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The Activation of the Catalytic Cracking Process of Vacuum Gasoil with Vegetable Oils under the Influence of Magnetic Field

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ABSTRACT

The catalytic cracking process of raw vacuum gasoil and the mixture of it with cottonseed oil (10%) at 480°C, in 0.2-0.55 T induction of magnetic field, with 0.5-1 sec-1 of mass velocity of the feedstock by using Omnikat-210P industrial catalyst has been investigated. It has been revealed that, as a result of the thermocatalytic conversion of vacuum gasoil, the yield of diesel fraction was 25% (by mass) in the given conditions. The conversion depth of vacuum gasoil increased from 72.6% to 85.7%.

When 10% of cottonseed oil was added to vacuum gasoil, the conversion depth increased up to 91.4%, the yield of gasoline and diesel fraction was 39%. The quality pointers of the produced gasoline fraction from the process is compatible to the standard gasoline fractions.

Keywords: catalytic cracking, vacuum gas oil, diesel fraction, gasoline fraction, the magnetic field, cottonseed oil

INTRODUCTION

Growing dieselization of cars fleet in recent years increases the consumption of diesel fuel. It requires the involvement of middle distillate catalytic cracking and other secondary processes to the total fuel Fund. Therefore it becomes important to develop processes diesel fuel variant of catalytic cracking, which provides increased yield of light gas oil catalytic cracking and, at the same time, an acceptable yield and quality of the gasoline fractions, in connection with which there are numerous studies on the intensification of the catalytic cracking process by introducing a raw material of various additives and subjecting it to low-energy wave action [1-3].

The intensification of a catalytic cracking process by modifying the raw hydrocarbon additives olefin series has been studied [4]. It demonstrated that the introduction of linear and branched olefins in the feedstock of catalytic cracking increases the yield of the desired products of the process by 1.9-9.9% (rel.), and the effect depends on the time of initiation of contact of raw material with the catalyst. 2-fold reduction of a contact time results in gasoline yield increase by 54.7% and gas - by 33.3%, coke - 25.0% (rel.).

The introduction of 10% vegetable oils in the feedstock of catalytic cracking leads to an increase in resources of the gasolines by 2.5% while increasing the octane number by 2 points increase the total content of C2-C4 olefins in the composition of the gases at 4.5-8.2 wt.%, and increases the yield of light gas oil at 9.4-9.7% by weight under appropriate conditions of the process [5,6].

Currently, work to intensify CC is underway through the use of modifiers - hydrogen donors [7], contributing to a significant reduction in coke yield and increasing the yield. The additives such as monohydric alcohols, aliphatic ethers, aldehydes, ketones, etc. are used.

The new trend to intensify the processes of treatment of different types of petroleum feedstock is a low-energy method of physical effects that can be used without any significant external costs of energy and the use of internal resources to rebuild the structure of matter. As the external factors

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affecting the structure of substances, including oil dispersions, electrical, electromagnetic, magnetic, vibratory, or acoustic fields can be applied. By means of this way it is relatively easy to achieve effects which correspond to an increase or, conversely, decrease of order in the supramolecular structure of substances. These methods are the most promising ones in terms of their efficiency, effectiveness and accessibility [8-12].

Intensification methods of Catalytic Cracking process by means of ozonation of vacuum gas oil and the addition of rapeseed oil fatty acid were investigated. These studies improve the yield of the desired product - gasoline by 4.6 wt.%, and lower the yield of heavy gas oil and gas by 3.7 and 4.8%, respectively.

It was found out that the optimum concentration of ozone is 2 g / kg of raw material in which the content of aromatics in gasoline is reduced by 12%, whereas the amount of isoalkanes increased by 14%.

The energy of the magnetic field is one of the most effective, efficient and affordable types of energy known to humankind. Widespread use of constant magnetic field energy is limited by insufficient theoretical development of the problem of influencing forces of the magnetic field due to the complexity of the structural and energy transformations that occur in materials with different structures at micro and macro level. Therefore, further study of the behavior of oils of different compositions under a constant magnetic field allows broadening knowledge of the matters dealt with the influence of physical fields on the properties of structured systems [8-10].

