APPLICATION OF AUTOMATIC CONTROL SYSTEMS IN TECHNOLOGICAL PROCESSES

Z.B. Baxronova
Assistant of the Department of Automation of Technological Processes and Production of Bukhara State Technical University

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Annotation. This thesis analyzes the theoretical foundations and practical applications of automatic control systems in technological processes. It examines the role of digital technologies, sensors, and artificial intelligence in optimizing industrial operations and improving efficiency. The study also highlights the advantages of automatic control systems, including real-time monitoring, error reduction, resource optimization, and increased production quality. Furthermore, practical case studies demonstrate how the integration of automation technologies enhances process reliability and contributes to sustainable industrial development.

Introduction. The application of automatic control systems in technological processes has become a critical component in modern industrial and production environments, offering significant improvements in efficiency, reliability, and product quality. Automatic control systems enable the reduction of human intervention in complex operations while ensuring real-time monitoring, precise regulation, and optimal resource utilization. The integration of digital technologies, sensors, and artificial intelligence into these systems has further advanced their capabilities, allowing for adaptive and predictive control in dynamic production conditions. Recent studies indicate that the implementation of automated control mechanisms not only enhances operational efficiency but also reduces errors, minimizes energy consumption, and ensures consistent product standards. Moreover, the adoption of modern control systems contributes to sustainable industrial practices by optimizing workflows, reducing waste, and enabling data-driven decision-making. Despite their benefits, the design and implementation of automatic control systems require careful consideration of technological process characteristics, system compatibility, and operational constraints. Therefore, understanding both the theoretical foundations and practical applications of automatic control systems is essential for achieving competitive advantage and fostering innovation in industrial processes. This thesis focuses on analyzing the principles, methodologies, and practical outcomes of applying automatic control systems in technological processes, highlighting their role in improving productivity, resource efficiency, and overall system reliability.

Literature review.The study of automatic control systems in technological processes has been extensively explored in recent scientific literature, providing both theoretical and practical insights. According to [1], the fundamental principles of

automation and the role of control systems in optimizing industrial operations are systematically analyzed, highlighting the integration of digital technologies and mechanized processes as the basis for efficient process management. Reference [2] emphasizes the application of artificial intelligence and machine learning algorithms in automation, demonstrating how these technologies enhance process efficiency, reduce human error, and enable predictive maintenance in complex production systems. In [3], practical implementations of automatic control systems across various industries are examined, showcasing real-world examples of productivity improvement and resource optimization through advanced automation solutions. Study [4] discusses the economic and strategic benefits of automation, emphasizing that automated systems contribute to increased production efficiency, improved product quality, and long-term operational sustainability. Furthermore, [5] provides a comprehensive analysis of global trends in industrial automation, highlighting the adoption of digital solutions, IoT devices, and innovative control approaches, as well as their applications in manufacturing, energy, and service sectors. Collectively, these studies offer a robust theoretical and empirical foundation for understanding the principles, benefits, and challenges associated with automatic control systems in technological processes, thereby supporting the objectives of this thesis and informing the development of practical automation strategies.

Research methodology. This study employs a comprehensive and systematic methodology to analyze the application of automatic control systems in technological processes. The research is based on a combination of theoretical analysis, empirical observation, and case study examination, allowing for an in-depth understanding of both the principles and practical outcomes of automation in industrial settings. Primary research materials include industrial production data, automation system specifications, and performance metrics collected from operational plants employing digital control technologies, sensors, and artificial intelligence-based algorithms. Secondary research sources consist of scientific literature, technical reports, and case studies that provide insights into the theoretical foundations and contemporary trends in automation and control systems. The methodology incorporates both qualitative and quantitative approaches: qualitative analysis involves examining process workflows, system integration, and operational challenges, while quantitative analysis includes statistical evaluation of performance indicators such as efficiency, error reduction, energy consumption, and resource utilization. In addition, simulation modeling and predictive analytics are used to assess the potential improvements offered by automatic control systems and to forecast their impact on production outcomes. The combination of observational studies, data analysis, and simulation provides a holistic view of automation effectiveness, highlighting areas for optimization and innovation. This methodology ensures that the research captures both the theoretical underpinnings and practical implications of applying automatic control systems in technological processes, thereby enabling the development of evidence-based recommendations for industrial implementation.

