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АВТОМАТИЗАЦИЯ ПРОЦЕССА ОЧИСТКИ ОРГАНИЧЕСКИХ КИСЛОТ
AUTOMATION OF ORGANIC ACIDS PURIFICATION PROCESS

Аннотация: Понимание процессов образования органических кислот в нефтепродуктах важно для повышения эффективности методов очистки и их автоматизации. Присутствие органических кислот оказывает отрицательное воздействие на нефтепродукты. Кислоты вызывают коррозию трубопроводов, сокращают срок хранения продукта и ухудшают его качество. В связи с этим, процессы очистки считаются необходимыми как для поддержания качества продукции, так и для защиты окружающей среды. Основной целью процессов нефтепереработки является получение высококачественных и стабильных нефтепродуктов. Для этого исследуются, оптимизируются и эффективно внедряются различные методы очистки с помощью систем управления.

Abstract: Understanding the processes of organic acid formation in petroleum products is important for improving the efficiency of purification methods and their automation. The presence of organic acids negatively impacts petroleum products. Acids cause pipeline corrosion, reduce the shelf life of products, and degrade their quality. Because of these effects, refining processes are considered necessary both to maintain product quality and to protect the environment. The main goal of refining processes is to produce high-quality and stable petroleum products. To this end, various cleaning methods are researched, optimized, and effectively implemented using modern control systems.

Ключевые слова: органическая кислота, система управления, оптимальное управление, процесс очистки, алгоритм процесса.

Keywords: organic acid, control system, optimal control, purification process, process algorithm.

It is known that oil extracted from the earth's interior is accompanied by water formation saturated with salts such as chlorides, sulfates, and carbonates, as well as sodium, calcium, and magnesium ions. These impurities can make up to 30% of the oil extracted volume. Therefore, no large oil field or oil refinery can do without an electrical desalting installation that purifies oil from water and salts [1-7].

Petroleum products contain a wide range of organic acids, the most common of which are petroleum acids, carboxylic acids derived from olefins, and similar compounds. Organic acids increase the risk of corrosion, negatively affect petroleum product's quality, and make them unsuitable for consumer use. Corrosion problems caused by organic acids cause serious damage to infrastructure. Pipeline corrosion, storage tanks, and other petroleum infrastructure increase operating costs and safety risks. For this reason, substances that slow down or completely stop certain chemical reactions are used to prevent corrosion. In this case, various analysis methods are used to determine the organic acids level. These methods include pH testing and acid number measurement, which help ensure the effectiveness of the cleaning processes.

The automated control system for organic acid purification allows the process to be carried out under full control. The operating principle of the control system is mainly divided into several stages:

- at the first stage, the acidity level of the oil product and other indicators are monitored using sensors. These indicators are collected and analyzed by the PLC. If the indicators do not correspond to the established limits, the PLC automatically intervenes in the process, increasing or decreasing the cleaning process intensity;

- in the second stage, when the acid level is high, the PLC sends a signal to the actuators and activates the adding neutralizing chemicals process. This process reduces the acid amount and returns the product quality to normal;

- the third stage provides centralized data management via the control system. The control interface allows the operator to monitor the purification process and intervene if necessary. When the process is complete and the technological parameters are within normal limits, the PLC completes the process by sending final commands to the actuators.

The automated control system increases the efficiency and precision of the purification process, thus ensuring product quality and reducing energy consumption. Data collection and processing in an automated control system is one of the most important parts of this process. The data collected by the sensors is transferred to the PLC, where it is analyzed and the necessary commands are issued. Among this information, parameters such as temperature, acidity level, and pH value play a key role. The collected data enables continuous monitoring of the purification processes and, if necessary, intervention in the cleaning process in real-time. The control system processes this data to monitor product quality indicators and ensure process efficiency. By collecting and processing data, optimal process control is ensured, any changes are immediately eliminated and the purification process continues without interruption. This allows for both maintaining product quality and reducing operating costs.

