Optimum control of gasoline catalytic reforming based on of kinetic model

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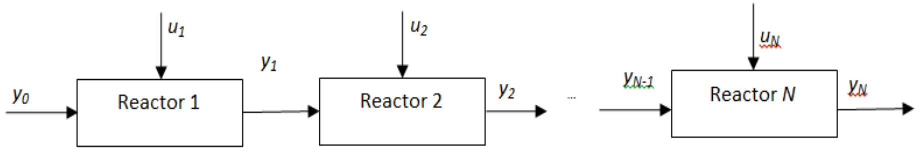
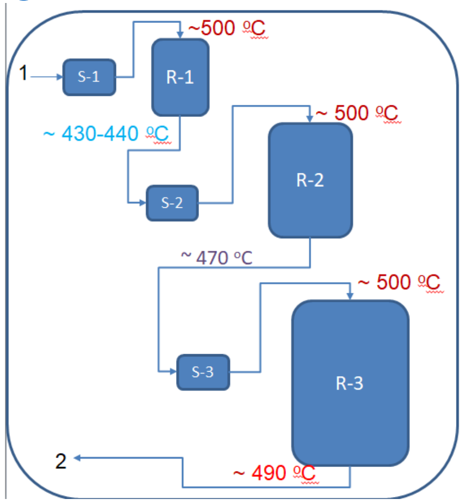




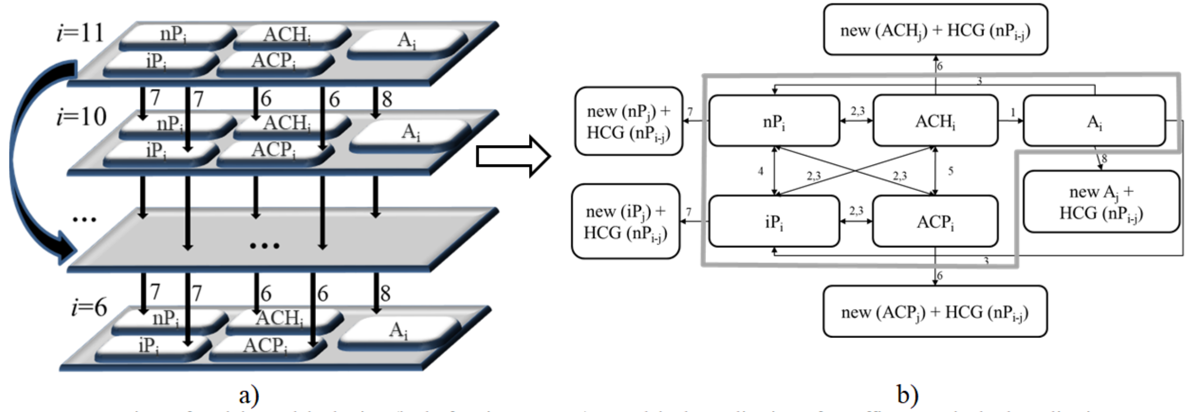
Introduction

To start new catalytic processes in industry and intensification of existing production, it is necessary a detailed study of the laws of chemical reactions, which is fully reflected in the kinetic model of the reaction. The development of a kinetic model is the basis for the subsequent decision of problems of optimum control study catalytic processes.

Control of a multi-stage catalytic process

When considering the catalytic processes taking place in multistage reactors, the optimal control methodology is used. Catalytic processes in multistage reactors or a cascade of reactors, with a series connection of the inputs and outputs of devices located one after another, are called multi-stage. In such reactor units y_0 – reactant concentration at the input to reactor stage; y_N – concentration at the exit from it. The reaction mixture at the exit of one apparatus is the input to the next apparatus. Real catalytic processes are described by phase variables y_i and control action vectors u_j. In fig. 1. presents the management of a multi-stage catalytic process.

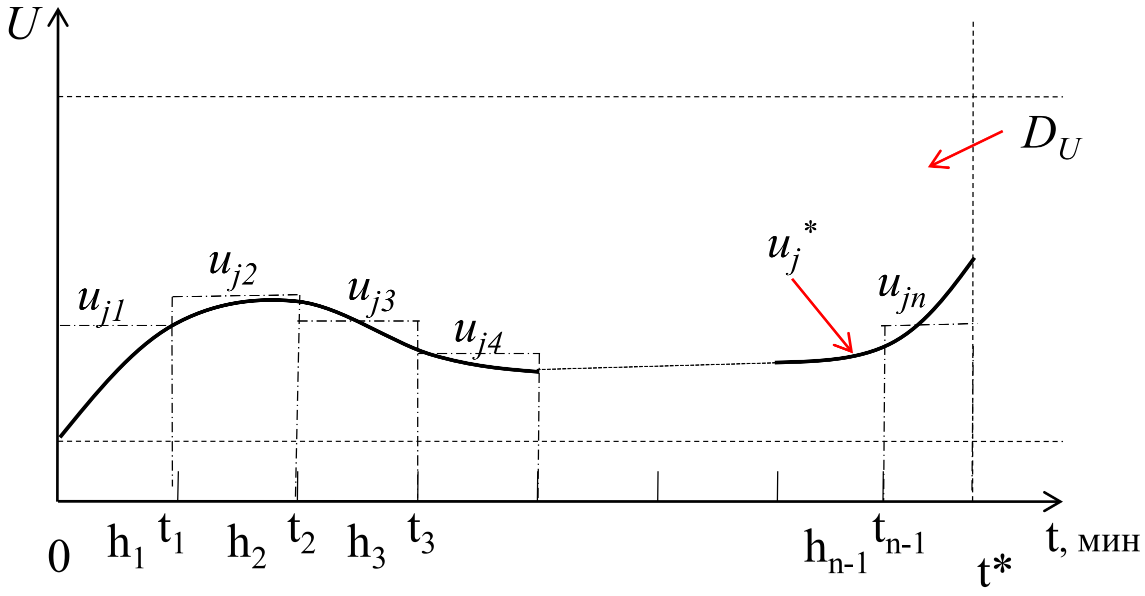
Scheme of the gasoline catalytic reforming transformations



