DOI 10.37539/2949-1991.2026.38.3.005
УДК 66.069

Ханбутаева Натаван Агадаи, Доцент,
Азербайджанский Государственный Университет
Нефти и Промышленности
Xanbutaeva Natavan Agadai, associate professor,
Azerbaijan State University of Oil and Industry

Эйюбов Эйюб Эльхан,
Азербайджанский Государственный Университет
Нефти и Промышленности
Eyyubov Eyyub Elkhan, master,
Azerbaijan State University of Oil and Industry

ИНФОРМАЦИОННЫЕ СИСТЕМЫ АВТОМАТИЗИРОВАННОГО КОНТРОЛЯ ПРОЦЕССОВ ПЕРЕРАБОТКИ УГЛЕВОДОРОДОВ
INFORMATION SYSTEMS FOR AUTOMATED MONITORING OF HYDROCARBON CONVERSION PROCESSES

Аннотация. В настоящее время для эффективного, безопасного управления и внедрения производственных процессов в промышленности необходимо использовать автоматизированные информационные системы, основанные на операционном анализе с мониторингом в реальном времени. Ненадлежащий контроль основных параметров, таких как температура, давление, расход и уровень жидкости, приводит к нежелательным последствиям, таким как нестабильность процесса, повышенное энергопотребление и низкое качество товарной продукции. В статье исследованы функциональные возможности автоматизированных информационных систем, их применение в мониторинге основных параметров. В рамках исследования проанализированы измерения производственных параметров, сбор данных и человеко-машинный интерфейс, а также системы управления на основе SCADA и ПЛК. После внедрения автоматизированных систем, таких как SCADA и ПЛК, зафиксированы повышение стабильности процесса, снижение энергопотребления и увеличение экономической эффективности. Исследование подтверждает важность и преимущества применения автоматизированных систем для оптимизации процессов переработки углеводородов.

Abstract. Currently, the efficient and safe control and implementation of industrial production processes require automated information systems based on operational analysis and real-time monitoring. Inadequate control of key parameters, such as temperature, pressure, flow rate, and liquid level, leads to undesirable consequences such as process instability, increased energy consumption, and poor product quality. This article examines the functionality of automated information systems and their application in monitoring key process parameters. The study analyzes production parameter measurements, data collection, and human-machine interfaces, as well as SCADA and PLC-based control systems. Implementation of automated systems such as SCADA and PLCs has resulted in improved process stability, reduced energy consumption, and increased cost efficiency. This study confirms the importance and benefits of using automated systems for optimizing hydrocarbon processing.

Ключевые слова: Переработка углеводородов, мониторинг, информационная система, оптимизация технологических параметров.

Keywords: Hydrocarbon processing, monitoring, information system, optimization of technological parameters.

Currently, the hydrocarbon processing sector accounts for the bulk of energy and petrochemical production. Hydrocarbon processing processes include distillation and pyrolysis, as well as complex operations in complex, multi-parameter systems. Effective control of these processes requires proper control of key process parameters, such as temperature, pressure, flow rate, and liquid level. Accurate monitoring and analysis of these process parameters in real time is achieved using automated information systems. However, due to the limited capabilities of the automated information systems currently used by most companies, optimal operation control becomes more complex, the stability of key parameters is disrupted, energy consumption increases, and production efficiency is reduced due to delays in operator decision-making. These negative consequences increase the importance of using information systems for monitoring and controlling technological processes [1-8].

The article essentially examines changes in process parameters resulting from the effective use of automated information systems in technological processes and assesses their impact on production optimization. The study confirms that the use of automated information systems leads to reduced energy consumption in the process, maintaining stability, and simultaneously increasing the economic efficiency of production.

The use of SCADA and PLC systems plays a crucial role in the proper monitoring and control of technological processes. However, the integrated management of the key process parameters of hydrocarbon processing has not yet been fully explored and understood. This gap addresses the main scientific problem of the study and increases the topic relevance.

