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АВТОМАТИЗАЦИЯ ТЕХНОЛОГИЧЕСКОГО ПРОЦЕССА ПОЛУЧЕНИЯ КОКСА
AUTOMATION OF THE TECHNOLOGICAL COKE PRODUCTION PROCESS

Аннотация: В настоящее время нефтяная политика продвигается как насущная необходимость в нефтедобывающих странах. В этой связи, ускорение развития уровня экономики этих стран одновременно закладывает основу для снижения зависимости их от нефти в будущем. В таком случае правильная и рентабельная переработка добываемой сырой нефти является одним из важнейших и актуальных вопросов экономики. Улучшение качественных показателей нефтяных фракций и целевых нефтепродуктов с учетом энергоэффективности возможно непосредственно в результате оптимальной переработки добываемой нефти. Коксование превращает тяжелые остатки нефти, таких как гудрона, мазута и “смолистые” потоки от атмосферной и вакуумной перегонки в продукты с добавленной стоимостью с высокой степенью чистоты и прочности.

Abstract: At present, petroleum policy is promoted as a pressing need in oil-producing countries. In this regard, accelerating the level of development for these countries' economies simultaneously lays the foundation for reducing their dependence on oil in the future. In this case, the correct and profitable crude oil extraction is one of the most important and pressing economic problems. Improving the quality of oil fractions indicators and target oil products, taking into account energy efficiency, is possible directly as a result of optimal extracted oil processing. Coking converts heavy petroleum residues such as tar, mazut, and “resinous” streams from atmospheric and vacuum distillation into value-added products with high purity and strength.

Ключевые слова: замедленное коксование, целевые нефтепродукты, ректификация, математическая модель, оптимальное управление, технологический процесс.

Keywords: delayed coking, target oil products, rectification, mathematical model, optimal control, technological process.

Oil refining and petrochemistry, based on the products of oil and natural gas processing, are among the fastest-growing industries. Increasing production and improving the oil refining products quality is the most important problem for the scientific and technical complex of many countries [1-8]. In the context of the continuing increase in the oil refining share in the industry, such an important technological process as coking is acquiring ever-increasing importance [9].

During the coke production process, heavy petroleum products are used in unheated chambers. In addition to coke, the plant also produces coke benzine, dry gas, light gas oil, which is a heating oil component, heavy gas oil, which is a boiler fuel component, and stable liquid.

The rectification section of the delayed coking installation is single-flow, and the coke chamber is double-flow.

The delayed coking installation operates in the following modes:

1) continuous mode (due to the raw materials supply);

2) periodic operation mode (by unloading coke).

The main and technological parts of the investigated technological installation are as follows:

- raw material (tar) heating block;
- coking product rectification and raw material coking block;
- unit for collecting cooling products and blowing coke;
- benzine alkalization unit;
- light gas oil fraction alkalization block during coking;
- pump cooling block;
- heat and flue gas utilization unit for petroleum products;
- water preparation unit required for coke cutting;
- coke bunkers, green coke storage, coke transportation, its separation;
- storage unit.

The coking process of oil products is carried out in a delayed coking installation. The coking process, carried out in coke chambers at a pressure of 0.6 MPa (6 kg/sm^2) and a temperature of 450 ÷ 500°C, can also be called a thermal cracking process.

The coking process, which occurs by a radical mechanism, is a sequential-parallel reaction set. Oil product coking is a technically feasible and economically advantageous technological process that allows for increasing the depth of crude oil processing. In the coke production process, after many intermediate compounds, the final product is obtained, coke.

The main essence of the technological process under consideration is the coking process implementation by continuously feeding raw materials preheated to a temperature of 495 ÷ 520°C into coke chambers with external thermal insulation, thereby accumulating its heat. Heated light gas oil (515 ÷ 520°C) is injected into the chambers, which leads to the coking process completion.

The following operating parameters are maintained at most operating delayed coking technological installations:

- excess pressure (in the upper chamber part) 0.15 ÷ 0.4 MPa (1.5 ÷ 4.0 kg/sm^2);
- temperature of the processed raw material (at the furnace outlet) 495 ÷ 520°C;
- recirculation coefficient (1.2 ÷ 1.8).

An increase in temperature and pressure in the system, as well as the recirculation coefficient, leads to an increase in the yield of benzine, gas, coke, and light gas oil and a decrease in the heavy gas oil yield [4].

To implement the delayed coking process while maintaining minimal losses and efficiency indicators, automation equipment is used that meets international requirements and at the same time has a high accuracy class and short response time [3].

