# CURRENT ISSUES IN AUTOMATIC CONTROLLING OF TECHNOLOGICAL PROCESSES

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## ABSTRACT:

*This paper explores the current challenges and advancements in the automatic control of technological processes. It reviews various control strategies, including PID controllers, Model Predictive Control (MPC), fuzzy logic, and AI-based systems, highlighting their effectiveness in managing complex, nonlinear industrial processes. A primary challenge is ensuring the accuracy and reliability of sensor data, as inaccuracies can lead to poor control performance. Recent developments in sensor technology and the integration of Internet of Things (IoT) with SCADA systems are improving real-time monitoring and decision-making. The paper also addresses the complexity of industrial processes, particularly in chemical and power generation sectors, where nonlinearities and disturbances complicate control. Adaptive and robust control strategies, as well as AI and machine learning, offer potential solutions for maintaining performance in dynamic conditions. Despite progress, challenges in sensor reliability, system integration, and real-time data processing remain. The study emphasizes the need for further research to enhance the efficiency and resilience of control systems.*

**INTRODUCTION.** Technological processes form the core of all industrial production systems, encompassing a wide range of operations such as heating, cooling, mixing, separation, chemical reactions, material transport, and product packaging. The efficiency, stability, and quality of these processes directly determine the overall productivity and economic performance of an enterprise. In this context, the implementation of automatic control systems has become essential for managing these complex and often nonlinear processes with high precision and reliability. Automatic control in technological processes refers to the continuous monitoring and regulation of process variables such as temperature, pressure, flow rate, level, and composition using sophisticated control algorithms and hardware components. These systems ensure that industrial operations proceed within defined safety and quality parameters, despite external disturbances or internal process variability. Especially in sectors like chemical processing, oil and gas refining, food production, and pharmaceutical manufacturing, automatic control is critical for maintaining product standards and ensuring regulatory compliance. With the rise of Industry 4.0, technological processes are becoming increasingly digitized, interconnected, and data-driven. This shift has introduced both new opportunities and significant challenges for automation. On one hand, real-time data acquisition and advanced analytics allow for more accurate process modeling, predictive maintenance, and adaptive control. On the other hand, increased system complexity, the need for integration across various platforms, and the management of massive volumes of process data introduce new layers of difficulty in control design and implementation.

One of the most pressing issues in this domain is the inconsistency in process dynamics due to changes in raw materials, environmental conditions, and equipment aging. These factors can cause significant deviations in process behavior, which, if not properly managed, can lead to quality loss, energy inefficiency, or safety hazards. Furthermore, traditional control systems often lack the flexibility to adapt to such dynamic variations without manual intervention or reconfiguration.

