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Study of the influence of feedstock of the processed raw materials at naphtha catalytic reforming and isomerization

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Abstract

A mathematical method of optimization of naphtha catalytic reforming and isomerization of industrial unit A100 of Pavlodar oil refinery combined with separation unit B300S was proposed. In order to achieve the required quality of the products of the splitter column for the C_6 hydrocarbon content in the heavy gasoline fraction and the C_{7+} hydrocarbon content in the light gasoline fraction, the research was carried out to optimize the process parameters. The obtained data were checked for adequacy and confirmed by the simulation results presented for different modes of operation of isomerization reactors and columns. The data can be used to solve real technological problems arising in production.

Keywords: Separation of raw materials, mathematical simulation, isomerization, reforming, splitter;

1. Introduction

Reforming is the most common process in Russia for producing high-octane gasoline. However, this fuel does not meet the EURO-5 and EURO-6 standards due to the high content of aromatic hydrocarbons. Therefore, there is a need to produce high-octane non-aromatic components such as alkylates, oligomerizates and isomerizates[1].

1.1. Materials and methods

The isomerization process is gaining importance in the present refining context due to limitations on gasoline benzene, aromatics, and olefin contents. The isomerization process upgrades the octane number of light naphtha fractions. Isomerate products are the most practical materials because of their low cost and high availability. The purpose of the isomerization process in modern refining is to obtain high-octane isoalkanes. Low-octane oil components and catalytic reforming refined products are used as raw materials in isomerization process[2].

The object of the research is the industrial unitA100/B300S of Pavlodar Refinery. To increase the efficiency of the isomerization and reforming units there was an attempt to modernize the early phase of the process by properly separating the raw materials between the units.

1.2. Results and discussion

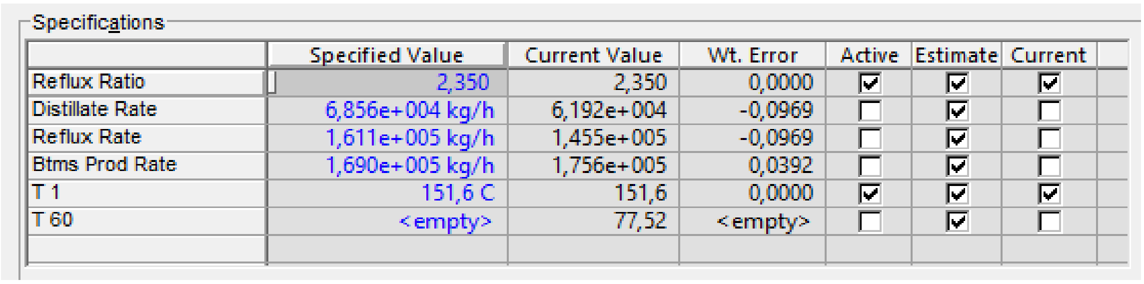
The mathematical simulation of the splitter column B300S was carried out in Aspen HYSYS software. The isomerization process was performed using IZOMER software, while the reforming process was performed using AKTIV software.The data for modelling are the compositions of the input streams; the technological parameters of the rectification process are pressure, temperature and mass flow. The design values of the operation of the splitter column B300S are presented in Table 1.

Table 1 – B300S column parameters

Parameter	Design value
Mass flow, kg/h	237588
Light gasoline fraction flow, kg/h	68565
Heavy gasoline fraction flow, kg/h	169023
Column top temperature, °C	81.32
Light/Heavy fractions ratio	0.42

By comparing the feedstocks of light and heavy gasoline fractions with their design values taking into account the optimal technological parameters we may assume the efficiency of separation of fractions in the column.