When setting up the system, the critical points of the oil refining process are first identified and the corresponding sensors are installed at each point. These sensors measure parameters such as acid level, temperature, and pH at each stage and transmit the data to the control system. Based on this data, the system fully monitors the refining process and allows for maintaining product quality. This structure ensures the safe, accurate, and uninterrupted system operation. During control system operation, maximum and minimum temperature values, pH values, and acidity levels may vary depending on the type of oil refining process, the technology used, and the process requirements. Below are the approximate maximum and minimum values for these technological parameters:

1. Temperature. In the process of refining oil products, temperature directly affects the chemical reactions speed and the product quality. Too low or too high temperatures can reduce the reactions efficiency or the refining process. Minimum temperature: 20°C÷25°C. Maximum temperature: 150°C÷180°C.

2. pH value. The pH value indicates the acidity or alkalinity of the petroleum product. The pH value is very important for petroleum products because high acidity (low pH) can adversely affect the product quality and cause corrosion. Minimum pH: 3-4. Maximum pH: 9-10.

3. Acidity level. The acidity level shows how much acid is contained in the oil product. This is one of the main indicators for oil purification during the oil refining process. High organic acids content reduces the product quality. Minimum acidity level: 0. Maximum acidity level: 0.2-0.5.

When developing a control system, it is important to define these parameters as the system's regulation limits to ensure the efficiency and safety of the process. Software and algorithms are of particular importance for the purification process automation. Figure 1 shows a block scheme of the control algorithm for cleaning oil products from organic acids.

In the first stage, sensors measure the petroleum products parameters and transmit them to the PLC, which analyzes this data. If the acidity level or other indicators exceed the established limits, the PLC determines intervention measures depending on the situation.

In the second stage, the PLC activates the chemical neutralization process by activating actuators, the necessary reagents are added to the technological process, and the acid level returns to normal.

In the third stage, the data provided by the PLC is collected and controlled centrally via the automated control system. Operators are allowed to intervene if necessary. These stages guarantee the continuity and accuracy of the cleaning process.

Thanks to the algorithm presented, all necessary stages of the cleaning process

are carried out consistently and efficiently. Changes are automatically made in real- time using the software, which optimizes the process and maintains product quality.

