCS) market in Russia from 2019 to 2023 in value terms, million RUB.



3. *Augmented Reality (AR) and Virtual Reality (VR) tools for device maintenance and staff training.* AR technology integrates virtual objects into the real world. While on the production floor, using AR devices such as glasses, a mobile phone, or a tablet, one can view specifications, drawings, step-by-step instructions, settings for the operator, process transitions, workflows, and more, superimposed onto equipment and factory spaces. VR technology immerses users into a virtual world. The advantage of a virtual reality environment is that training can take place in a setting separate from the actual workplace, while retaining the ability to reproduce all operational processes on a physical model of the enterprise's equipment.
4. *Deployment of cloud and edge solutions.* In industrial settings, edge technology is used to obtain real-time data at the point of origin, leading to faster and better decision-making and improved management of production processes. The analyzed and processed data is then sent to the cloud, allowing IT professionals to use this critical business information. The current approach involves deploying local devices with built-in analytics, local servers, gateways, and cloud infrastructure, which must ensure industrial-level availability and performance.

Thus, automation of technological processes contributes to increasing production efficiency, product quality, reducing raw material costs, as well as enhancing safety, environmental sustainability, and economic efficiency. However, to maximize process optimization, the facility must be designed to accommodate the latest technologies from the early stages.

#### 1) Modern Solutions in Designing Production Facilities

Creating a new production facility is a multi-stage process that requires careful planning and a professional approach to design.

The main stages include concept development, site selection, preliminary planning, detailed design, construction, and commissioning. At the concept stage, key requirements for the future facility are determined, including production capacity, types of equipment, and technological processes. This is followed by risk analysis and the development of risk minimization strategies. When selecting a site, logistics, economic, and environmental factors are considered. Preliminary planning involves developing the building plan, equipment layout, and engineering systems. Detailed design entails creating a full set of technical documentation necessary for construction and commissioning.

Key principles of production facility planning include:

- *Rational use of space:* every square meter of the facility must be utilized to ensure an uninterrupted production process.
- *Flexibility and scalability:* production areas should be designed so that they can be easily adapted to changes in production lines or increased production volumes.
- *Safety and accessibility:* the facility's organization must ensure worker safety and comply with all regulatory requirements while also allowing easy access to equipment for maintenance and repair.
- *Optimization of workflows:* efforts should be made to minimize the time and effort required to move materials and semi-finished products between workstations.

The use of modern technologies in design plays a key role in ensuring the efficiency and safety of production processes. Careful planning and coordination of all construction stages enable the integration of robotic systems and production management systems into the facilities, preparing them for quick adaptation to changes in production processes.

Key areas of development in production facility design include:

1. *Application of modular construction principles.* Modular construction provides flexibility and shortens the construction time of facilities. Modular production systems can be quickly reconfigured for current tasks and requirements, thus becoming closely linked with flexible automated production (FAP), a concept aimed at creating adaptive production systems capable of responding quickly to changes in market conditions and shifting customer demands.
2. *Use of 3D modeling in design.* With the help of 3D modeling software, such as CAD (Computer-Aided Design) and BIM (Building Information Modeling), engineers can virtually recreate the production facility, optimize the layout of equipment and engineering systems, and anticipate potential problems before construction begins. These technologies reduce design time, minimize errors, and ensure a high level of system integration within the facility.
3. *Use of eco-friendly materials and renewable energy sources to reduce environmental impact.* In today's world, where ecological issues and the depletion of natural resources are becoming increasingly urgent, environmental standards and sustainable development play a key role in the design of new production facilities. The application of environmental standards such as ISO 14001 (environmental management systems) and LEED (Leadership in Energy and Environmental Design) helps minimize harmful environmental impacts and contributes to biodiversity conservation.

It is worth noting that the use of renewable energy sources in new production facilities is one of the most effective ways to achieve energy efficiency and reduce the carbon footprint. The most promising technological solutions include energy-saving lighting sources, heat pumps, wind turbines, photovoltaic solar panels, solar collectors, and 3D-printed buildings designed for energy efficiency. These technologies significantly reduce dependence on fossil fuels and lower operational costs. This not only benefits the environment but also increases the competitiveness of enterprises by reducing energy expenses. Additionally, integrating renewable energy sources highlights a company's social responsibility and strengthens its image among consumers and investors who increasingly value environmental sustainability in business.

#### *Integration of Smart Manufacturing Systems:*

Smart manufacturing systems analyze real-time data to optimize workflows. This technology implies that all elements of the production facility are interconnected and optimized for maximum efficiency. Commonly, automation technologies such as AI, IIoT, AR, VR, and Edge computing are employed for this purpose.

Thus, trends and innovations in the design of production facilities reflect the drive for maximum process optimization and resource efficiency.

## II. CONCLUSION

Production facilities are on the brink of significant transformations driven by rapidly changing global economic processes. On the one hand, increasing competition and the need to reduce costs push companies to seek more efficient

production approaches. On the other hand, economic instability and demand fluctuations require production facilities to be flexible and quickly adaptable to market changes. This emphasizes the development of smart and modular production systems that can swiftly reconfigure to meet current needs.

The potential directions for development and innovation in the design of production facilities encompass a wide range of technologies. Among the top priorities are the concept of "smart manufacturing," where all production facility elements are interconnected and optimized for maximum efficiency, and 3D modeling, which enhances the quality of design.

The environmental factor is also becoming increasingly important in the design of new production facilities. The adoption of clean technologies, the transition to renewable energy sources, and the improvement of energy efficiency are key directions for reducing the industrial sector's carbon footprint. All of this leads to the creation of a new generation of production facilities that not only meet market demands but also contribute to the preservation of natural resources and the improvement of environmental conditions.

In conclusion, the future of production facility design promises revolutionary changes in the industry. Adapting to global economic trends, implementing cutting-edge innovations, and striving for environmental sustainability will be key factors shaping the future of production facility design. The combination of these elements will foster the development of smart, flexible, and green production systems that meet the growing needs of both society and the economy.

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