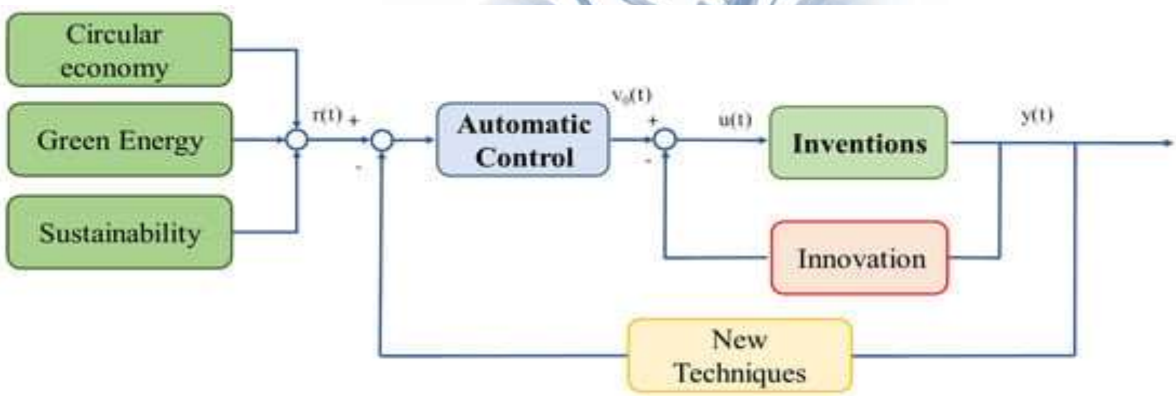


Figure 2. Automatic control and system theory and advanced applications

Another major issue concerns the latency and accuracy of sensor measurements, which serve as the foundation for all control decisions. Delayed or incorrect data can result in inappropriate control actions, especially in time-sensitive processes. Likewise, actuator performance must be continuously monitored and maintained to ensure that control commands are executed effectively. Without reliable interaction between sensors, controllers, and actuators, the stability of technological processes cannot be guaranteed. This paper focuses on the current challenges associated with automatic control of technological processes, emphasizing the technical, operational, and systemic factors that affect control performance. It aims to provide a detailed overview of existing problems, explore innovative control strategies, and highlight the role of digital technologies—such as artificial intelligence, edge computing, and industrial IoT—in optimizing complex industrial systems. Through this analysis, the study contributes to the advancement of robust and intelligent automation solutions tailored to the ever-evolving demands of modern process industries.

**Literature review.** The automation of technological processes has evolved significantly over the last several decades, driven by advancements in control theory, sensor technology, and computational power. Technological processes, ranging from simple physical operations to complex chemical reactions, require precise monitoring and control to maintain optimal performance. Automatic control systems are integral to managing these processes efficiently, particularly in industries like chemical manufacturing, petrochemicals, food processing, and power generation.

The primary challenge in automating technological processes is managing their inherent complexity, which often involves nonlinearity, time delays, and multiple interacting variables. Early research primarily focused on linear systems with well-defined dynamics, where traditional controllers like Proportional-Integral-Derivative (PID) controllers were highly effective. However, as processes became more complex, the limitations of PID control became apparent, prompting further research into more advanced control strategies. Model Predictive Control (MPC), as detailed by Qin and Badgwell (2003), has become a preferred method for controlling multivariable systems where constraints are present. MPC allows for the optimization of control inputs over a prediction horizon while considering system constraints. This makes it particularly valuable for processes where maintaining precise control over multiple variables is critical, such as in chemical and petrochemical industries. However, MPC's computational demands require significant resources, which has led to ongoing efforts to develop more efficient algorithms suitable for real-time applications. Fuzzy Logic Control (FLC) and neural network-based controllers have also seen increasing application in the automation of nonlinear systems. FLC, as explored by Mamdani (1974), offers a solution for systems where the mathematical modeling is too complex or undefined. These controllers operate based on linguistic variables and expert knowledge, which can be particularly useful for processes with uncertain or imprecise data. Neural networks, particularly deep learning approaches, have further expanded the scope of automation by enabling systems to learn from historical data and adapt to changing conditions without explicit reprogramming.

The foundation of any automatic control system is the accurate and reliable measurement of process variables, which are typically gathered through sensors. The precision of these measurements is crucial because inaccurate or delayed data can significantly impact the control process. Research in sensor technology has focused on improving the reliability and responsiveness of sensors used in industrial environments. Advances in wireless sensor networks, smart sensors, and multi-sensor fusion techniques have contributed to more accurate and real-time data acquisition, enhancing overall control performance. For example, the integration of advanced sensors in the food processing industry has enabled continuous monitoring of product quality parameters, such as moisture content and temperature, leading to better control of product consistency and reduced wastage. Similarly, in petrochemical processes, the use of advanced flow meters and pressure sensors has enhanced the ability to regulate chemical reactions and ensure safety standards.

Given the dynamic nature of technological processes, adaptive and robust control strategies have gained increasing attention. These approaches are designed to handle variations in the process that may not be predictable or easily modeled. Adaptive control, as described by Astrom and Wittenmark (2008), allows control parameters to adjust in response to changes in the process or environmental conditions. This is particularly important in processes where external disturbances, such as fluctuations in raw material quality or temperature, can significantly affect performance. Robust control techniques, on the other hand, are developed to ensure that control systems can maintain stability and performance even under uncertain conditions or disturbances. The work of Zhou and Doyle (1998) on $H\infty$ control, for instance, has provided methods to design controllers that can maintain system robustness against system uncertainties and external disturbances, which is particularly useful for industries like power generation, where system parameters can vary widely.