In general, control and measuring instruments are structures that directly or indirectly compare the measured value with the measurement parameter. To ensure simultaneous measurement and control of pressure, temperature, level, and flow at the delayed coking technological installation, high-quality and effective measuring instruments used in international practice are used. Based on statistical data obtained as a measurement result carried out using modern intellectual instruments, a mathematical model was constructed that reflects the dependence of the rectification column performance on the main input parameters of the apparatus. At the next stage, the coefficients for the mathematical model in the form of a regression equation are found using the Excel program [5].

As mentioned above, after finding the regression equation coefficients, the question of ensuring optimal functioning arises from the technological apparatus (column) that carries out the

rectification process. The optimal control system is defined as the system that operates most effectively at the selected point in time. The state is determined, which is obtained by adjusting the operating parameters of the control system based on specified regulatory restrictions. To do this, first of all, it is necessary to determine the optimality criterion, including economic or technical efficiency indicators of the constructed automated control system, which is an indicator of this system's efficiency. In this case, the objective function of the optimal control problem is the core for the selected optimality criterion.

In the presented study, the regression equation is adopted as the objective function. The objective function specifies the optimality criterion (light gas oil yield), as well as the dependence of its value on the independent output parameters of the problem that affects it. To solve the optimal control problem, the Mathcad software package was used, employing the optimal values of the input, output, and control parameters for the studied column, which carries out the rectification process, were calculated. As a result, the obtained optimal values are compared with the actual real values, reflecting the obtained solution effectiveness [2].

Taking into account all of the above, the optimal functioning of the column implementing the complex rectification process is ensured. As a solving result of the set optimal control problem for the studied technological apparatus, the efficiency and optimality of the process for secondary crude oil processing increases, quality indicators improve, delays in the control system are eliminated and losses of used energy, obtained intermediate and final oil products are reduced. Ensuring optimal productivity of the technological process of oil refining creates conditions for saving financial resources directed to this area of the industry.

Список литературы:

1. Melikov E.A., Maharramova T.M., Safarova A.A. Automation and control of the vacuum block. EPJ Web of Conferences (France), EDP Sciences – Web of Conferences, III International Conference on Advances in Applied Physics and Mathematics for Energy, Environment and Earth Science (AAPM-III 2025), vol. 318, 2025, 05009. https://doi.org/10.1051/epjconf/202531805009

2. Guseinov I.A., Khanbutaeva N.A., Melikov E.A., Efendiev I.R. Models and Algorithms for a Multilevel Control Systems of Primary Oil Refinery Installations. Journal of Computer and Systems Sciences International, Pleiades Publishing, Ltd., 2012, Vol. 51, No. 1, pp. 138–146. https://doi.org/10.1134/S1064230711060098

3. Melikov E.A., Maharramova T.M., Safarova A.A. Control problem for a vacuum technologıcal complex. Eurasıan Physıcal Technıcal Journal, Publisher: Karaganda University named after Academician E.A. Buketov, Vol. 21, No. 4 (50), 2024, pp. 71-78. https://doi.org/10.31489/2024No4/71-78

4. Safarova A.A., Melikov E.A, Magerramova T.M. Control of a tube furnace in conditions of risk and increased explosion hazard. Reliability: Theory and Applications, Electronic Journal of International Group on Reliability Journal is Registered in the Library of the U.S. Congress, Spesial Issue, USA (The 4-th Eurasian Conference and Satellite Symposium, RISK-2022, Baku, Azerbaijan), 17 (SI 4 (70)), 2022, pp. 516-521. https://doi.org/10.24412/1932-2321-2022-470-516-521

5. Safarova A.A., Melikov E.A., Magerramova T.M. Features of modelling in automation for the primary oil refining technological process, Proc. SPIE 13217, Third International Conference on Digital Technologies, Optics, and Materials Science (DTIEE 2024), 132170M (31 July 2024). https://doi.org/10.1117/12.3035889

6. Melikov E.A. Principles of optimizing the control of propylene purification process from acetylene derivatives. Proceedings of the 7th International Conference on Control and Optimization with İndustrial Applications, Vol. II, 26-28 August, 2020, Baku, Azerbaijan, pp. 272-275.

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. Principles of modeling and optimal control of a fraction purification reactor from micro impurities, III International scientific and practical conference "Technologies, materials science and engineering" (EEA-III-2024), AIP Conference Proceedings, 2024, 3243, 020014.

https://doi.org/10.1063/5.0247869

9. Safarova A.A., Melikov E.A., Magerramova T.M. Constructıon of a multı-connected control system for safe coke productıon. "Reliability: Theory and Applications", Electronic Journal of International Group on Reliability Journal is Registered in the Library of the U.S. Congress, USA. The 5-th Eurasian Conference and Satellite Symposium, RISK-2023), Special Issue № 5 (75), vol.18, 2023, pp. 510-517. https://doi.org/10.24412/1932-2321-2023-575-510-517