

DOI 10.37539/2949-1991.2026.37.2.020
УДК 66.069

Магеррамова Тамелла Мустафа, доцент,
Азербайджанский Государственный Университет
Нефти и Промышленности
Maharramova Tamella Mustafa, associate professor,
Azerbaijan State University of Oil and Industry

Амрахов Ислам Фатулла,
Азербайджанский Государственный Университет
Нефти и Промышленности
Amrahov Islam Fatulla, master,
Azerbaijan State University of Oil and Industry

**АВТОМАТИЗАЦИЯ ПРОЦЕССА В ПИРОЛИЗНЫХ
ПЕЧАХ ПРОИЗВОДСТВА ЭТИЛЕНА
AUTOMATION OF THE PROCESS IN PYROLYSIS
FURNACES FOR ETHYLENE PRODUCTION**

Аннотация. Статья посвящена изучению вопросов автоматизации процессов, происходящих в пиролизных печах технологической линии производства этилена, а также их оптимизации. Основным методом производства этилена в промышленном секторе является пиролиз легких и средних углеводородных фракций при высоких температурах. Основным аппаратом производства является пиролизная печь, в котором происходит процесс термического разложения. На основе полученной модели сформулирована и решена задача оптимизации. При эксплуатации пиролизной печи проблема коксования возникает из-за нестабильного контроля температурных интервалов, изменений в потоке углеводородного сырья, а также неправильного поддержания температурного режима. В настоящее время в промышленности автоматизация и регулирование процесса пиролиза и снижение коксования являются основными приоритетными задачами по их совершенствованию.

Abstract. This article examines the automation and optimization of processes occurring in pyrolysis furnaces in an ethylene production line. The primary method for producing ethylene in the industrial sector is the pyrolysis of light and medium hydrocarbon fractions at high temperatures. The main production apparatus is a pyrolysis furnace, in which the thermal decomposition process takes place. When operating a pyrolysis furnace, coking problems arise due to unstable temperature control, variations in the hydrocarbon feedstock flow, and improper temperature maintenance. Automation and control of the pyrolysis process and reducing coking are currently the top priorities for industrial improvement.

Ключевые слова: Производство этилена, пиролизная печь, автоматизация, управление процессом.

Keywords: Ethylene production, pyrolysis furnace, automation, process control.

In the petrochemical industry, which uses oil or natural gas as feedstock, the pyrolysis process is used to produce ethylene. The chemical bonds of the feedstock are thermally broken by heating with steam, releasing ethylene gas, which is fed to processing plants. Ethylene plays an indispensable role in the production of goods in high demand in everyday life [1-6].

Light and medium hydrocarbon compounds are used as feedstock. Temperature and pressure parameters for the pyrolysis process are appropriately selected within the range of 700-900°C at



atmospheric pressure. Thus, the process primarily produces ethylene and propylene. Along with the commodity product, byproducts containing large amounts of benzene, toluene, and xylene are obtained in liquid form. The amount of byproducts produced in the process is reduced by properly selecting the correct operating mode. In the pyrolysis furnace, naphtha, ethane, propane, or gas condensate fed to the unit are decomposed at the required temperature ranges and with a short residence time, resulting in ethylene production. Steam is introduced into the furnace during the process, resulting in increased product yield, a partial reduction in the amount of coke formed on the tube surfaces, and, most importantly, reaction kinetics optimization. Improved heat transfer between the tubes located within the apparatus and proper temperature control increase productivity, reduce energy consumption, and optimize reactor tube maintenance costs. Figure 1 shows the principal scheme of a pyrolysis furnace.