1 — reactions of naphthene dehydration (hydroforming process); 2 —dehydrocyclization of paraffins; 3 — hydrodecyclization; 4 — paraffins isomerization; 5 — naphthenes isomerization; 6 — naphthenes hydrocracking; 7 — paraffins hydrocracking; 8 — hydrocracking of aromatic hydrocarbons; i, j – number of carbon atoms (j < i).

A method for reducing an optimal control problem to nonlinear programming problem

Optimal control $u_j^*(t), j=1,\ldots,m$ define in the class of piecewise constant or piecewise linear functions $u_j=(u_{j1}, u_{j2}, \ldots u_{jn})$



Optimality criteria for catalytic reforming of gasoline

$$f_1(U) = ONRM(U) = \sum_{i=1}^{I} y_i(U) \cdot ONRM_i \rightarrow \max$$

$$f_2(U) = Yield\_Rif(U) = 1 - \sum_{i=1}^{5} y_i(U) - \Delta y_{H_2}(U) \rightarrow \max$$

$$f_3(U) = ONRM\_ton(U) = ONRM(U) * Yield\_Rif(U) \rightarrow \max$$

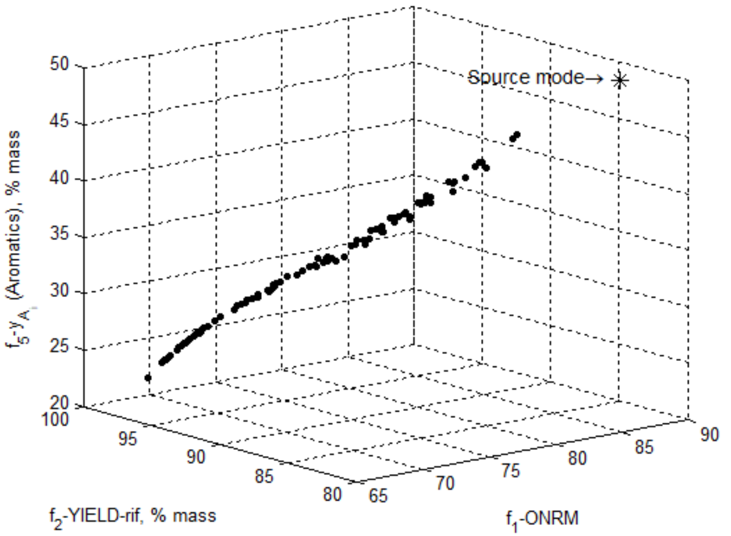
$$f_4(U) = y_{A_6}(U) \rightarrow \min$$

$$f_5(U) = \sum_{i-6}^{11} y_{A_i}(U) \rightarrow \min$$

Results of solving the problem optimum control of gasoline catalytic reforming based on of kinetic model

By varying the temperature at the reactor inlet

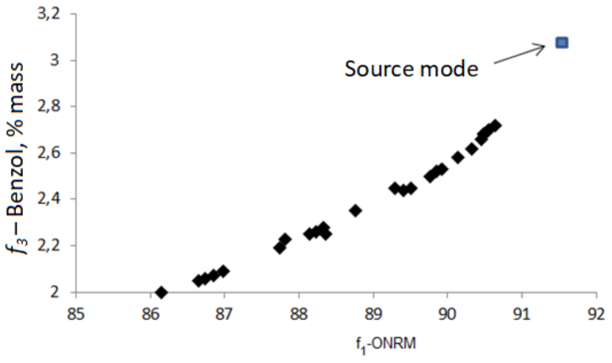
$$x_1 = T_1 \in [400;500]$$
$$x_2 = T_2 \in [400;500]$$
$$x_3 = T_3 \in [400;500]$$

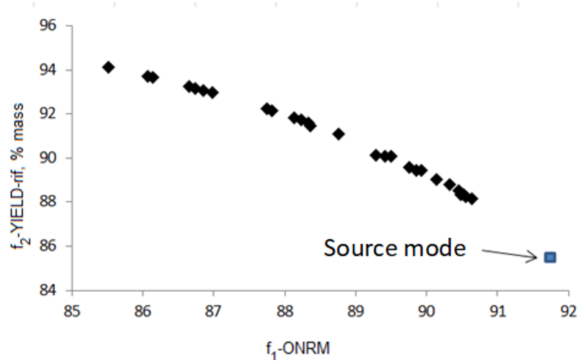


The study of catalytic reforming kinetics and influence of temperature mode on the target product yield provides for modernization and improvement of technological process, and allows one to obtain smaller content of benzol and aromatic components in the resultant at permissible decrease of the octane number.

By varying the ratio of catalyst in the reactors

[N1:N2:N3]





There is almost a linear relationship in the Pareto front (area optimality criteria). There is a proportional decrease in ONRM with a decrease in the benzene yield. Then study the relationship of the catalyst in reactors not fundamentally alter the operation of the reactor block.