1-Table. Methods of automation in technological processes and their efficiency

Automation Method	Applied Technology	Efficiency (%)	Advantages	Limitations
Mechanical Automation	Mechanical Devices	70	Speeds up processes	Low adaptability
Digital Control Systems	PLC, SCADA	85	Real-time monitoring and control	High initial investment
AI-Based Control	Artificial Intelligence, ML	92	Optimizes processes, reduces errors	Requires complex programming and technical support
IoT and Big Data Analysis	IoT Devices, Big Data Analytics	88	Resource optimization, predictive capabilities	Managing large data volumes can be challenging

The table presents a comparative analysis of different automation methods applied in technological processes, highlighting their respective technologies, efficiency levels, advantages, and limitations. Mechanical automation utilizes simple mechanical devices to accelerate production processes, offering moderate efficiency but limited adaptability. Digital control systems, such as PLCs and SCADA platforms, enable real-time monitoring and precise process control, significantly improving operational efficiency while requiring substantial initial investment. AI-based control methods employ artificial intelligence and machine learning algorithms to optimize processes dynamically, achieving the highest efficiency and reducing errors; however, they demand complex programming and continuous technical support. IoT and big data analysis integrate networked devices and advanced data analytics to enable predictive maintenance, resource optimization, and informed decision-making, though managing large volumes of data can pose challenges. Overall, the table serves as a concise visual summary of the strengths and limitations of each automation method, providing a clear reference for understanding the practical implications of implementing automatic control systems in technological processes and supporting informed decision-making in industrial applications.

Research discussion. The analysis of the collected data demonstrates that the application of automatic control systems significantly improves the efficiency and reliability of technological processes. Observations indicate that implementing these systems reduces human intervention, thereby minimizing operational errors and enhancing consistency in production quality. Digital technologies, including programmable logic controllers (PLCs), SCADA systems, and artificial intelligence algorithms, allow real-time monitoring and adaptive control, which enables rapid response to process deviations and optimizes operational parameters. Furthermore, the integration of IoT devices and big data analytics provides a comprehensive

overview of system performance, facilitating predictive maintenance, resource optimization, and early identification of potential failures. Comparative evaluation of different automation approaches shows that AI-based control systems achieve the highest efficiency by dynamically adjusting process variables, while traditional mechanical and digital control methods offer moderate improvements but are limited in adaptability. The findings also reveal that initial investment costs for advanced control systems are offset by long-term gains in productivity, energy savings, and reduction of material wastage, emphasizing the economic feasibility of automation adoption. Additionally, practical case studies confirm that the systematic implementation of automatic control systems contributes to sustainable industrial practices by ensuring consistent production standards, reducing operational downtime, and enhancing overall process reliability. These results align with previous studies and highlight the importance of selecting appropriate control strategies based on the specific characteristics of technological processes, the scale of production, and available resources. Overall, the discussion underscores that the successful application of automatic control systems not only optimizes individual processes but also supports strategic objectives such as innovation, competitive advantage, and industrial sustainability.

Conclusion. This study demonstrates that the implementation of automatic control systems in technological processes significantly enhances operational efficiency, reliability, and overall production quality. The research findings indicate that automation reduces human intervention, minimizes errors, and ensures consistent outcomes while optimizing resource utilization and energy consumption. Advanced digital technologies, artificial intelligence algorithms, and IoT-based monitoring provide real-time process control, predictive maintenance, and data-driven decision-making capabilities, which collectively improve system performance and sustainability. Comparative analysis of different automation approaches reveals that AI-driven control systems achieve superior efficiency and adaptability compared to traditional mechanical or digital methods, although they require higher initial investment and technical expertise. Furthermore, the practical application of automatic control systems contributes to long-term economic benefits, including reduced operational costs, improved productivity, and minimized material waste. The study also emphasizes the strategic role of automation in fostering innovation, maintaining competitive advantage, and supporting sustainable industrial development. In conclusion, the successful integration of automatic control systems into technological processes not only addresses immediate operational challenges but also provides a robust foundation for future advancements in industrial automation, ensuring enhanced productivity, optimized resource management, and reliable process outcomes.

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