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STUDY OF THE EFFECT OF DIFFERENT FEEDSTOCK MIXTURES ON CATALYTIC CRACKING PARAMETERS IN A FLUIDIZED CATALYST BED

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Abstract
The article examines the influence of blended feedstock on the parameters of the catalytic cracking process. The chemical composition of feedstock significantly affects the yield and quality of catalytic cracking products obtained. Therefore, there is an urgent need for extensive research that can significantly expand the range of feedstock by using heavy oil residues, such as fuel oil, by mixing them with traditional catalytic cracking feedstock. However, with the heaviness of the feedstock, the content of sulfur-containing, nitrogen-containing and oxygen-organic compounds, resins, metals and other substances that worsen catalytic cracking indicators increases. In this regard, feedstock preparation is one of the main issues in intensifying the catalytic cracking process. In order to intensify the catalytic cracking process, we prepared a feedstock mixture consisting of 70% by mass of straight-run fuel oil and 30% non-hydrotreated vacuum gas oil obtained by vacuum distillation of fuel oil from oil mixtures from the Buzachi, Aktyubinsk and Kumkol deposits. During the conducted studies, it was established that the introduction of up to 30% vacuum gas oil into the fuel oil composition contributes to a reduction in coke formation on the catalyst and an increase in the yield of the target product - gasoline, as well as a reduction in the amount of harmful emissions into the environment.

Keywords: Catalytic cracking, fuel oil, vacuum gas oil, gasoline, reactor, catalyst, fuel oil, heavy oil residues, fluidized catalyst bed, coke.

Introduction

Catalytic cracking is a process designed to convert heavy fractions of oil refining into lighter and more valuable products at high temperature and moderate pressure in the presence of a highly dispersed catalyst with a matrix of silica or aluminum oxide.In the process of catalytic cracking of large hydrocarbon molecules into smaller molecules, deposits form on the catalyst - a non-volatile carbon-containing substance, usually called "coke." Coke deposited on the catalyst reduces the catalyst's activity in the catalytic cracking process, thereby blocking access to its active centers. To restore the initial activity of the catalyst, coke is burned off the catalyst by means of air in the regenerator.One of the significant advantages of the catalytic cracking process is the ability of the catalyst to move freely between the reactor and regenerator during fluidization with the corresponding vapor phase. In catalytic cracking units, the vapor phase in the reactor circuit is represented by hydrocarbons in a vapor state and water vapor, while in the regenerator circuit the fluidization medium is represented by air and flue gases. Thus, fluidization facilitates the interaction of hot regenerated catalyst and fresh feedstock: hot catalyst converts liquid feedstock into a vapor state, and then the cracked vaporized feedstock forms lighter hydrocarbon products. After separation of gaseous hydrocarbons from the spent catalyst, the resulting hydrocarbon vapors cool down and are separated by fractionation into the required product cuts.As feedstock for catalytic cracking units, heavy fractions from various technological units of the oil refinery are used. As a rule, the feedstock comes after primary processing or after vacuum distillation and represents a fraction with a boiling temperature from 350 to 550°C. In case of production necessity, the possibility of using an additional feedstock preparation unit is provided, for example, a hydrotreating or deasphalting unit. Products obtained at the catalytic cracking unit include gases, gasoline, light catalytic gas oil (LCO) and heavy gas oil. In addition, flue gases are formed during coke burning in the regenerator. Furthermore, catalytic cracking units usually process heavy fractions from other secondary processing units, which are an integral part of the combined catalytic cracking feedstock mixture. Such types of feedstock include gas oils from coking units, bottom product of the fractionation column of hydrocracking, thermal cracking and visbreaking units, as well as heavy liquid residue from the bitumen oxidation unit, called black solar oil. The use of vacuum gas oil as one of the feedstock components in catalytic cracking allows increasing the depth and efficiency of oil processing, especially heavy oils.In recent years, there has been an urgent issue of increasing the depth of oil processing, for example, by using heavy residues such as fuel oil as catalytic cracking feedstock. This issue is also relevant because currently there is an acute shortage of catalytic cracking feedstock at the cracking units of modern industrial installations G-43-107 at Pavlodar Refinery and the RFCC catalytic cracking unit at Shymkent Refinery.Therefore, it is especially relevant to conduct extensive research that will expand the resources and range of feedstock used, through the use of heavy oil residues, such as fuel oil, by mixing them with conventional catalytic cracking feedstock. However, with the heaviness of the feedstock, the content of sulfur-containing, nitrogen-containing and oxygen-organic compounds, resins, metals and other substances that worsen catalytic cracking indicators increases. In this regard, feedstock preparation is one of the main issues in intensifying the catalytic cracking process and improving product quality.The heavy oil residue catalytic cracking unit at Shymkent Oil Refinery - RFCC is one of the most modern installations in this direction. The unit's feedstock is fuel oil obtained after primary oil processing from the LK-6u complex. To lighten the unit's feedstock, scientific experiments were conducted to determine the optimal ratio of a mixture of vacuum gas oil and straight-run fuel oil in order to, as stated above, increase the range of feedstock used and at the same time reduce the negative impact on the process and product quality of sulfur-, nitrogen-, oxygen-organic compounds, resins and metals contained in fuel oil. Thus, the optimal feedstock mixture ratio was determined experimentally, consisting of 70% straight-run fuel oil and 30% non-hydrotreated vacuum gas oil obtained by vacuum distillation of fuel oil from oil mixtures from the Buzachi, Aktyubinsk and Kumkol deposits. Table 1 shows the percentage ratio of oils from which the fuel oil was obtained during processing.

