OPTIMIZATION OF A SEMIREGENERATIVE CATALYTIC REFORMING OF NAPHTHA WITH THE MATHEMATICAL MODELLING METHOD USING

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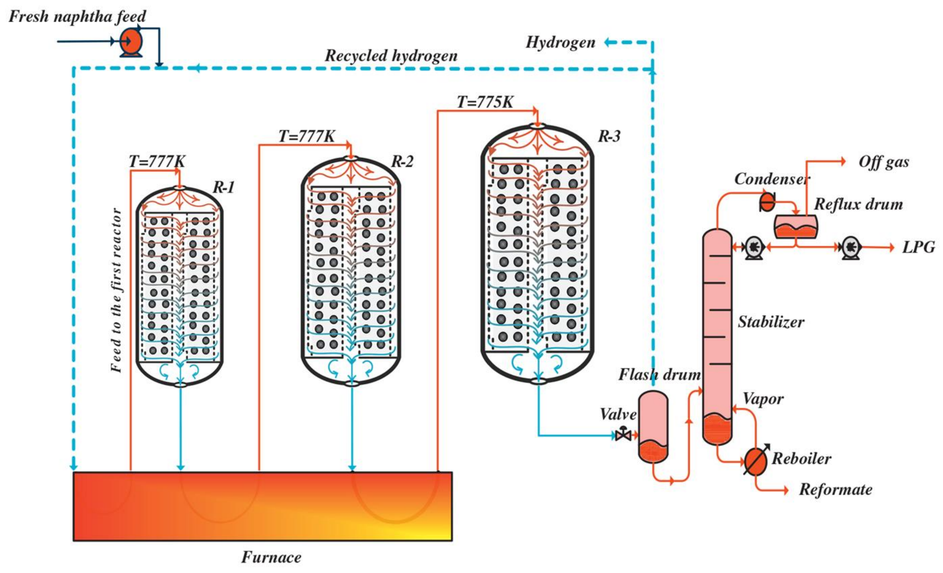
Introduction

Catalytic naphtha reforming is extensively applied in petroleum refineries and petrochemical industries to convert low-octane naphtha into high-octane gasoline. Besides, this process is an important source of hydrogen and aromatics obtained as side products. The bifunctional Pt-catalysts for reforming are deactivated by coke formation during an industrial operation. This results to a reduction in the yield and octane number. Modeling and optimization of a semiregenerative catalytic reforming of naphtha is carried out considering catalyst deactivation and a complex multicomponent composition of a hydrocarbon mixture. The mathematical model of semiregenerative catalytic reforming considering coke formation process was proposed. The operating parameters (yield, octane number, activity) for different catalysts were predicted and optimized.

Objectives

The experimental data including the chromatographic analyzes results of feedstock and product compositions, the technological modes of the production unit operation were obtained from two different industrial SSR reforming units of the Russian refinery and were used as the initial data.



Schematic diagram of semiregenerative reforming unit with fixed-bed reactors [1]

Methods

A model and an object of investigation have different physical nature but the same properties [2,3]. The mathematical model of a technological process is designed by a system of algebraic or differential system of equations adequately describing properties of an object.

$$\begin{cases} G_c \frac{\partial C_i}{\partial Z} + G_c \frac{\partial C_i}{\partial V} = \sum_{j=1}^{m} a_j \cdot r_j \\ G_c \frac{\partial T}{\partial V} + G_c \frac{\partial T}{\partial Z} = \frac{1}{\rho \cdot C_p^{mix}} \sum_{j=1}^{m} a_j \cdot r_j \cdot \left(\frac{RT}{P}\right) \cdot \Delta H_j \end{cases}$$

The boundary conditions are:

$z = 0$, $C_i = C_{i0}$, $T = T_{en}$;

$V = 0$, $T = T_{en}$, $C_i = C_{i0}$.

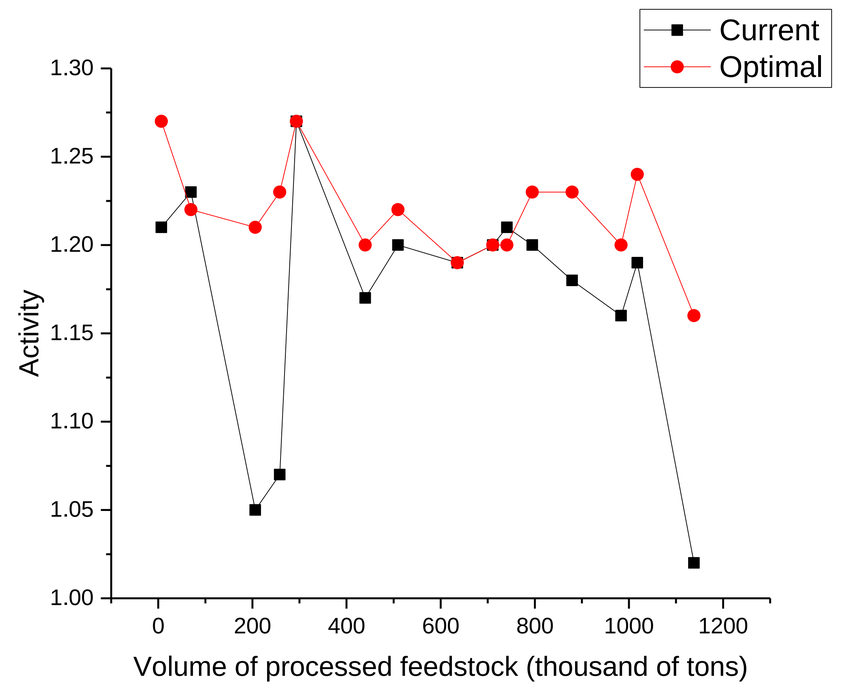
Comparing the values presented in Table 3, we can see, that data calculated on model agree very well with the experimental data from the industrial units (the calculation error should not exceed an error of chromatographic analysis).

