FORECASTING INDICATORS OF THE FLUID CATALYTIC CRACKING PROCESS OF VACUUM GAS OIL WITH THE INVOLVEMENT OF DIFFERENT RATIOS OF SELECTIVE OIL EXTRACT

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With a lot of low-grade heavy oil products such as lubricating oil distillates, atmospheric gas oils, coking gas oils, residues from the hydrocracking process, paraffin wax, deasphalted oil residues, and selective oil extracts from primary and secondary refining oil processes, refineries are faced with the question of what to do with these products. Co-processing these low-grade products with vacuum gasoil oil with a boiling point of 370–540 °C at the fluid catalytic cracking unit (FCC) will not only reduce waste at refineries but also increase the raw material base of the FCC as well as reduce the cost of purchasing oil, which is up to 85–95% of all refinery costs [1]. A thorough physicochemical and techno-economic analysis of the mixed feedstocks is a more efficient technique to optimize the refining process.

In this article, we forecast important indicators of the FCC process of vacuum gas oil (Feed#1) with the involvement of different ratios of selective oil extracts (5 %, 10 %, and 20 % for Feed#2–4, respectively). These indicators tend to influence the process parameters as well as affect the product yields. They include the hydrocarbon chemical composition (saturates, aromatics, and resins) determined by the methods of liquid adsorption chromatography with gradient displacement on the device "Gradient-M" using ASKG silica gel as the stationary phase, other physicochemical properties (molecular mass, refractive index, sulfur content, and density determined by GOST 9300-85, p. 2.2.3.2), and material balance. The results of the physicochemical analysis of the feedstocks are presented in Table 1.

Furthermore, we applied a complex mathematical model [2] to forecast the effects of the changes in the feedstock composition on the product yields at the studied FCC unit of which the results are shown in Figure. 1.

For the FCC unit under study, we fixed the catalyst-to-feedstock ratio at 6.3, the feedstock and slurry flowrate at 240 and 9.35 m^3/hr, respectively, and the cracking temperature at 522 °C. The model application shows that Feed#1 yielded the maximum amount of gasoline, PPF, and BFF, which correspond to 54.9, 4.2, and 5.0 wt %, respectively (Fig. 1a), and this is due to its high content of saturates. However, it has the lowest RON (92 units), which can be explained by its low aromatic content compared to Feed#2–4. As the selective oil extract ratios increased in the mixed feedstock Feed#2–4, there was a slight decrease in the gasoline (54.4, 53.1, and 51.2 wt %), PPF (4.1, 3.9, and 3.6 wt %), and BBF (4.9, 4.6, and 4.3 wt %) yields, respectively, and this is due to the decrease in its saturates content. Meanwhile, as the aromatic content increased, so did the RON (92.2, 93, and 93.6 units).

Feed#1–4 contain a significant amount of resins (over 6 wt %), which have a high propensity for coke formation and easily deactivate the catalyst as well as disrupt the heat balance of the process. While the coke yield (7.1–8.2 wt %) and coke on the catalyst increased (1.13–1.3 wt %) with increasing resin content, the catalyst activity decreased (41.1–

Table 1. Results of laboratory studies of FCC feedstocks

Properties/Feed composition	Feed#1	Feed#2 5 %	Feed#3 10 %	Feed#4 20 %
Density 20 °C, g/cm^3	0.9107	0.9121	0.9149	0.9209
Molecular weight, g/mol	377.6	351.76	358.89	363.6
Sulfur, wt %	0.9655	1.022	1.022	1.101
Refractive index 20 °C	1.5098	1.5126	1.5145	1.5179
Saturates, wt %	61.0	60.0	56.8	53.6
Aromatics, wt %	32.9	33.7	36.4	38.7
Resins, wt %	6.1	6.3	6.85	7.7