EXPERIMENTALS

Materials and Methods

This particular work reveals investigation of effect of magnetic field (0.2-0.9Tl) upon the catalytic cracking of vacuum gas oil by means simultaneous addition up to 10% of cotton oil in its content. Experiments were carried out in a flow reactor with a fixed bed of industrial catalyst such as Omnikat-210P at 480-520 °C and a mass space velocity of 0.5-1 h^{-1}.

Vacuum gas oil was obtained from the Baku Oil Refinery named after H. Aliyev. Cottonseed oil was obtained from the factory "Azersun", Baku. Quality of raw materials used is shown in Table 1.

Table1. *The qualitative composition of the used vacuum gas oil and cottonseed oil*

Parameters	Vacuum gas oil	Cottonseed oil
Indicators, kq/m^3	900,5	923
Composition :		
sulfur, ppm	800	-
nitrogen, ppm	1053	-
hydrogen, mass%.	11,94	-
carbon, mass%.	83,67	-
oxygen, mass%.	1,94	-
Fractional composition, °C		
Start of boiling	280	-
10 % is boiled at	348,5	-
50 %	410,0	-
90 %	485,5	-
End of boiling	574,8	-
Iodine number q J_2/100 q	-	110
Acidity number q KOH/q	-	2,5
Kinematic viscosity at 40°C, mm^2/s	7,1	
Flash point, °C	175	
Pour point, °C	10	-18
Molecular mass, g/mole	205	780
Hydrocarbon content, % mass.		
Unsaturated	-	-
Aromatic	36,0	-
Paraffins+naphthenes	64,0	-

RESULTS AND DISCUSSION

Table 2 illustrates material balance of catalytic cracking process of vacuum gas oil with 5 and 10% of cottonseed oil in its content with and without presence of magnetic field.

As can be seen from the data presented, the effect of the magnetic field with intensity range of 0,2-0,55 Tl significantly influences on the yield of the mixture of vacuum gas oil with 5% and 10% of cottonseed oil. For example, when carrying out the process without the influence of the magnetic field at 500 °C gasoline fraction yield is 46.6 and 47.4 wt.%, while for that of diesel fraction these values are 6.4 and 6.7wt.%. Both of these yields correspond to the vacuum gas oil with 5% and 10% of cottonseed oil, respectively.

Table2. *Composition of products obtained as a result of catalytic cracking of vacuum gas oil with 5-10% content of cottonseed oil under the influence of continuous magnetic field with induction of 0.2-0.55Tl.*

Indicators	Without influence of magnetic field						Under the influence of the magnetic field					
	Temperature, °C											
	480	500	520	480	500	520	480	500	520	480	500	520
Used, wt%.												
Vacuum gas oil	95	95	95	90	90	90	95	95	95	90	90	90
Cottonseed oil	5	5	5	10	10	10	5	5	5	10	10	10
obtained, wt%,:												
Liquid catalysate	82,1	80,2	75,5	79,6	77,8	73,2	86,4	84,1	81,7	84,5	82,8	77,9
Gases till C4	13,0	14,6	18,8	13,5	15,0	19,3	9,4	10,8	13,4	9,8	11,0	15,1
coke	2,7	2,9	3,2	3,8	4,0	4,3	2,4	3,1	2,8	3,6	3,8	4,1
loses	2,2	2,3	2,5	3,1	3,2	3,2	1,8	2,0	2,1	2,1	2,4	2,9
Composition of catalysate Wt%:												
l.b. fraction.-200 °C	39,1	46,6	41,9	39,8	47,4	42,5	38,9	46,2	41,1	39.0	46,8	41,6
Fraction of 200-350 °C	16,3	6,4	5,0	16,8	6,7	5,3	37,0	27,2	27,4	39,0	26,4	25,5
fraction > 350 °C	26,7	27,2	28,6	23,0	23,7	25,4	10,5	10,7	13,2	6,5	9,6	10,8
Conversion , Wt%	73,3	72,8	71,4	77,0	76,3	74,6	89,5	89,3	86,8	93,5	90,4	89,2

The Effect of magnetic field with intensities of 0.2-0.55Tl under the same conditions leads to the considerable increase of diesel fraction yield. The increase in the output of the diesel fraction is 20,8-19,7wt.%. However, the yield of the gasoline fraction reduces by 0.4-0.6wt% which is 46,2-46,8wt.%.