Comparison between experimental and calculated data of catalytic reforming process with mathematical model

Group composition, % wt.	Calculated	Experimental
n-Alkanes	10,08	10,26
i-Alkanes	21,87	21,85
Methylcyclopentanes	1,92	1,94
Methylcyclohexanes	1,89	1,83
Aromatic hydrocarbons	64,25	64,21

Results

The model enables to monitor the industrial process and find the optimal mode of the operation, which is determined by the equilibrium conditions for the reactions of coke formation and hydrogenation of the intermediate compaction products.

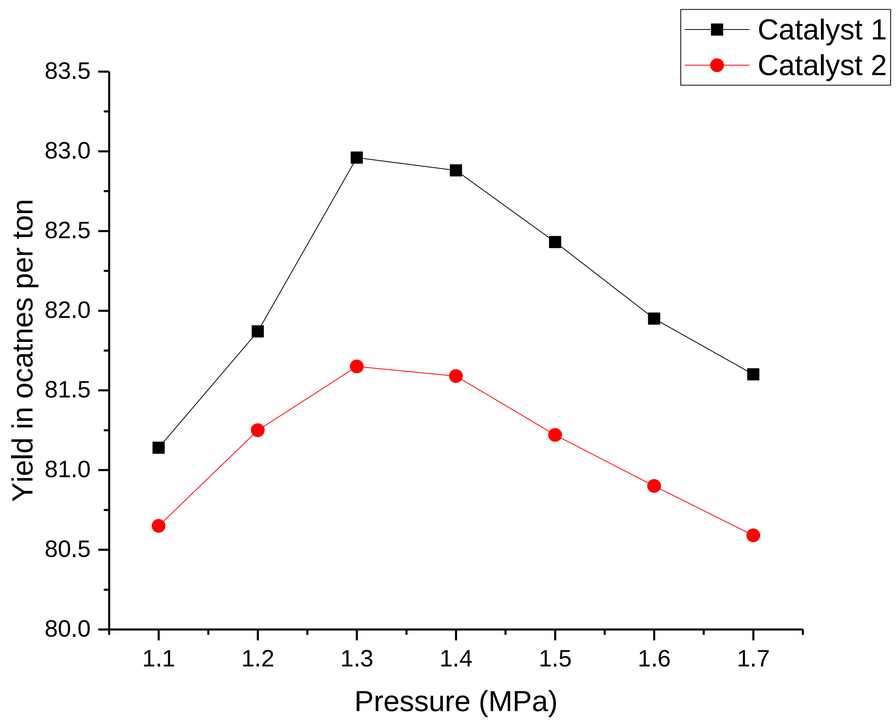


Comparison between current and optimal activity of catalyst (model calculation results)

Hydrocarbon feedstock composition has a strong effect on the process.

Parameter	Feedstock №1			Feedstock №2			Feedstock №3		
Pressure, MPa	1.6	1.4	1.2	1.6	1.4	1.2	1.6	1.4	1.2
Yield of hydrogen, %	1.79	1.83	1.91	1.78	1.85	1.93	1.74	1.81	1.89
Aromatic hydrocarbon, wt. %.	62.5	63.0	63.5	63.3	63.8	64.3	61.6	62.2	62.6
Research octane number	91.8	92.1	92.4	94.0	94.3	94.5	93.5	93.8	94.0
Yield, wt. %.	86.3	86.8	87.3	86.7	87.2	87.6	86.5	87.0	87.5

The change in SRR process parameters with hydrocarbon composition of feedstock and pressure variation (simulation results)



Change in yield with pressure (simulation results)

References

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3. Yakupova I.V., Chernjakova (Sharova) E.S., Ivanchina Je.D., Belyj A.S. et al., «Performance Prediction of the Catalyst PR-81 at the Production Unit Using Mathematical Modeling Method», *Procedia Eng.,* 2015, 113, 51–56.