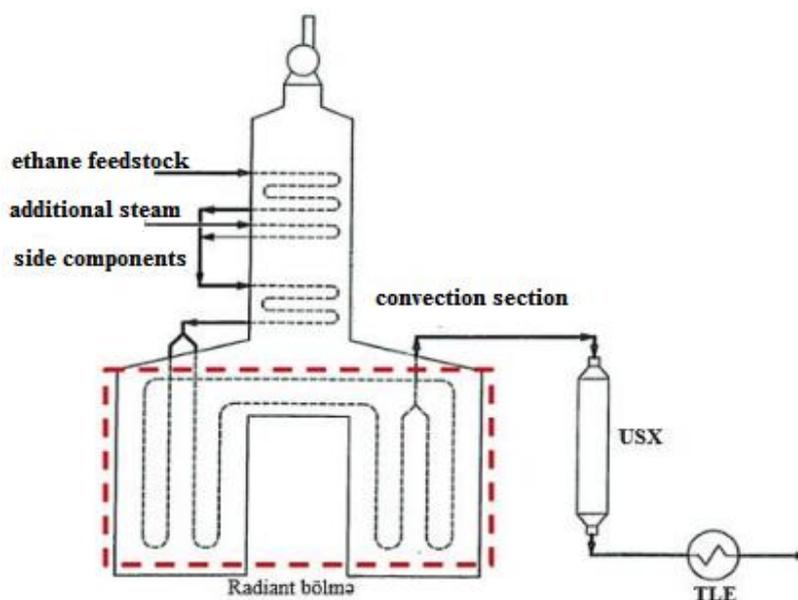


Figure 1. Principal scheme of a pyrolysis furnace

By controlling the temperature in the furnace's preheating, pyrolysis, and cooling zones, ethylene yield can be increased and the risk of coking reduced. A short residence time of 0.1-0.5 seconds allows the decomposition reaction to occur fully, preventing carbon deposits from forming inside the tubes. With the correct steam ratio, the rate of thermal decomposition of the compound molecules increases, the amount of coking decreases, and the product yield increases. The feedstock flow balances the production process. Carbon deposits forming on the pipes installed inside the pyrolysis furnace reflect coking. The resulting carbon deposits lead to increased maintenance costs, reduced equipment performance, and compromise the continuous process. For these reasons, the company has optimized key process parameters and uses a real-time monitoring system.

The main causes of coke formation include prolonged, uncontrolled storage at high temperatures and improper selection of parameters based on feedstock characteristics. The resulting coke layer causes piping constriction, preventing the process from flowing as intended, disrupting the furnace's temperature balance, and reducing product yield. PLC/SCADA systems are now used for automated control in accordance with industry standards. Thanks to the use of automated control systems, the pyrolysis furnace ensures long-term and safe operation. Before the experimental study, Figure 2 shows a graph of the furnace tube surface temperature versus time.



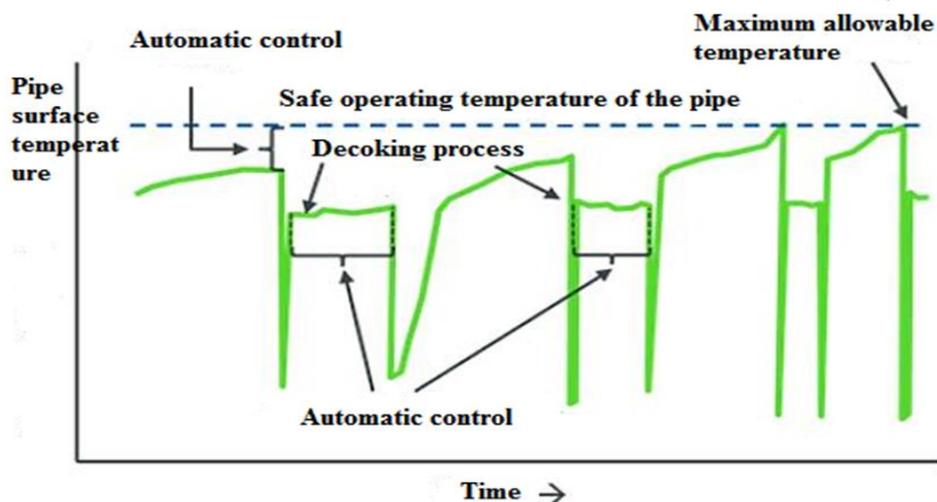


Figure 2. Graph of the furnace tube surface temperature versus time

Figure 3 shows a dependence graph of the pipe surface temperature on time after the automation system implementation.