The reducing of the yield of residual fractions, boiling above 350 °C, till 10,7-9,6 from 27,2-23,7wt% indicates an increase in the degree of conversion of raw materials, which is probably due to a change in the size of the dispersed particles under the influence of a magnetic field.

Comparison of the yields of vacuum gas oil from the cracking process performed under conventional conditions (temperature 500 °C, mass space velocity of 0.5-1 h^{-1}, no influence of the magnetic field, table 3) shows that the addition of cottonseed oil to the feedstock enables to maintain high output fraction of gasoline with simultaneous increase of the yield of the diesel fraction and an increase in the degree of conversion of raw materials to 89.3-90.4wt%.

Table3. *Composition of products as a result of catalytic cracking process of gas oil with 5 and 10% content of cottonseed oil under the influence of the magnetic field with induction range of 0.2-0.55Tl.*

Indicators	Without influence of magnetic field			Under the influence of magnetic field		
	Temperature,°C					
	480	500	520	480	500	520
Used wt%						
Vacuum gas oil	100	100	100	100	100	100
Obtained wt%:						
Liquid catalysate	83,2	81,4	76,6	87.9	85.1	81.1
C_1-C_4 gases	12,5	13,8	17,6	8.4	10.7	14.2

coke	2,4	2,6	3,2	2.1	2.4	2.8
Fractional composition of catalysate						
l.b.-200 °C	38,3	45,6	41,2	31.1	36.6	33.2
200-350 °C	17,5	7,5	6,1	42.5	32.5	29.1
fr. > 350 °C	27,4	28,3	29,3	14.3	16.0	18.8
loses	1,9	2,2	2,3	1.6	1.8	1.9
conversion, %	72.6	71.7	70.7	85.7	84.0	81.2

It should be noted that the high degree of conversion for vacuum gas oil and its mixtures with 5-10% cottonseed oil, exposed to a constant magnetic field is observed at a temperature of 480 °C, which is 20 °C below than that of the industrial catalytic cracking process.

Quality indicators of derived gasoline and diesel fractions are given in Table 4. As it can be seen from the data, quality indicators of both benzene and diesel fractions obtained from a catalytic cracking process of vacuum gasoil without and under the influence of a constant magnetic field are almost identical. Some minimal amount of aromatic and unsaturated compounds in the composition of the fractions obtained is explained by the reduction of secondary cracking reactions on strongly acidic sites of the catalyst under the influence of the magnetic field, which are responsible for the formation of unsaturated and aromatic compounds.

Table4. *Quality indicators of benzene and diesel fractions after the catalytic cracking process of vacuum gas oil without and under the influence of the magnetic field.*

Indicators	Benzene fraction		Diesel fraction	
	Without influence of magnetic field	Under the influence of the magnetic field	Without influence of magnetic field	Under the influence of the magnetic field
Density at 15 °C, kg/m3	728,0	736,0	948,5	924,8
Fractional composition				
10% distilled, °C,	35	36	180	185
50 % distilled, °C ,	80	91	275	245
95 % distilled, °C ,	190	192	360	355
Flash temperature, °C	-	-	76	76
Acidity , mg KOH/100 cm3	1,5	1,5	9,2	9,4
Iodine number, g J2/100 g	49,1	46,8	6,4	6,1
Total sulfur content, wt%.,	0,012	0,014	0,16	0,14
Coking behavior of 10 % residue, wt%.	-	-	0,14	0,14
Hydrocarbon composition, Wt%.				
Aromatics + unsaturated	68	64,3	86	80
Paraffine-naphthenes	32,0	35,7	14	20

CONCLUSIONS

To sum up, conducted experiments showed us the opportunity of using magnetic field for variation of composition and quality of obtained products as a result of catalytic cracking of vacuum gas oil and its 5 to 10% cottonseed oil mixtures.

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