Various hydrocarbon processing processes, such as distillation, pyrolysis, catalytic cracking, reforming, and others, comprise a system of technological operations involving several stages of physical and chemical transformations. For the stable, efficient, effective, and safe implementation of these processes, proper monitoring and control of the key process parameters is essential. Industrial enterprises currently use automated control systems to monitor these process parameters.

In technological processes, the main parameters are maintained constant, and the overall process regime is maintained. This is achieved by using sensors and transducers to measure temperature, pressure, flow, and liquid level. Physical parameters are measured and converted into electrical signals by the sensors, which are then fed into the automated control system. The measured data is processed by control devices to ensure optimal process operation.

Temperature has a direct impact on the kinetics of technological processes, as well as product quality, and is measured using thermocouples or resistance temperature detectors. Because thermocouples can operate at high temperatures, they are used in pyrolysis furnaces, while resistance temperature detectors are used in constant-temperature processes, such as distillation columns, due to their high measurement accuracy. Pressure is measured using pressure sensors and differential pressure sensors. The former converts the measured pressure into an electrical signal and transmits it to the control system, while the latter is used to determine the difference between two points. Mass, vortex, and differential flowmeters measure these parameters, ensuring process stability and material balance. As a substance flows through a pipeline, its total flow rate is determined by a mass flowmeter, while a differential pressure device measures the pressure difference created in the flow, and a vortex flowmeter determines the vortex frequency and measures the flow rate. The sensors used in the process are the primary source of data for the automated control system. The sensors monitor parameters in real time, detecting deviations and alerting operators. This improves process safety, ensures the required product quality, and utilizes energy resources more efficiently. During hydrocarbon processing, a microprocessor-based control device based on a programmable logic controller (PLC) is used to process data received from the production environment and simultaneously automatically control actuators. The structural elements of the PLC are shown in Figure 1.

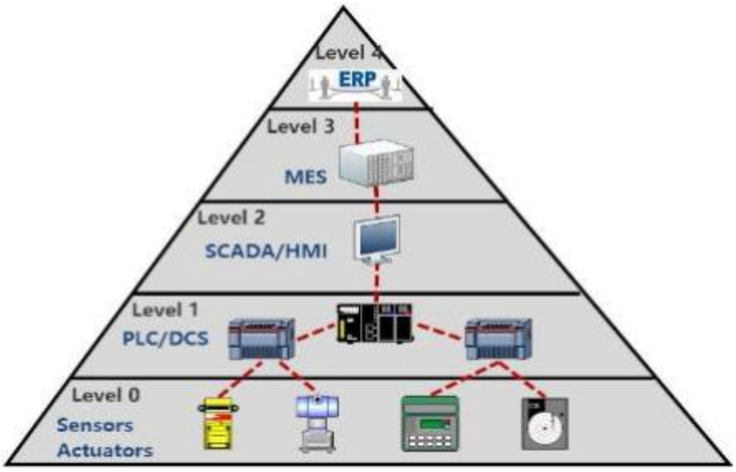

Figure 1. PLC structural elements

The structural elements of a PLC include a central processing unit (CPU), input modules, and output modules. Data transmitted from sensors is first processed, and then the signals are transmitted to actuators via the CPU. Analog or digital signals transmitted from sensors measuring physical parameters are received by input modules. Signals generated by the control system are transmitted to actuators via output modules. The transmitted signals are used to control valves, pumps, and some equipment. Processes in a PLC system are controlled using the control loop principle. The control loop consists of five main stages: data collection, signal transmission to the PLC, data processing, control signal generation, and actuator control.

In automated processes, a PID control algorithm is used as a control method. A control signal is generated by analyzing the difference between the actual practical and reference values of the parameter controlled by the PID controller. The PID control system consists of three main components: proportional, integral, and differential. PLC-based automation ensures stable operation of the hydrocarbon processing process, optimizes energy consumption, improves product quality, ensures production safety, and, most importantly, minimizes human error. Monitoring and visualization of PLC-controlled parameters are implemented in SCADA systems. An integrated flowchart of the combined operation of sensor, PLC, and SCADA systems is shown in Figure 2.

