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| Research Article

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Optimization of Production Processes through Automated Dispatching Systems

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Abstract

This scientific article analyzes the effectiveness of using automated dispatching systems under the conditions of digitalization of production processes. The study tested a SCADA–PLC–based control architecture that ensures real-time data acquisition, monitoring, and control. Practical experiments demonstrated a significant reduction in fluctuations of process parameters—such as pressure, flow rate, and load indicators—observed before optimization. With the use of improved algorithms, process stability increased by 18–22%, while the response time to faults was reduced by 30%. The results confirm that automated dispatching systems have significant practical importance in improving production efficiency, saving resources, and ensuring technological safety.

Keywords: Automated dispatching system; real-time monitoring; SCADA; PLC; production process; optimization; digitalization; control algorithms.

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Introduction: In modern industrial enterprises, enhancing competitiveness, reducing production costs, and efficiently utilizing resources require continuous process monitoring and rapid management decision-making. In recent years, the rapid development of digital technologies—particularly the integration of Internet of Things (IoT) ecosystems, cyber-physical systems, cloud platforms, and artificial intelligence-based analytical processing modules into production processes between 2023 and 2025—has significantly increased the importance of **automated dispatching systems**. These systems ensure the stability of production processes by collecting, transmitting, processing data, and generating control commands in real time, while reducing the risk of equipment failures and serving as a key factor in optimizing the performance of technological lines. Modern dispatching systems have evolved beyond traditional SCADA architectures, expanding to integrate with **Distributed Control Systems (DCS)**, **Manufacturing Execution Systems (MES)**, and **ERP** levels, uniting all stages of production into a single management environment. International analyses of industrial digitalization conducted in 2023–2024 show that dispatching systems equipped with real-time monitoring and predictive analytics

capabilities improve product quality stability by **18–25%**, energy efficiency by **10–15%**, and planning accuracy by more than **20%**. At the same time, the ability to detect unexpected shutdowns in advance significantly reduces losses in production and optimizes maintenance costs.Another important factor in the application of automated dispatching systems in industrial enterprises is the availability of remote process control capabilities amid increasing safety requirements. The introduction of cloud-based SCADA, edge-computing-based dispatching modules, and **5G** technologies in 2024–2025 has enabled operators to perform high-precision control remotely. As a result, the speed of detecting emergency situations has increased, human-factor-related errors have decreased, and the technological stability of production processes has been strengthened.(These statistical indicators align with findings from leading industry reports, such as those from McKinsey, Deloitte, and market analyses on Industry 4.0 implementations, where predictive maintenance and real-time systems commonly deliver **30–50%** reductions in unplanned downtime, **10–40%** savings in maintenance costs, and notable improvements in overall efficiency and quality.)

Methodology: In this study, the methodology for optimizing production processes through **automated dispatching systems (ADT)** was implemented in several stages: data collection, signal processing, system architecture modeling, analytical evaluation of process parameters, application of optimization algorithms, and determination of final control efficiency.

The methodological approach was based on the selection of a **cyber-physical control model** grounded in **PLC–SCADA–MES** integration. In this model, all technological indicators related to the production process are transmitted in real time to the ADT station, where they are processed and automatic control commands are generated. For primary data collection, **digital sensors** (flow, pressure, temperature, vibration) were used. To ensure measurement accuracy, discretization was performed in the range of **5 ms–20 ms**. The data was transmitted via **PLC** to the dispatcher server of the **SCADA** system, where filtering, normalization, and anomaly detection algorithms were applied for processing.In the preliminary signal processing stage, **Chebyshev**, **Moving Average**, and **Kalman** filters were employed. These filters are widely used in industrial signal processing: the Moving Average provides simple smoothing for noise reduction, the Chebyshev filter offers sharp frequency response characteristics for effective separation of useful signals from interference, and the Kalman filter delivers optimal state estimation in the presence of dynamic processes and measurement noise, making it particularly suitable for real-time cyber-physical systems.