Another significant aspect of modern automatic control in technological processes is the integration of various systems into a unified, real-time control architecture. The use of distributed control systems (DCS) and supervisory control and data acquisition (SCADA) systems has been instrumental in achieving this goal. These systems allow for centralized monitoring of dispersed processes and enable operators to make informed decisions based on real-time data from multiple sources.

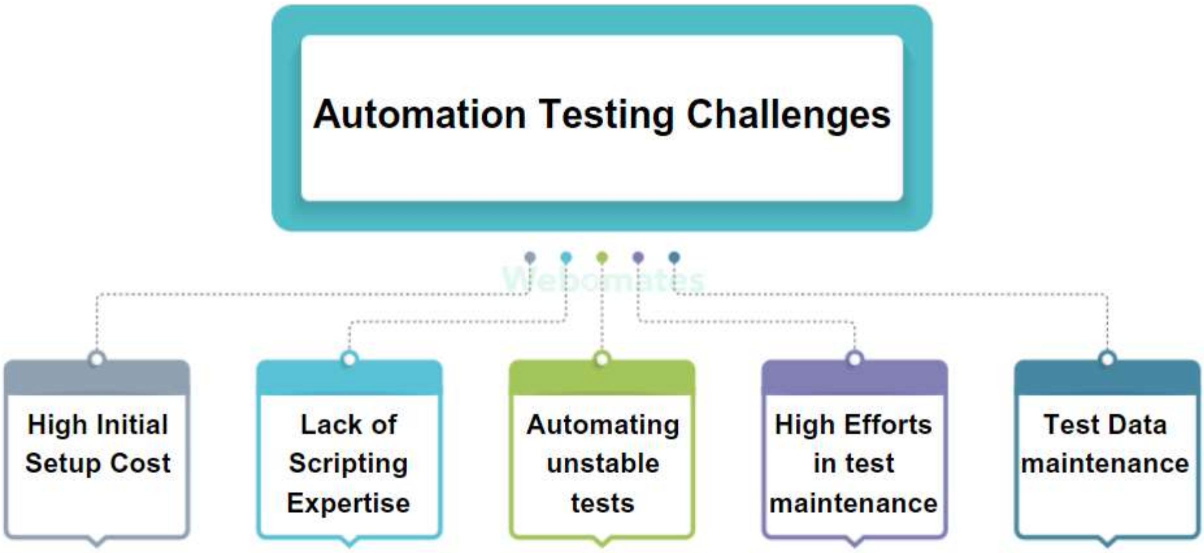


Figure 2. Test Automation challenges

In recent years, the integration of the Internet of Things (IoT) with SCADA systems has further enhanced the real-time control and monitoring capabilities of industrial processes. The ability to access process data remotely, coupled with predictive analytics, allows for more proactive decision-making and faster response to process deviations. IoT-enabled sensors, when integrated into automated control systems, provide more granular control, allowing industries to optimize performance and reduce downtime. Despite the significant advances in control strategies and sensor technologies, several challenges persist in the automation of technological processes. These challenges include:

Process Complexity and Nonlinearity: Many technological processes, especially in industries like chemical manufacturing and metallurgy, exhibit complex, nonlinear behavior that is difficult to model accurately. Traditional control strategies often fail to cope with such complexities, necessitating the use of advanced methods like MPC or AI-based controllers. Sensor Accuracy and Reliability: Sensor faults or inaccuracies can lead to poor control decisions and reduced system performance. Researchers continue to focus on developing more reliable sensors, as well as sensor fusion techniques that combine data from multiple sources to improve accuracy.

Real-Time Data Processing and Control: The real-time processing of large volumes of data is a significant challenge. Advances in edge computing, which process data closer to the source rather than sending it to a central server, are helping to mitigate some of the delays and bottlenecks associated with traditional control systems.

Integration of Heterogeneous Systems: Many industries rely on a mix of control technologies from different vendors, leading to challenges in system interoperability and integration. Ongoing research focuses on developing standardized communication protocols and flexible control architectures that can accommodate various types of hardware and software.