Pic 1.Specifications for feedstock 1



Specifications

	Specified Value	Current Value	Wt. Error	Active	Estimate	Current
Reflux Ratio	2,350	2,350	0,0000	☑	☑	☑
Distillate Rate	6,856e+004 kg/h	6,192e+004	-0,0969	☐	☑	☐
Reflux Rate	1,611e+005 kg/h	1,455e+005	-0,0969	☐	☑	☐
Btms Prod Rate	1,690e+005 kg/h	1,756e+005	0,0392	☐	☑	☐
T 1	151,6 C	151,6	0,0000	☑	☑	☑
T 60	<empty>	77,52	<empty>	☐	☑	☐

Three different feedstocks of the proceed raw materials were selected for the research. For every feedstock there are different technological parameters which match them best. For example, for feedstock 1 these specifications are the most optimized (Pic. 1)

The feedstock of light and heavy gasoline fractions has these values:

Table 2- Feedstock of light and heavy gasoline fractions with T_1=152.1°C and Reflux ratio = 2.950

Component (light fraction)	Alkanes, kgmole/h	Isoalkanes, kgmole/h	Cycloalkanes, kgmole/h	Aromatic hydrocarbons
C_4	18.71	1.44	0.00	0.00
C_5	198.64	172.22	140.08	0.00
C_6	92.59	128.11	124.66	9.16
C_7	0.00	10.30	12.99	0.00
Component (heavy fraction)	**Alkanes, kgmole/h**	**Isoalkanes, kgmole/h**	**Cycloalkanes, kgmole/h**	**Aromatic hydrocarbons**
C_6	0.00	0.00	0.00	0.00
C_7	96.02	100.88	205.61	28.24
C_8	79.49	92.57	175.70	33.53
C_{9+}	179.54	99.76	289.91	44.29

Thus, the decrease of C_7 hydrocarbons in the content of the light gasoline fraction and complete absence of C_6 components in the heavy fraction is observed. In addition, there is a uniform distribution of components in the light gasoline fraction.

If the same technological parameters are used for the feedstock with less amount of C_7 hydrocarbons in the content, there will be worse results due to the huge percentage of C_6 components in the heavy gasoline fraction (table 2).

Table 3 – Feedstock of light and heavy gasoline fractions for feedstock 2 with T_1=156.6°C and Reflux ratio = 2.350

Component (light fraction)	Alkanes, kgmole/h	Isoalkanes, kgmole/h	Cycloalkanes, kgmole/h	Aromatic hydrocarbons
C_4	18.71	1.44	0.00	0.00
C_5	198.64	172.22	140.08	0.00
C_6	81.73	127.63	31.21	6.12
C_7	0.00	0.70	0.00	0.00
Component (heavy fraction)	Alkanes, kgmole/h	Isoalkanes, kgmole/h	Cycloalkanes, kgmole/h	Aromatic hydrocarbons
C_6	10.86	0.48	93.45	3.04
C_7	48.01	55.58	109.31	28.24
C_8	79.49	92.57	175.70	33.53
C_{9+}	179.54	99.76	289.91	44.29

In the feedstock 3 there are less aromatic hydrocarbons than in the previous feedstocks. The content of light and heavy gasoline fractions for feedstock 3 has these values:

Table 4 –Feedstock of light and heavy gasoline fractions with T_1=152.1°C and Reflux ratio = 2.950

Component (light fraction)	Alkanes, kgmole/h	Isoalkanes, kgmole/h	Cycloalkanes, kgmole/h	Aromatic hydrocarbons
C_4	18.71	1.44	0.00	0.00
C_5	198.64	172.22	140.08	0.00
C_6	92.55	128.11	71.97	4.57
C_7	0.00	0.70	0.00	0.00
Component (heavy fraction)	Alkanes, kgmole/h	Isoalkanes, kgmole/h	Cycloalkanes, kgmole/h	Aromatic hydrocarbons
C_6	0.04	0.00	52.69	0.01
C_7	96.02	110.48	218.60	14.12
C_8	79.49	92.57	175.70	16.78
C_{9+}	179.54	99.76	289.91	22.15

1.3. Conclusion

There is just a little amount of C_7 isoalkanes in light gasoline fractions. In addition, the good point isthere are less aromatic hydrocarbons in general. However, there are a little moreofC_6 cycloalkanes in heavy fraction. Thus, the processed raw materials affect the quality of the separation of the B300S splitter column.

It became possible to reduce C_{7+} hydrocarbon content in the light gasoline fraction and the C_6 hydrocarbon content in the heavy gasoline fraction by optimizing the parameters of the B300S splitter column such as changing the temperature profile along the column and changing the ratio between the light and heavy gasoline fractions.

References

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