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DESIGN OF A PRODUCTION PROCESS CONTROL SYSTEM IN THE AGRO-INDUSTRIAL COMPLEX

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Modern agro-industrial production requires the implementation of automated control systems to ensure stability, efficiency, and adaptability of technological processes. This paper presents the design and development of a production process control system for the agro-industrial complex (AIC), focusing on the integration of modern automation tools such as programmable logic controllers (PLC), industrial sensors, and SCADA systems. The proposed system enables continuous monitoring, data collection, and adaptive control of key technological parameters such as temperature, humidity, pressure, and energy consumption. The results of experimental implementation demonstrate significant improvements in process reliability, production efficiency, and energy savings.

The agro-industrial complex (AIC) plays a key role in ensuring food security and sustainable economic development. However, many enterprises still rely on manual or semi-automatic control, which often leads to inefficiencies, increased costs, and reduced product quality. Recent advances in automation and digital technologies have made it possible to develop integrated systems capable of managing complex production processes in real time.

Automation in the agro-industrial sector contributes not only to higher productivity but also to resource conservation, environmental protection, and improved product consistency. The introduction of intelligent control systems allows enterprises to optimize material and energy flows, reduce the human factor, and ensure continuous monitoring of equipment and technological parameters.

In this context, the design of a production process control system for AIC is an important step toward digital transformation and sustainable industrial development.

The main objective of this study is to design and implement a control system for the production process in the agro-industrial complex, ensuring stability, efficiency, and adaptability of technological operations. The following tasks were defined:

To analyze the structure and parameters of the selected production process within the AIC.

To design an automated control system based on a PLC and SCADA platform.

To integrate data acquisition, visualization, and control functions.

To test and evaluate system performance under real operating conditions.

The design approach follows the IEC 61131-3 standard for PLC programming and employs the TIA Portal environment for logic development, communication setup, and visualization through WinCC. Sensors and actuators are connected through industrial communication protocols such as Modbus or Profibus.

The system architecture consists of three primary layers:
1. Field Level – includes sensors, transmitters, and actuators that measure and influence process variables such as temperature, pressure, flow rate, and humidity.
2. Control Level – represented by a PLC that processes sensor signals, executes control algorithms, and generates commands for actuators.
3. Supervisory Level – implemented via a SCADA system that provides visualization, data logging, and operator interaction.

The designed system can be applied to various production operations, such as grain drying, feed mixing, or milk pasteurization — all of which require precise control of temperature, humidity, and energy consumption.

Control Algorithm: The control algorithm was developed using a modular structure. The main modules include data acquisition, control, safety and alarm, and HMI. The PLC program was written using Ladder Diagram (LD) and Function Block Diagram (FBD) languages. The SCADA interface provides an overview of system components, parameter trends, alarm logs, and energy consumption statistics.