The literature on the automatic control of technological processes reveals a rich body of research aimed at improving the performance, adaptability, and reliability of control systems. While significant progress has been made, the increasing complexity of industrial processes and the need for real-time, adaptive control systems ensure that this area of research will remain a key focus for years to come.

**Discussion.** The automation of technological processes is essential for improving efficiency and safety in industries such as chemical production, power generation, and food processing. One significant challenge is the nonlinearity and complexity of many processes. Traditional methods like PID controllers are often inadequate, leading to the adoption of Model Predictive Control (MPC) and adaptive systems, which offer more precise control over variable conditions. AI and machine learning are also becoming integral in process control, allowing systems to learn from data and adjust autonomously. However, these technologies introduce challenges in model transparency and generalization across processes, requiring further development for practical, real-world applications. Sensor accuracy remains another critical issue. Harsh industrial environments affect sensor performance, leading to inaccurate data. Innovations like wireless sensor networks and sensor fusion are improving reliability, but challenges like calibration and drift persist. Research is still needed to develop more robust and cost-effective sensors.

The integration of IoT with SCADA systems has enhanced real-time monitoring and remote control, improving process responsiveness. However, this also introduces concerns about data security and system interoperability, particularly in complex industrial environments. Finally, while automation offers significant benefits, there is a risk of operator complacency. It is essential to maintain a balance between automation and human oversight to ensure effective decision-making and intervention when needed. In summary, while advancements in control methods, sensor technologies, and IoT integration have improved automation, ongoing research is necessary to overcome the challenges of system complexity, sensor reliability, and human-machine interaction.

**Conclusion.** In conclusion, the automation of technological processes remains a cornerstone for improving efficiency, safety, and product quality across various industries. While traditional control methods like PID controllers have been widely used, their limitations in handling complex, nonlinear processes have led to the adoption of more advanced strategies such as Model Predictive Control (MPC) and AI-based systems. These methods offer greater precision and adaptability in controlling dynamic processes. However, challenges such as sensor accuracy, system integration, and real-time data processing persist. Innovations in sensor technologies and the integration of IoT with SCADA systems are enhancing monitoring capabilities and decision-making but introduce new complexities related to security and interoperability. Additionally, the balance between automation and human oversight remains crucial to prevent operator complacency and ensure effective control. Overall, while substantial progress has been made in process automation, ongoing research is required to refine control strategies, improve sensor reliability, and ensure the resilience and sustainability of automated systems in increasingly complex industrial environments.

## Foydalanilgan adabiyotlar ro`yxati

1. Djuraev, K., Yodgorova, M., Usmonov, A., & Mizomov, M. (2021, September). Experimental study of the extraction process of coniferous plants. In *IOP Conference Series: Earth and Environmental Science* (Vol. 839, No. 4, p. 042019). IOP Publishing.

2. Abduraxmonov, O. R., Soliyeva, O. K., Mizomov, M. S., & Adizova, M. R. (2020). Factors influencing the drying process of fruits and vegetables. *ACADEMICIA:" An international Multidisciplinary Research Journal" in India*.

3. Mizomov, M. S. (2022). Analyzing Moisture at the Drying Process of Spice Plants. *Texas Journal of Agriculture and Biological Sciences*, *4*, 84-88.

4. Mizomov, M. (2025). ANALYZING TECHNOLOGICAL PROCESSES WITH MAIN TECHNOLOGICAL PARAMETERS. *International Journal of Artificial Intelligence*, *1*(3), 120-124.

5. Mizomov, M. (2025). RESEARCHING HIGHER EDUCATIONAL ACTIVITIES AROUND UNIVERSITIES. *Journal of Applied Science and Social Science*, *1*(2), 284-291.

6. Mizomov, M. (2025). REVISITING STRATEGIES FOR IMPROVING ORGANIZATIONAL MECHANISMS. *Journal of Applied Science and Social Science*, *1*(1), 364-370.

7. Mizomov, M. (2025). ANALYZING DRYING PROCESS OF SPICES USING THE LOW TEMPERATURE. *Journal of Applied Science and Social Science*, *1*(1), 645-651.