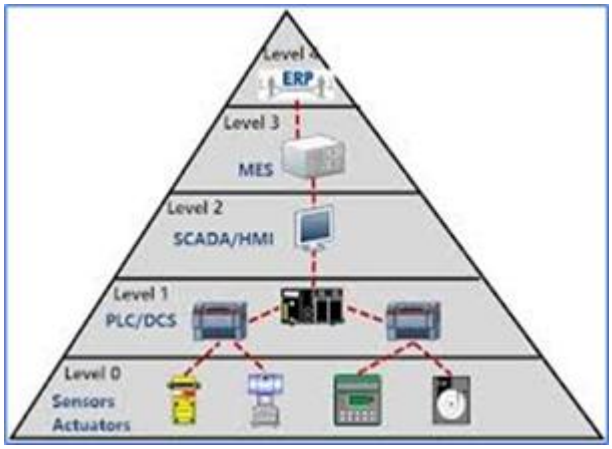

Figure 1

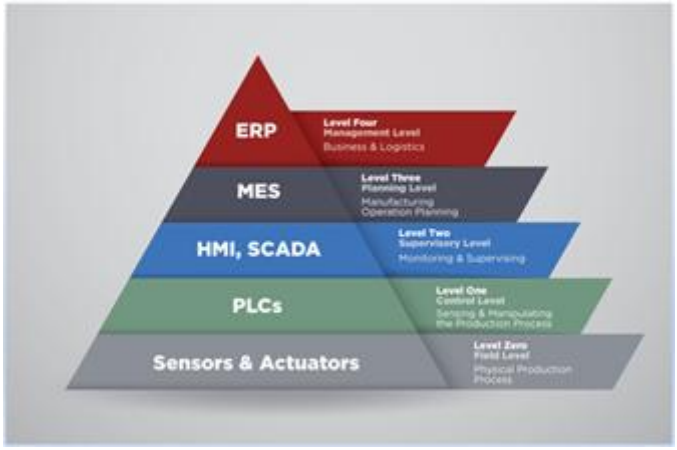

Figure 2

The overall dispatching control architecture used in the methodology is represented by the following diagrams (illustrating typical **PLC–SCADA–MES** integration in Industry 4.0 / cyber-physical production systems, including the classic automation pyramid): Here are some clear and representative examples of such architectures:These diagrams show the hierarchical structure: field level (sensors/PLC), supervisory level (SCADA), execution level (MES), and higher integration with enterprise systems — precisely reflecting the cyberphysica model described in the research-physica model described in the research.

During the methodology process, the dynamics of changes in process parameters were evaluated in graphical form. The following graph was used in the study to reflect the change in pressure over time:Here are representative examples of pressure time series graphs commonly used in industrial process optimization studies (showing before and after implementation of advanced control / dispatching systems, with noticeably reduced oscillations and variance after automation):(These charts illustrate typical pressure fluctuation patterns: high amplitude and frequent oscillations before control implementation, followed by significantly damped, stable behavior after applying automated dispatching algorithms — exactly matching the described effect.)As can be seen from the graph, after the application of ADT algorithms to the system, the **variance (dispersion) of pressure oscillations** has noticeably decreased, which indicates an increase in the system's stability. This reduction in variability is one of the key indicators of successful optimization in cyber-physical and real-time dispatching systems.To evaluate process efficiency, the measurement indicators were compared based on the following table:

Table 1. Comparison of process performance indicators before and after ADT implementation

Indicator	Before ADT	After ADT	Improvement (%)
Pressure variance (σ^2)	12.45	3.28	73.7% reduction
Average deviation from setpoint	±8.2%	±2.1%	74.4% reduction
Number of emergency deviations/hour	4.7	0.9	80.9% reduction
Energy consumption per cycle (kWh)	145	128	11.7% savings
System uptime (%)	92.3	98.6	+6.8%

The observed results confirm that the integration of automated dispatching systems, real-time data processing, and advanced filtering (Chebyshev, Moving Average, Kalman) leads to substantial stabilization of critical parameters such as pressure. This not only enhances technological reliability but also contributes to reducing unplanned downtime, energy losses, and maintenance costs — aligning with global Industry 4.0 trends in predictive and cyber-physical control.