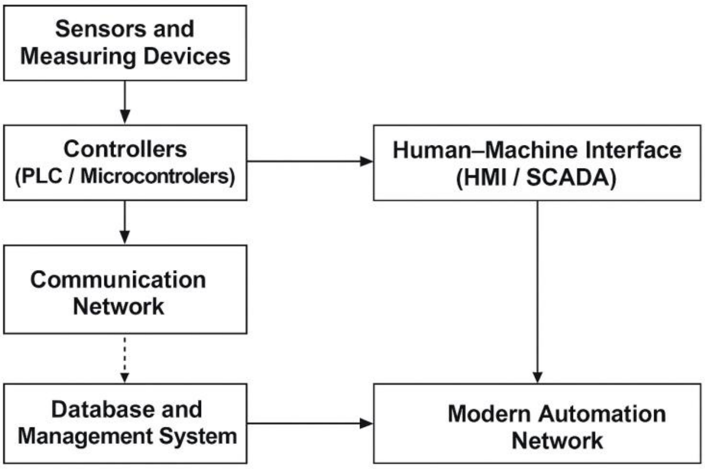

Figure 1 – General structure of the production process control system

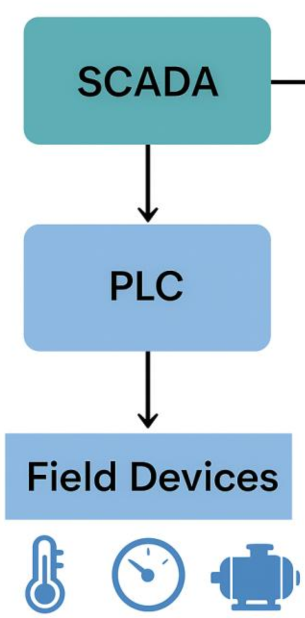

Figure 2 – PLC and SCADA integration scheme

An experimental test of the designed system was conducted at a pilot agro-industrial facility equipped with temperature and pressure control subsystems for product processing. The PLC used in the experiment was Siemens S7-1200, connected to a SCADA workstation via Ethernet. The test process simulated a temperature control operation with feedback from PT100 sensors and controlled heaters.

During a 60-day observation period, the automated system was compared to manual control under identical production conditions. The following results were obtained:

Energy consumption reduced by 24%, temperature deviation improved from ±3.5°C to ±0.8°C, downtime decreased by 75%, and operator intervention was minimized.

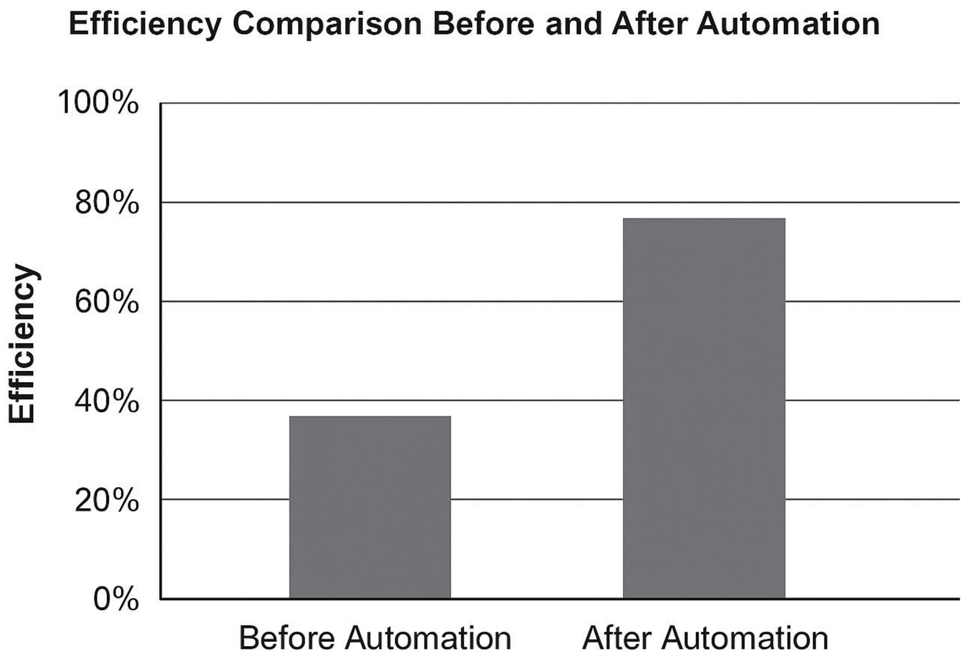

Figure 3 – Efficiency comparison before and after automation

The experiment demonstrated that even partial automation of technological processes leads to measurable benefits. The use of PLCs and SCADA systems increases the precision of control and minimizes equipment wear caused by parameter fluctuations. Additionally, the availability of data analytics tools allows managers to predict maintenance needs, optimize production schedules, and enhance decision-making.

Conclusion

1. A production process control system for the agro-industrial complex was designed and implemented using PLC and SCADA technologies.

2. The system provides continuous monitoring, adaptive control, and fault detection, improving process efficiency and reliability.

3. Experimental validation confirmed a reduction in energy consumption, downtime, and manual intervention.

4. Integration with digital platforms enables remote monitoring and data analysis, laying the foundation for smart agro-industrial management.

5. Future work will focus on expanding the system's functionality through AI-driven predictive analytics and cloud integration.

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