Table 1 - Mixture of oils from different fields

Blend	Ratio, %
Kumkol Oil	55,7
Blend of West Kazakhstan oils, including:	
Aktobe Oil	40,1
Buzachin Blend	4,2
Total:	100

As can be seen from Table 1, the largest amount, up to 55.7%, of the oil used comes from the Kumkol deposit. Since the major part of the fuel oil mixture consists of Kumkol oil and this composition affects the technological properties of the feedstock, we first conducted studies to determine various properties of this fuel oil separately. Below, Table 2 provides data on the physicochemical properties of fuel oil obtained from Kumkol feedstock, boiling at temperatures above 350°C.

Table 2 - Physicochemical Properties of Fuel Oil

	Kumkol Oil	**Kumkol Oil**	**Kumkol Oil**	**Kumkol Oil**
	Mazut fraction.>350 ^{0}C	0,968	2,24	0,87

Group composition, % by weight.

	Paraffin-naphthenic hydrocarbons	Aromatic	including: light m	mediu	heavy	Resins
2	74,0	23,5	5,0	4,7	6,3	10,0

Fractional composition, 0C

н.к.		10%	50%	90%	к.к.
2	340	400	448	490	-

As can be seen from the data in Table 2, Kumkol oil fuel oil consists mainly of paraffin-naphthenic hydrocarbons up to 74%, but a positive distinction is that the feedstock composition contains significantly fewer sulfur compounds - approximately 0.87%.

Subsequently, the physicochemical properties and chemical composition of the used fuel oil obtained from the oil mixture (Table 1) and vacuum gas oil were also investigated. The research results are presented in shows that the amount of heavy metals in the composition of the mixture of vacuum gas oil and straight-run fuel oil obtained from the oil mixture (Table 1) is lower than in the composition of straight-run fuel oil (Table 2). The metal content in fuel oil is (ppm by mass): iron 12.8, vanadium 24.68, nickel 20.75, manganese 0.40, antimony 0.77, copper 0.18. The above-mentioned organometallic compounds during regeneration vary within the range of 0.4-1.0, and sometimes increase up to 2.0 ppm by mass. These metals, both in laboratory

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catalytic cracking experiments and under industrial plant conditions, deposit on the surface of catalysts, causing so-called catalyst poisoning, which reduces the rate and efficiency of the catalytic cracking process.

We conducted extended laboratory tests as well as physicochemical analyses of the selected blended feedstock in the optimal ratio of fuel oil:vacuum gas oil - 70:30 respectively, and Table 4 presents the results of physicochemical analysis of the properties of the selected optimal blended feedstock, as well as data on their metal content.

Table 3 - Metal Content and Physicochemical Properties of Blended Feedstock

Here's the English translation:

Cracking feedstock	Cracking feedstock	Cracking feedstock
Yield of cracking products, % of initial	100%	70%+30%
Gas	15,76	17,46
Gasoline	43,75	49,69
Light gas oil	22,03	17,59
Heavy gas oil	12,04	8,51
Coke + losses	6,42	6,75

Data on the product yield during catalytic cracking, according to show that during cracking of the optimal feedstock mixture "70% fuel oil + 30% vacuum gas oil," the yield of gasoline and gas is significantly higher: 49.69% and 17.46% respectively, compared to cracking only fuel oil, where the gasoline yield is 43.75% and gas is 15.76%.

CONCLUSIONS:The possibility of processing an optimal mixture at the catalytic cracking unit has been demonstrated: fuel oil and vacuum gas oil in a ratio of 70:30, obtained from oils of the Buzachi, Aktyubinsk and Kumkol deposits.Here's the English translation:

During the research, it was established that the introduction of an optimal volume of up to 30% vacuum gas oil into the fuel oil composition contributes to a reduction in coke formation on the catalyst and an increase in the yield of the target product - gasoline by up to 6%.

The incorporation of 30% vacuum gas oil into the fuel oil composition in the catalytic cracking process is an effective method of using non-hydrotreated vacuum gas oil as a feedstock component, which contributes to the prevention of harmful emissions into the environment.

During industrial testing, it was shown that the quantity of metals (nickel, vanadium, copper, etc.) in the optimal blended feedstock is less than in the composition of the feedstock used, consisting of 100% fuel oil. This positively affects the activity, selectivity and service life of the catalyst, which ultimately leads to increased efficiency of the catalytic cracking process and increased yield of the finished product.

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