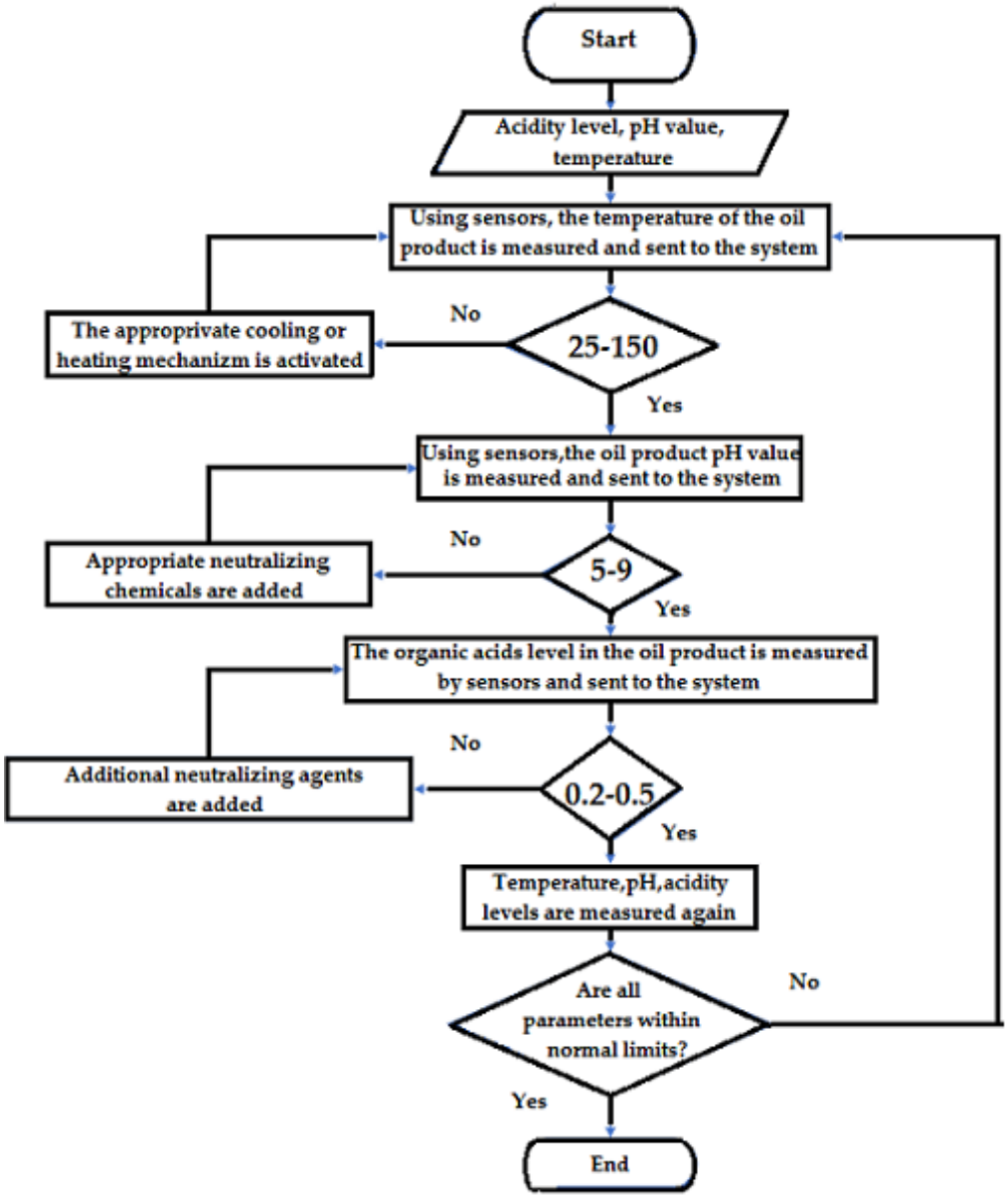

Figure 1. Block scheme of the control algorithm for cleaning petroleum products

Accurate acid quantity determination is essential for effective refining process control. At the process beginning, the acidity level of the petroleum product is measured using special analysis methods. As these analyses result, the initial product parameters are determined and the required process parameters are set. The acid content determination is made based on the chemical acids composition, the pH value, and the physical properties of the product.

The start and end points of the process are automatically set by the PLC system. At the initial stage, the product enters the purification process and all indicators are recorded by sensors. At the final stage, the purified product is re-analyzed and based on the results, a decision is made to terminate the process. If the product characteristics are within the norm after purification, the PLC completes the process and the product is prepared for the next stage. Automatic intervention operations are necessary for safe and accurate process execution. The system automatically monitors process parameters and intervenes in case of deviations from the norm. When the acid level exceeds the set limit, the PLC sends a signal to the actuators to add neutralizing agents, thereby reducing the acid amount. This automatic operation type ensures high efficiency of the purification process and eliminates any negative impact on product quality.

Список литературы:

1. 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

2. 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

3. Melikov E.A., Xanbutayeva, N.A. Algorithm optimization static rejimes installation of primary oil refining. National Science Review, Chinese Academy of Sciences, Oxford University Press, 2017, Vol. 4, No. 4 (2), pp. 1459-1466.

4. Hasanov Kh., Melikov E.A. Increasing the extraction of vacuum gas oil at the ELOU-AVT unit. Proceedings of Azerbaijan High Technical Educational Institutions (PAHTEI). Multidisciplinary Journal, Refereed & Reviewed Journal, 2023, Vol. 35 No. 12, pp. 251-257. https://doi.org/10.36962/PAHTEI35122023-251

5. 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", 2024, AIP Conference Proceedings, 3243, 020014. https://doi.org/10.1063/5.0247869