RESEARCH ON DIFFERENCE IN THE GROUP AND STRUCTURAL-GROUP COMPOSITION OF VACUUM GAS OIL BEFORE AND AFTER HYDROTREATING

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The growth in consumption of petroleum oil products, as well as the depletion of oil fields, is bringing the era of «light oil» closer to the end. Today heavy oil, which is characterized by a high content of sulfur and asphalt-resin compounds, acts as an alternative resource. As a result, oil refining companies are faced with the task of increasing the depth of oil refining [1]. At the same time, there is a tightening of requirements for the quality of fuels and for its environmental properties, described in the regulations of the Russian Federation «On requirements for the motor gasoline and aviation motor gasoline, diesel and marine fuels, jet engine fuel and black oil fuel» [3]. One of the main oil recycling processes is catalytic cracking, which makes it possible to obtain liquefied petroleum gas, high-quality fuel components (diesel, gasoline) and heavy gas oil. The feedstock for thermal catalytic processing is heavy vacuum gas oil containing heteroatomic compounds (sulfur, oxygen, nitrogen) and some metals. Therefore, in order to improve the performance of motor fuel components, as well as to reduce the formation of coke on catalysts and the content of sulfur oxides in the flue gases of the regenerator, catalytic cracking feedstock is often subjected to preliminary hydrotreatment.

The process of preliminary hydrotreatment of vacuum gas oil is carried out at high temperature and pressure in a hydrogen environment using a bifunctional catalyst. In reactors on a catalyst, hydrogenation of heteroatomic compounds occurs, with the formation of volatile sulfur, nitrogen, oxygen-containing compounds (hydrogen sulfide, ammonia, water), saturation of olefins and aromatic structures.

The quality, in particular, the group composition of feedstock is one of the main factors affecting the quality and yields of target cracking products [3].

A favorable feedstock for catalytic cracking in terms of the yield of target products (gasoline and liquefied petroleum gases) is a feedstock with a predominance of paraffinic and cyclane hydrocarbons. Polycyclic arenas and resins under cracking conditions produce little gasoline and a lot of heavy fractions and coke. Sulfur compounds of the same type of chemical composition of feedstock do not significantly affect the material balance of catalytic cracking, but worsen the quality of the products. However, it should be noted that with an increase in the content of heteroorganic compounds in the feedstock, as a rule, the content of polycyclic hydrocarbons and resins in it also increases.

The aim of this work is research on difference in the group and structural-group composition of vacuum gas oil before and after hydrotreating.

The analysis of the group composition of vacuum gas oil from the hydrotreating unit was carried out using the «Gradient M» chromatograph and the quantitative content of hydrocarbons of various classes was determined, such as saturated (paraffins and naphthenes), aromatic (light, medium and heavy) and resins (benzene and alcohol-benzene) (Table 1).

Table 1

Group composition of vacuum gas oil before and after hydrotreating

Group composition, % wt	Feed		Product	
	№1	№2	№1	№2
Saturated hydrocarbons	54,8	57	69,7	68,7
Light aromatic hydrocarbons	10,2	11,4	16,2	15,9
Medium aromatic hydrocarbons	7,5	6,8	4,9	5,2
Heavy aromatic hydrocarbons	20,2	19,1	7,4	8,1
Benzene resins	2,3	2,3	0,6	1,8
Alcohol-benzene resins	4,9	2,5	1,2	0,3

Vacuum gas oil before hydrotreatment is characterized by a high content of aromatic compounds (37,3-37,9 % wt) and resins (4,8-7,2 % wt), while the mass fraction of polyaromatic hydrocarbons is 19,1-20,2 % wt. The content of saturated hydrocarbons is 54,8-57 % wt. As a result of hydrotreatment, the group hydrocarbon composition of vacuum gas oil changes towards an increase in the content of saturated hydrocarbons and amounts to 68,7-69,7 % wt, a decrease in the content of aromatic hydrocarbons – 28,5-29,2 % wt and resins – 1,8-2,1 % wt. It should be noted that the saturation of polycyclic aromatic hydrocarbon compounds as a result of hydrotreating (mass fraction decreased to 7,4-8,1 % wt) increases their crackability and conversion. Thus, preliminary hydrotreatment of vacuum gas oil significantly improves the characteristics of the feedstock, which will undoubtedly lead to higher yields of the target products.

For the structural-group analysis of oil fractions with a boiling point above 220 °C, the n-d-M method is used. The number of rings and carbon content in the various structural groups that make up the "average molecule" are calculated using formulas and nomograms based on the values of specific refraction, density and molecular weight. The results of determining the structural-group composition of vacuum gas oil are shown in Table 2.

Table 2

Results of calculation of the structural-group composition of vacuum gas oil

Group composition, wt.%	Feed		Product	
	№1	№2	№1	№2
Content of carbon in aromatic structures	23,022	22,448	15,813	17,322
Content of carbon in naphthenic structures	17,569	18,247	22,877	20,907
Content of carbon in paraffinic structures	59,409	59,305	61,310	61,771
Number of aromatic rings	0,937	0,912	0,748	0,790
Number of naphthenic rings	0,983	1,008	1,540	1,372
Total number of rings	1,92	1,92	2,288	2,162

From the obtained results that the number of rings in the vacuum gas oil is 1,92 wt. %, the carbon content in the paraffin and naphthenic structures is 59,305-59,409 wt. % and 17,569-18,247 wt. %, respectively. As a result of hydrotreatment, the composition of vacuum gas oil changes towards an increase in the carbon content in alkane (61,310-61,771 wt. %) and cycloalkane structures (20,907-22,887 wt. %), the proportion of carbon in aromatic structures decreases, which is associated with the reactions of saturation of olefins and benzene rings with hydrogen. The average number of arene rings in the fraction decreases, while the average number of naphthenic rings, on the contrary, increases.

The obtained data will be used in the development of a mathematical model that will allow choosing the optimal process parameters and deepening the vacuum gas oil hydrotreatment.

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HIGH-VISCOSITY OIL EXTRACTION USING DOWNHOLE STEAM GENERATOR

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Nowadays, there is a problem of field development, the operation of which is impossible using the existing methods and equipment. Such fields are called shale or hard-to-recover fields. Traditional oil reserves are lowering, therefore, the need for the development of technologies, allowing to extract the hard-to-recover oil is gradually increasing [1].

The Krasnoyarsk Territory, for instance, has a huge number of oil fields, some of which are related to the general group – Vankor cluster. This cluster consists of 4 fields – Vankorskoe, Suzunskoe, Tagulskoe and Lodochnoe. The geological structure of them is very similar, but the Tagulskoye field in terms of the physical and chemical composition of oil is different.

Viscosity is the most important technological characteristic that determines the mobility of oil in layer conditions, which has a significant impact on the methods of oil production. The question of high-viscosity oil extraction at the Tagulskoe field remains open today: effective methods and technologies have not been determined for the extraction of such oil; solutions for uninterrupted production of hard-to-recover oil have not been implemented. An analytical review of modern scientific and technical literature and an analysis of existing methods for the production of high viscosity oil made it possible to draw a conclusion about the relevance of the problem under consideration [2].

The purpose of this work is to develop equipment that allows to extract high viscosity oil more efficiently, environmentally safely and cost-effectively, as well as to think over the ways of using this equipment in the production process.