



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

Tomsk Polytechnic University

Vladimir Chabanenkov^a

^a Engineering school of natural resources, Tomsk Polytechnic University

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 C₆ hydrocarbon content in the heavy gasoline fraction and the C₇₊ 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 unit A100/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	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Distillate Rate	6,856e+004 kg/h	6,192e+004	-0,0969	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Reflux Rate	1,611e+005 kg/h	1,455e+005	-0,0969	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Btms Prod Rate	1,690e+005 kg/h	1,756e+005	0,0392	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
T 1	151,6 C	151,6	0,0000	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
T 60	<empty>	77,52	<empty>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

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 $T_1=152.1^\circ\text{C}$ 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 C₇ hydrocarbons in the content of the light gasoline fraction and complete absence of C₆ 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 C₇ hydrocarbons in the content, there will be worse results due to the huge percentage of C₆ components in the heavy gasoline fraction (table 2).

Table 3 – Feedstock of light and heavy gasoline fractions for feedstock 2 with T₁=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 T₁=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 C₇ isoalkanes in light gasoline fractions. In addition, the good point is there are less aromatic hydrocarbons in general. However, there are a little more of C₆ 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 C₇₊ hydrocarbon content in the light gasoline fraction and the C₆ 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

1. Chuzlov V.A., Chekancev N.V., Ivanchina E.D. (2013). Feedstock composition optimization at naphtha catalytic reforming and C₅-C₆ isomerization units with the help of "HYSYS IZOMER ACTIV" simulator. *Fundamental research*. № 8 (part 3). pp. 766-772.
2. Valavarasu G., Sairam B. (2013). Light naphtha isomerization process: a review. *Petroleum Science and Technology*, Volume 3 (1). pp. 580-595.