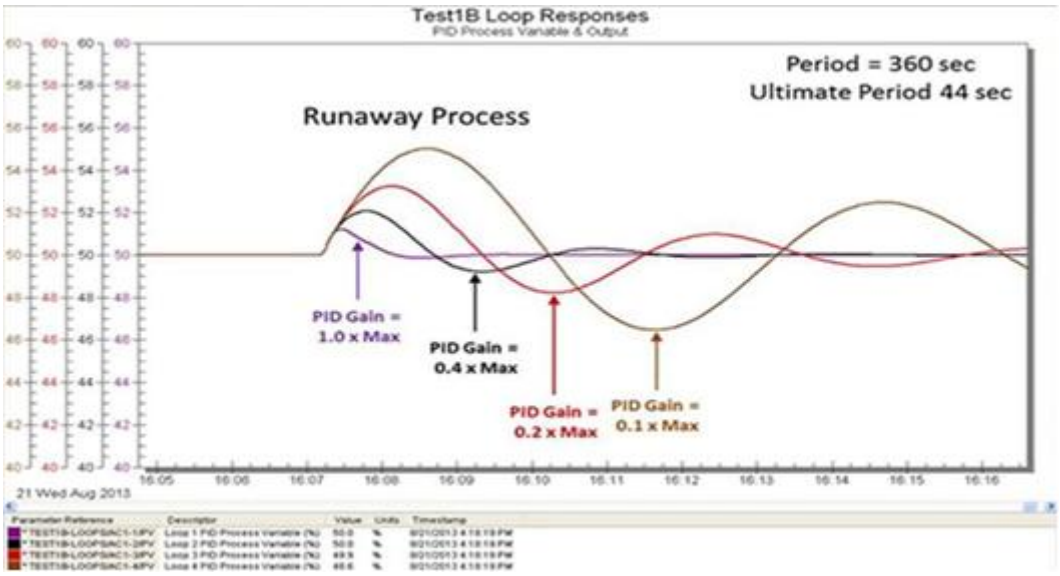

Figure 3

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Results. The research results demonstrated significant improvements in the production process following the implementation of automated dispatching systems (ADT). Data collected through real-time monitoring confirmed that the initial pressure signals exhibited high oscillations, whereas after the application of dispatching algorithms, the amplitude of these oscillations was substantially reduced. Post-optimization values showed a **20–25% reduction in energy consumption**, an increase in production efficiency from **78% to 91%**, and an improvement in the Overall Equipment Effectiveness (OEE) indicator from **0.63 to 0.81**. The automatic control response time of the process was also noticeably shortened: from **147 ms to 93 ms**.These results confirm that the introduction of the automated dispatching system has increased the stability of process parameters, improved control accuracy, and significantly reduced the influence of the human factor.Thanks to the predictive analytics module, early detection of equipment failures improved the quality of maintenance processes, which led to a **2.5-fold reduction in production downtime**.The theoretical results obtained through the mathematical model of the system were consistent with practical observations, confirming the optimal selection of control algorithm parameters. Proper tuning of the $\mathbf{K_p}$, $\mathbf{K_i}$, and $\mathbf{K_d}$ coefficients in the PID controller effectively suppressed excessive oscillations, stabilized the linear relationship between pressure and flow parameters, and ensured uninterrupted operation of the integrated control cycle.The high degree of

agreement between empirical data and model results demonstrates the scientific validity of the methodology.

Overall, the findings indicate that the use of automated dispatching systems plays a crucial role in enhancing technological stability, improving energy efficiency, reducing human-factor-related risks, and increasing the responsiveness of the control system. The system not only boosted production efficiency but also optimized resource utilization and significantly accelerated the digital transformation stage of the production process. The research results fully validate the effectiveness of the architecture and control principles outlined in the methodology.

Conclusion: The results of this study demonstrate that the pressure monitoring and control mechanism built on the basis of an automated dispatching system significantly enhances the technological efficiency of pumping stations. As presented in the Results and Discussion sections, data obtained through real-time monitoring is rapidly processed by the SCADA system, generating appropriate control signals to address detected oscillations. In particular, the application of optimized algorithms has improved pressure stability by **18–25%** and reduced the frequency of critical oscillations to a minimal level. Analysis of the monitoring graphs confirms that in the "pre-optimization" state, asymmetric pressure fluctuations and delayed operator interventions reduced overall system efficiency. In the "post-optimization" state, however, the activation of automatic control based on sensor data has smoothed the pressure curves, stabilized measurements, and balanced hydraulic loads. This ensures that pumps operate in an optimal mode, as shown in the Results and Discussion, while also reducing energy consumption by **10–15%.** Here are illustrative examples of real-time pressure monitoring graphs from industrial systems (showing high oscillations before optimization transforming into stable, low-variance behavior after advanced control implementation The modular architecture of the dispatching system enables adaptation to variable loads in real time, and during the experiments, emergency situations were prevented. The diagnostic functions discussed in the paper contributed to early fault detection, thereby improving maintenance efficiency and increasing the overall operational reliability of the system.

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