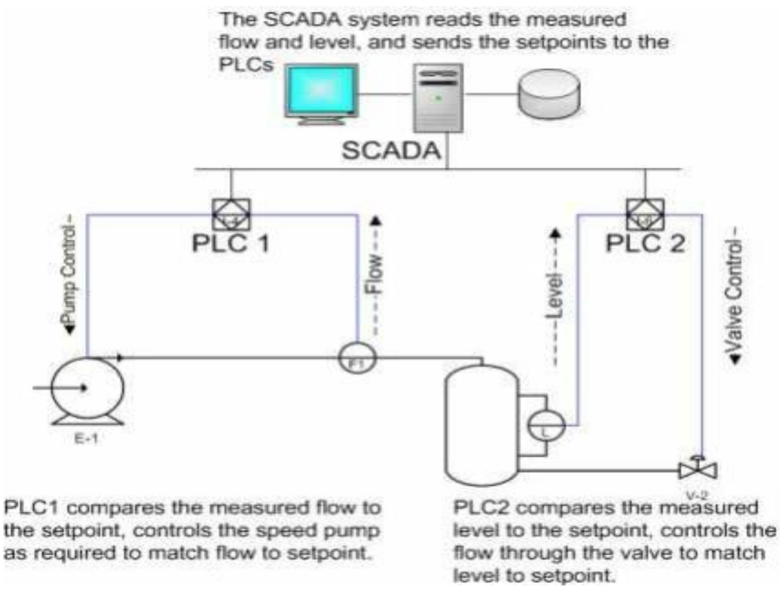

Figure 2. Block diagram of the sensor→PLC→SCADA connection

The SCADA system is used to visually display the current process status to the operator, monitor it, and analyze it. Key functions of this system include visual HMI monitoring, data logging and analysis, as well as a notification system and the ability to quickly intervene. The combined use of PLC and SCADA systems ensures the stability of hydrocarbon processing processes, reduces energy consumption, improves product quality, and, most importantly, minimizes potential accident risks. As part of the study, a model-based SCADA system was developed, with parameters transmitted via an OPC server. A graphical user subsystem was also implemented. Process parameters are monitored, controlled, and visualized graphically through this subsystem. The study concluded that the use of PLCs and SCADA systems is essential for optimizing production in technological processes.

References:

1. D. E. Seborg, T. F. Edgar, D. A. Mellichamp, F. J. Doyle. Process Dynamics and Control. 3rd ed. Hoboken: John Wiley Sons, 2017, 512 p.
2. C. D. Johnson. Industrial Automation and Process Control. London: Springer, 201.6, 410 p.
3. W. Bolton. Programmable Logic Controllers. 6-th ed. Oxford: Newnes (Elsevier), 2015, 336 p.
4. D. Bailey, E. Wright. Practical SCADA for Industry. Oxford: Newnes (Elsevier), 2016, 304 p.
5. W. L. Luyben, M. L. Luyben. Process Control: Modeling, Design, and Simulation. New York: McGraw-Hill Education, 2019, 480 p.
6. R. Singh. Sensors and Instrumentation in Process Industries. Cham: Springer, 2021, 350 p.
7. Safarova A.A., Melikov E.A., Magerramova T.M. Construction of a multi-connected control system for safe coke production. “Reliability: Theory and Applications”, Electronic Journal of International Group on Reliability Journal is Registered in the Library of the U.S. Congress, Special Issue, USA, No. 5 (75), Vol.18, pp. 510-517. https://doi.org/10.24412/1932-2321-2023-575-510-517
8. Safarova A.A., Melikov E.A, Magerramova T.M., Xanbutaeva N.A. Control algorithmization of complex technological systems under uncertainty conditions. IV International Conference on Digital Technologies, Optics, and Materials Science, Proceedings of SPIE, Vol. 13662, 1366204, 2025. https://doi.org/10.1117/12.3071739.