8. Djurayev, K., & Mizomov, M. (2024). Optimizing the efficient transport of mass from alternative energy sources and the process of heat and mass exchange during the processing of spices. *YASHIL IQTISODIYOT VA TARAQQIYOT*, *2*(3).

9. Khudoynazarov, F. J., Djuraev, H. F., Mizomov, M. S., & Fayziev, A. K. (2024, February). Development of an optimal mechanism for a solar-air collector for drying thermolabile products. In *Journal of Physics: Conference Series* (Vol. 2697, No. 1, p. 012015). IOP Publishing.

10. Mukhammad, M. (2024). THE MAIN TECHNOLOGICAL PARAMETERS IN THE PROCESS OF DRYING HERBS: HUMIDITY AND TEMPERATURE CONTROL. *Universum: технические науки*, *5*(9 (126)), 17-20.

11. Расулов, Ш. Х., Джураев, Х. Ф., Увайзов, С. К., Мизомов, М. С., & Файзиев, А. Х. РАЗРАБОТКА ОПТИМАЛЬНОГО МЕХАНИЗМА ПЕРЕМЕЩЕНИЯ ТЕПЛО–И МАССОПЕРЕНОСА В ПРОЦЕССЕ СУШКИ. *ЖУРНАЛИ*, 113.

12. Siddikov, I. K., Fayziev, S. I., Ismoyilov, K. B., & Uvayzov, S. K. (2020). Synthesis of the neuro-fuzzy adaptive control system of a dynamic object. *The Journal of Test Engineering and Management*, *83*, 11236-11246.

13. Xayrulla, D., Saidjon, U., & Azamat, M. (2021). DEVELOPMENT OF LIGHTING CONTROL SOFTWARE FOR “SMART CLASS”. *Universum: технические науки*, (5-6 (86)), 18-21.

14. Musaeva, R. X., Uvayzov, S. K., Musaeva, N. X., Qo'ldosheva, F. S., & Akramov, D. R. (2020). Research and experimental determination of thermo physical propertiesof highly foaming solution. *International Journal of Psychosocial Rehabilitation*, *24*(6), 4611-4620.

15. Djuraev, K., & Uvayzov, S. (2023). Synthesis of a digital PID controller to control the temperature in the agricultural products drying chamber. In *E3S Web of Conferences* (Vol. 390, p. 03002). EDP Sciences.

16. Кулдашева, Ф. С., Шарипова, Н. Р., & Увайзов, С. К. (2019). Проект лабораторной установки управления уровнем жидкости на основе

микропроцессорной технологии. In *ТЕХНИКА И ТЕХНОЛОГИИ: ПУТИ ИННОВАЦИОННОГО РАЗВИТИЯ* (pp. 205-210).

17. Джураев, Х. Ф., & Увайзов, С. К. (2019). Современные информационные технологии в образовании. In *Современные материалы, техника и технология* (pp. 160-163).

18. Xalikovna, M. R., Xamidovna, M. N., & Komilovich, U. S. (2021). Experimental Determination Of The Boiling Point Of Tomato Paste. *Turkish Journal of Computer and Mathematics Education*, *12*(13), 1274-1278.

19. АЧИЛОВА, Ш. И., & УВАЙЗОВ, С. К. (2017). РАЗРАБОТКА АРХИТЕКТУРЫ АВТОМАТИЧЕСКОГО УПРАВЛЕНИЯ РЕАКТОРОМ ПРОЦЕССА ИЗОМЕРИЗАЦИИ. In *МОЛОДЕЖЬ И СИСТЕМНАЯ МОДЕРНИЗАЦИЯ СТРАНЫ* (pp. 138-143).

20. УВАЙЗОВ, С. К., ИБРАГИМОВ, Ш. Р. У., & КУЛДАШЕВА, Ф. С. (2017). АВТОМАТИЗАЦИЯ РЕАКЦИОННОГО БЛОКА УСТАНОВКИ ПОЛИЭТИЛЕНА ВЫСОКОГО ДАВЛЕНИЯ. In *МОЛОДЕЖЬ И СИСТЕМНАЯ МОДЕРНИЗАЦИЯ СТРАНЫ* (pp. 255-259).