MATHEMATICAL MODELLING OF THE PROCESS OF ASSOCIATED PETROLEUM GAS CONVERSION INTO LIQUID HYDROCARBONS

V. V. Bykova, N. S. Belinskaya
Research Advisor – Candidate of Engineering Sciences, Research Associate N. S. Belinskaya

National Research Tomsk Polytechnic University
634050, Tomsk, Lenin Avenue, 30, belinskaya@tpu.ru

Combustion of associated petroleum gas is a source of VOC, CO, CO_2, polyaromatic hydrocarbons, sulfur oxides, nitrogen oxides and soot, which are environmental pollutants that directly and indirectly affect climate change. In this regard, new environmental regulations and tendencies in the sustainable utilization of natural resources have recently attracted the attention of researchers around the world, as well as forcing the oil industry to rationally utilize of by-products.

Zeolites used as catalysts in oil and gas processing have such advantages as high activity and low cost [1, 2]. Obtaining aromatic hydrocarbon components via catalytic processes using zeolite catalysts can become an alternative to the combustion o associated petroleum gas.

The purpose of the work is to develop a mathematical model for the process of converting associated petroleum gas.

Based on literature sources and the quantum-chemical calculations of the thermodynamic properties of molecules and reaction parameters, a formalized transformation scheme was drawn up, shown in Figure 1.

Thus, the transformation scheme takes into account 5 groups of components, 1 individual substance, 3 reversible reactions and 1 irreversible reaction.

On the basis of the presented conversion scheme, a system of equations of a mathematical model and a program containing an algorithm for solving the mentioned system of equations were compiled.

Using the developed model, a study was made of the effect of temperature on the content of various groups of substances in the product of associated petroleum gas conversion within the range of 515–525 °C with a step of 5 °C (Table 1).

Table 1. The influence of temperature on the content of various groups of substances in the product of the process of associated petroleum gas conversion

Content, % wt.	Temperature, °C		
	515	520	525
Paraffins	59.47	52.45	45.35
Aromatics	35.78	42.36	48.93
Hydrogen	3.82	4.08	4.32

The obtained results show that a rise in the process temperature provides the rise in the target product yield (aromatic hydrocarbons), as well as the hydrogen yield, which is also a valuable product of the process under consideration. However, it is vital to consider that an increase in temperature results in the increase in rate of formation of both aromatic compounds and hydrogen increases, but, on the other hand, it promotes rise in coke formation rate, which in turn promotes to the deterioration of the catalyst activity, and, as a result, to the decrease in the target product yields.

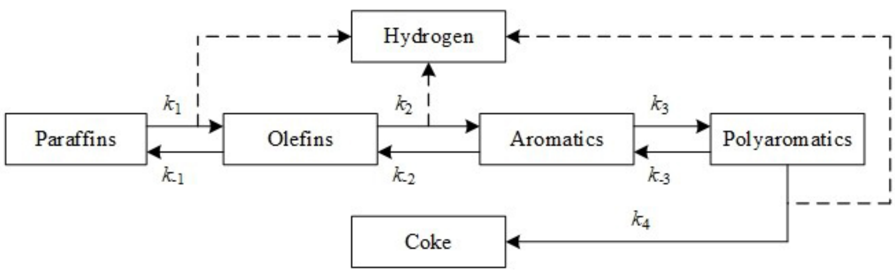

Fig. 1. *Formalized conversion scheme of associated petroleum gas on a zeolite catalyst*

References

1. *Belinskaya N., Altynov A., Bogdanov I., Popok E., Kirgina M., Simakov D. S. A. Production of gasoline using stable gas condensate and zeoforming process products as blending components // Energy and Fuels, 2019. – V. 33. – № 5. – P. 4202–4210.*
2. *Kirgina M., Belinskaya N., Altynov A., Bogdanov I., Temirbolat A. Transformations of stable gas condensate hydrocarbons into high-octane gasoline components over ZSM-5 zeolite catalyst // Journal of Natural Gas Science and Engineering, 2020. – Vol. 84. – Article number 103605.*

COMPARISON THE EFFECT OF THE VACUUM GASOIL AND HIGH-PARAFFIN FRACTION ADDITION ON THE EFFECTIVENESS OF THE DEPRESSOR

A. O. Efanova, I. A. Bogdanov

Scientific supervisors – researcher of Division for Chemical Engineering I. A. Bogdanov

Linguistic advisor – researcher of Division for Chemical Engineering I. A. Bogdanov

Tomsk Polytechnic University

634050, Russia, Tomsk, Lenina Avenue, 30, aoe4@tpu.ru

The active development of the Arctic and the northern territories of the Russian Federation leads to an increase in consumption and, accordingly, the need to produce diesel fuel capable of operating at low temperatures. In addition, for the smooth operation of the equipment, it is necessary that low freezing diesel fuel meets the requirements of the standard [1]. The most optimal and cost-effective way to achieve the necessary low-temperature properties of diesel fuel is the use of depressor additives.

In [2], it was found that when adding heavy components to the composition of diesel fuel with an additive, low-temperature proprties have a positive dynamic of changes.

The aim of this work is to compare the effect of the addition of vacuum gasoil and high-paraffin diesel fraction on the effectiveness of the depressor.

As samples for the study, 2 sets of diesel fuel blends with a depressor additive were used, which included a heavy component, namely a highly paraffin diesel fraction (1) and vacuum gasoil (2). The concentration of the depressor additive used was 0.6 ml per 100 ml of fuel, according to the recommendations from the manufacturer, the concentration of the heavy component was 0, 1, 3, 5 and 10 % vol.

To determine the effectiveness of adding vacuum gas oil and high-paraffin diesel fraction to blends of diesel fuel with a depressor additive, the cold filter plugging point (CFPP) was determined, according to the requirements of the standard [3]. The CFPP is strictly regulated by the standard [1].

Figure 1 shows the results of determining the CFPP of the studied samples.

According to the obtained data, it can be concluded that the addition of high-paraffin diesel fraction in concentrations of 1, 3 and 5 % vol. in the diesel fuel with a depressor additive have a positive effect. The maximum CFPP depression for the first set of diesel fuel blends with an additive is 7 °C.

Concentrations of vacuum gasoil equal to 1, 3 and 5 % vol. do not give significant changes in the low-temperature characteristic. The addition of vacuum gasoil at a concentration of 10 % vol. is impractical, since there is a deterioration of CFPP. The reason for this trend is the positive values of the CFPP of vacuum gasoil, the proportion of which in the studied blend becomes significant.

Thus, the greatest positive effect on CFPP is observed when adding a highly paraffin diesel fraction at a concentration of 5 % vol., in addition, the resulting blend, in contrast to the substandard source fuel, meet the requirements to the summer grade of diesel fuel according to CFPP [1].

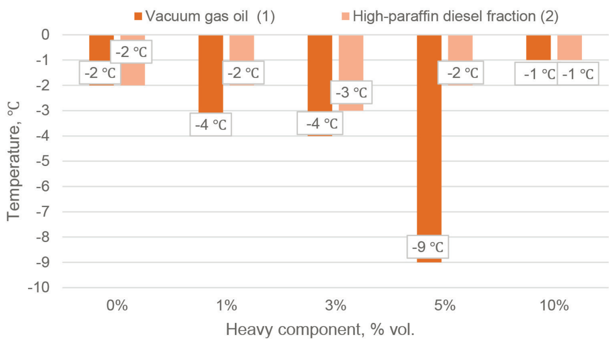

Fig. 1. *Results of the studied samples CFPP determination*