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АВТОМАТИЗАЦИЯ ТЕХНОЛОГИЧЕСКОГО ПРОЦЕССА КАТАЛИТИЧЕСКОГО КРЕКИНГА
AUTOMATION OF THE CATALYTIC CRACKING PROCESS

Аннотация: В настоящее время, во многих странах выдвигается постнефтяная политика, которая закладывает основу для существенного ускорения развития мировой экономики и одновременного снижения зависимости от нефти. Однако эффективная переработка сырой нефти остается актуальным вопросом. Повышение качества нефтепродуктов с учетом энергоэффективности возможно в результате полезной переработки нефти. В связи с этим, в предлагаемой статье на основе всестороннего изучения особенностей исследуемого процесса уделяется важное значение вопросам автоматизации и управления технологическим процессом каталитического риформинга.

Abstract: Currently, many countries are putting forward post-oil policies that lay the foundation for a significant acceleration of global economic development while reducing dependence on oil. However, efficient crude oil processing remains a pressing issue. Useful oil processing can improve the quality of petroleum products while preserving energy efficiency. In this regard, the proposed article, based on a comprehensive study of the process features under investigation, places great importance on the issues of automation and control for the catalytic cracking technological process.

Ключевые слова: каталитический крекинг, оптимальное управление, математическая модель, технологический процесс, переработка нефти, ректификация.

Keywords: catalytic cracking, optimal control, mathematical model, technological process, oil refining, rectification.

It is known crude oil refining is the process of producing petroleum products, primarily various types of fuel (automotive, aviation, boiler, etc.) and raw materials for subsequent chemical processing from oil [1-7]. Among the secondary methods of oil refining, hydrocarbon cracking is of great importance [8]. It is carried out to increase the gasoline yield (up to 65÷70%).

Cracking is a very complex process in which decomposition, polymerization, dehydrogenation, isomerization, and other processes occur simultaneously. Catalytic cracking carried out using zeolite and aluminosilicate catalysts, has become widely used in the oil refining industry. Catalytic cracking installations are often combined with various other installations. Such installations have sections for gas fractionation and product rectification obtained as a result of the cracking process. At enterprises of this type, raw materials hydrotreating primarily increases the output of products and reduces the amount of coke. This process ensures further oil purification. The main purpose of catalytic cracking is to obtain high-quality, clean gasoline with a high-octane number of 90÷92. As a result, a certain hydrocarbon amount is obtained from the gas containing the butylene fraction. At the same time, the isobutane hydrocarbon is also present in a certain amount in the fraction. For this reason, the fraction in question, as a component with a high-octane number, is considered a valuable raw material for obtaining alkylate.

Several process installations are implementing the catalytic cracking process, the most widely used of which is the Q43-103 installation. At the initial stage, the feedstock enters the hydrotreating installation for stabilization, and then, after certain processes have taken place there, it is heated in a furnace to remove light fractions and fed to a heater. The feedstock fed to the reactor reacts with the catalyst and steam for a very short time. The resulting product is pumped to a rectification column, where various products are obtained at several levels. Steam and sludge are removed from this column, and heavy and light gas oil products are obtained by passing through an additional evaporator. To maintain minimum losses and performance indicators of the catalytic cracking process, automation equipment that meets international requirements, as well as having a high accuracy class and short response time, is used.

In general, measuring instruments are structures that directly or indirectly compare the measured unit with the measurement parameter. In the considered object of study, high-quality, internationally recognized, and cost-effective instruments were used to measure pressure, temperature, level, and flow. Based on the data obtained as a measurement result carried out using these instruments, a mathematical model was constructed that reflects the dependence of the rectification column productivity on the input values. In the next stage, the regression equation coefficients are calculated using Excel or MATLAB software. The system that operates most efficiently for the technological apparatus in question is defined as the optimal system. The resulting situation of the functioning for the developed control system is regulated on the basis of the restrictions set on the main technological parameters. Ultimately, it is necessary to determine the optimality criterion, including economic or technical indicators of the developed system efficiency. The objective function specifies the optimality criterion, as well as the dependence of its value on the influencing technological parameters. As a result of using the Mathcad software, optimal values for the output parameters of the column implementing the rectification process were obtained. Then, the optimal values of the parameters obtained at the apparatus output are compared with the setting influences.

There are many complex factors in the control catalytic cracking stage, which is responsible for the production of benzine with high octane numbers, and they are presented below:

• non-linear nature of the existing process;
• time constants differ in different subsystems;
• presence of many uncontrolled variables;
• the controlled object is directly related to each other by significantly intersecting different nature relationships.

In any type of catalytic cracking technological process, there are three main functions:

1. Reaction. This is the process of splitting the feedstock into various hydrocarbon types as an interaction result of the catalyst solution with the feedstock;

2. Regeneration. This is the process of restoring the catalyst solution as a result of using the coke-burning method;

3. Fractionation. Here, various types of products are obtained from the streams consisting of cracked hydrocarbons.

In general, from a design and functional point of view, it can be noted that the catalytic cracking technological installation consists of two important sections: 1) reactor; 2) regenerator.

The main functional center of the installation is the reactor, which performs the following functions: the feedstock passes through a heating apparatus, combines with a catalyst solution, and enters a vertical pipe. The mixture of feedstock and catalyst solution is introduced into the lower part of the tank through the above-mentioned pipe. The residence time of the mixture in the reactor is minimal, in other words, this reaction occurs instantly. Another main function of the reactor is to remove hydrocarbons from catalyst solutions. During the entire process, coke absorption is observed in the catalyst solution, which leads to a decrease in the catalyst activity itself. To prevent a reverse reaction, this catalyst is sent to a specially designed apparatus called a regenerator. In this section, air heated to a temperature of 600 combines with the catalyst, which has lost a certain part of its properties. As this process results, the catalyst solution, which has been negatively affected by coke, is cleaned and restored. At the next stage, the hydrocarbon mixture released from the reactor is sent to a column where the rectification process takes place. In this section, the incoming product is separated into the following fractions: hydrocarbon gas (C4), benzine, light cracking gas oil, heavy cracking gas oil, circulating gas oil.

Taking into account all of the above, the optimal functioning of the column implementing the rectification process is ensured. The solution to the problem under study is implemented with the aim of improving the quality indicators for the technological process of refining crude oil, increasing efficiency, and reducing losses as a result of the process under consideration, as well as eliminating existing delays in the automated control system. Thus, the search and optimal indicators provision in the refining process of crude oil creates conditions for saving financial resources directed to such an important area and reducing the burden on the state budget in this area.

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