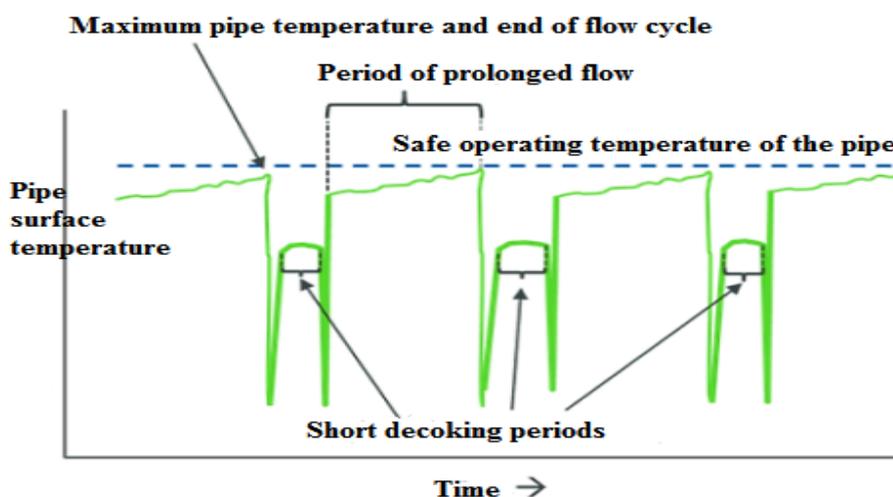


Figure 3. A dependence graph of the pipe surface temperature on time

A comparative analysis shows that after implementing the automation system, the furnace's operating time increases by 2-3 days, and productivity by 3-4%. The coke amount formed in the furnace decreases by 50-67%. Furthermore, it should be noted that the energy consumption during the process decreases by 0-2%.

Список литературы:

1. Emerson Electric. Ethylene Furnace Automation: Control and Optimization. Emerson Automation Experts, 2020.
2. Jim Cahill., Pete Sharpe. Ethylene Furnace Automation, Control & Optimization. Chemical, Industry, Services, Consulting & Training, Jan 23, 2020.
3. Melikov E.A. Modeling, algorithmization, and solution of the optimal control problem for the ethylene production complex under conditions of incomplete information. Nafta-Gaz, 2025, No. 5, pp. 359-369. <https://doi.org/10.18668/NG.2025.05.07>



4. 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, RISK-2023), Special Issue № 5 (75), vol.18, 2023, pp. 510-517. <https://doi.org/10.24412/1932-2321-2023-575-510-517>

5. Guseinov I.A., Kurbanov Z.G., Melikov E.A., Efendiev A.I., Efendiev I.R. Nonstationary Multistage Process Control in the Petrochemical Industry. Journal of Computer and Systems Sciences International, Pleiades Publishing, Ltd., 2014, Vol. 53, No. 4, pp. 556-564. <https://doi.org/10.1134/S1064230714030095>

6. Ibragimov I.A., Efendiyev I.R., Kopsitskiy V.T., Melikov E.A. Design principles of self-learning automatic-control systems for complex technological processes under conditions of information deficiency. Doklady akademii nauk SSSR, 320(6), 1991, pp. 1424-1427.

7. Guseinov I.A., Kurbanov Z.G., Melikov E.A., Efendiev A.I., Efendiev I.R. Nonstationary Multistage Process Control in the Petrochemical Industry. Journal of Computer and Systems Sciences International, Pleiades Publishing, Ltd., 2014, Vol. 53, No. 4, pp. 556-564. <https://doi.org/10.1134/S1064230714030095>

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>.