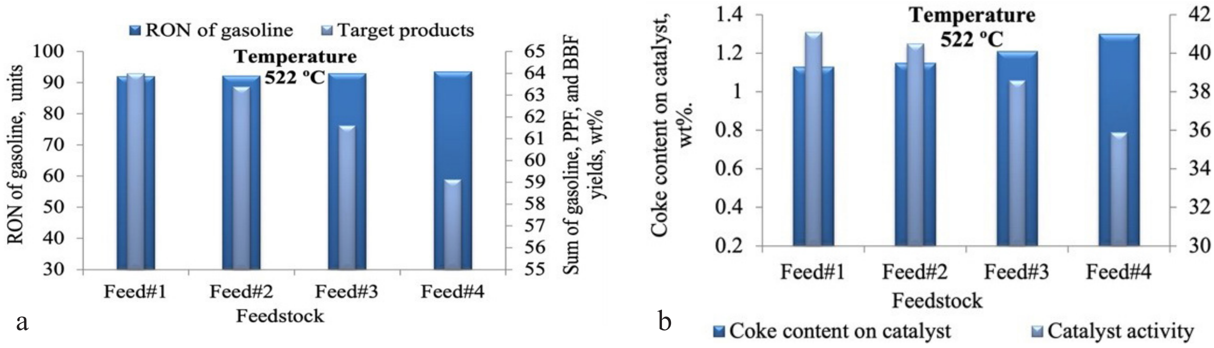

Fig. 1. *Effects of the changes in the feedstock composition on (a) RON of gasoline, sum of gasoline, PPF, and BBF yields (b) coke content on the catalyst and catalyst activity*

35.9 %) for Feed#1–4 as seen in Fig. 1b. In conclusion, physicochemical properties of feedstocks, particularly their SAR contents when heavy oil fractions such as extracts are involved, are a more efficient technique to forecast techno-economic parameters to optimize the FCC process.

References

1. *Chernysheva E. A., Piskunov I. V., & Kapustin V. M. // Pet. Chem. 60, 1–15 (2020). https://doi.org/10.1134/S0965544120010053.*
2. *Nazarova G., Ivashkina E., Ivanchina E., Oreshina A., Vymyatnin E. // Fuel Processing Technology. 217 (2021) 106720. https://doi.org/10.1016/j.fuproc.2020.106720.*

DEVELOPMENT OF RECIPES FOR BLENDING FUEL COMPOSITIONS FROM DIESEL FUEL AND BIODIESEL FROM USED VEGETABLE OIL

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Biodiesel is an alternative type of fuel consisting of monoalkyl esters of fatty acids obtained by the transesterification reaction during the chemical interaction of vegetable oil or animal fats with alcohol. Biodiesel is a proven type of fuel with more than twenty years of operational history in Europe and the USA [1].

In this work, biodiesel was synthesized. Waste oil, received from one of the catering enterprises of the Tomsk city was used as a feedstock.

The synthesis of biodiesel was carried out according to the methodology presented in [3]. The yield was 67,84 % by oil weight.

Six investigation samples were prepared from the obtained biodiesel and winter diesel fuel bought at a retail fuel station in Tomsk: B – 100 % vol. of biodiesel; D – 100 % vol. of diesel fuel; B5 – 5 % vol. of biodiesel and 95 % vol. of diesel fuel; B10 – 10 % vol. of biodiesel and 90 % vol. of diesel fuel; B15 – 15 % vol. of biodiesel and 85 % vol. of diesel fuel; B20 – 20 % vol. of biodiesel and 80 % vol. of diesel fuel.

The following characteristics were determined for the obtained samples: density, kinematic viscosity, cloud point, pour point. Table 1 shows the results.

Technical requirements for commercial diesel fuel according to [2] are presented in Table 2.

Thus, according to [2], fuel blends of B5, B10 composition meet the requirements for the winter grade of diesel fuel in terms of studied characteristics. Further increase of biodiesel content leads to increase of kinematic viscosity and density. This makes the B15 and B20 blends meet the requirements for the inter-seasonal diesel grade. In addition, with increasing biodiesel content in the blends, the resistance of the blend to sub-zero temperatures decreases.