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THE METHOD FOR OPTIMAL CONTROL WITH REACTOR-REGENERATOR UNIT OF THE PROCESS OF DEHYDROGENATION OF ISOBUTANE TO IZOBUTYLENE

R.A.Melikov

M.Nagiyev Institute of Catalysis and Inorganic Chemistry, NAS of Azerbaijan

laboratory_6@kqi.science.az

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A method has been developed for the optimal control of chemical processes taking into account the data on density, the thermal conductivity of the contact gas, the process parameters – temperature, catalyst consumption, and the mathematical models embedded in the computer.

Keywords: *density and heat conductivity sensors, mathematical model of the process.*

Introduction

A significant place in the total production of synthetic rubber is occupied by rubbers on the basis of polyisobutylene and butyl rubbers produced from isobutylene. To obtain the latter, a promising dehydrogenation of isobutane in the fluidized bed of IM-2201 catalyst circulating in the reactor–regenerator system is widely used. This process is characterized by high selectivity S (80–90%) and yield of the end product A (40–50%). However, the possibilities of this process under industrial conditions are not fully realized, mainly because of the operation of the reactor–regenerator system in a non-optimal mode, due to the influence of the reaction medium and regeneration conditions on the activity of the catalyst. Optimal conduct of the process is hampered by the lack of a convenient and simple mathematical model of the process, taking into account the mentioned influence on its.

The chromatographic methods for analysis of contact gas are discrete, they take considerable time to evaluate the process indicators. This makes it difficult to organize a continuous analytical control of process indicators and ultimately makes it difficult to obtain the adequacy of a process model that takes into account the change in catalyst activity over time. Toughening environmental requirements for the productive processes of the chemical industry and oil refining conditions the necessity search for ways to reduce the man-made burden on the environment. One of the ways to reduce it is to

increase the inter-regeneration run and the overall service life of the catalysts used in the deep processing processes, as well as to improve their regeneration and the competent utilization of the used contacts [1, 2].

Aim of work

1. Evaluation of the possibility of using contact gas density and thermal conductivity sensors for measuring the conversion and selectivity of the isobutane dehydrogenation process based on laboratory and industrial data, over a wide range of temperature and regeneration times.

2. Development of a simplified mathematical model of the reactor–regenerator block taking into account the influence of the reaction medium and the regeneration condition on catalyst activity.

In order to test the possibility of using continuous sensors for controlling the composition of products in tasks of optimal control of the isobutane dehydrogenation process, a functional relationship between the main process indices was investigated and a linear dependences between the conversion value α of the process and the density of the contact gas ρ , on the one hand, and the analogous dependence of the selectivity S of the process and the density of the contact gas ρ_0 , determined without taking into account hydrogen in its composition, on the other hand were obtained [3–5].

$$\alpha = -0.4\rho + 0.05, \quad (1)$$

$$S = 0.71\rho_0 - 0.89. \quad (2)$$

The value of ρ_0 is functionally related to the density ρ and thermal conductivity λ of the contact gas by an expression as follows:

$$\rho_0 = \frac{\lambda_{H_2} - \bar{\lambda}_i}{\lambda_{H_2} - \lambda} \left(\rho - \rho_{H_2} \frac{\lambda - \bar{\lambda}_i}{\lambda_{H_2} - \lambda_i} \right), \quad (3)$$

where ρ_{H_2} and λ_{H_2} are the density and thermal conductivity of hydrogen; $\bar{\lambda}_i$ – the average value of the hydrocarbon components of the mixture, close in their values to the thermal conductivities. Since, ρ_{H_2} , λ_{H_2} and $\bar{\lambda}_i$ are preliminarily specified experimentally, expressions (1) and (2) can be used to directly calculate α and S by the measured values of ρ and λ . The presence of a functional connection between α , S and ρ , λ of final products in the process of dehydrogenation of lower paraffin hydrocarbons makes it possible to create a continuous measurement circuit for α and S using standard density and thermal conductivity detectors included in the circuit of the reactor unit output line. The existing designs of these types of detectors are performed on a bridge circuit and ensure that the gas to be ρ and λ analyzed is located relative to ρ_c and λ_c of the comparative gas.

The yield of the desired component of reaction products A (isobutylene) is equal to

$$A = \alpha \cdot S. \quad (4)$$

With an increase in the catalyst regeneration duration, the maximum conversion is noted practically from the beginning of the reaction. An increase in the reaction temperature leads to an increase in the conversion and a decrease in the selectivity of the process. The value of the coke sediment varies linearly with the reaction time and increases with increasing temperature. Thus, it can be concluded that a change in the time and temperature of regeneration affects the activity of the catalyst during the dehydrogenation of isobutane to isobutylene. The change in conversion and selectivity under experimental conditions of regeneration is experimental.

Each regeneration temperature corresponds to a specific regeneration time at which the maximum conversion is achieved. Moreover, the higher the temperature, the shorter the regeneration time is required to achieve maximum conversion. There are optimal regeneration conditions, which correspond to the maximum process parameters - conversion and selectivity. It should be noted that only a combination of these regeneration conditions ensures maximum catalyst activity in dehydrogenation. The change in regeneration conditions also affects coke formation [6, 7].

Results and its discussion

Carrying out the proposed method consists in the following: after entering the specified process information into the computer, the calculated values of the density ρ and the thermal conductivity λ of the current conversion values α , the selectivity S and, based on them, the calculation of the yield of the target component A (isobutylene) in the reaction products. As well as given optimal values, a comparison is made in the mathematical model and if there is a deviation from the optimal operating mode, directs temperature parameter – fuel is added to the regenerator to provide energy to reduce the carbon on the catalyst and to heat the catalyst and the catalyst flow and impregnation [8, 9].

A high rate of cyclization of the catalyst provides a heated catalyst to continuously maintain the endothermic reaction. With rapid cyclization, a low content of coke is formed on the catalyst, and coke is quickly and easily removed during the reduction step. An additional excess of heat leaving the regenerator in the form of a flue gas can be returned to the recovery stream of a catalyst.

The proposed method allows, unlike the known ones, to carry out continuous monitoring of the main technological indicators of the process and continuous regulation. Selection of optimal technological parameters, in which the plant will work with minimal energy costs, and at the same time a qualitative product with quantitative yields is obtained, is the main task of this method under the most "soft" conditions,

when the environment causes minimal damage.

The use of the proposed method allows to increase the rate of formation of the target products, to reduce the consumption of the catalyst and it may be applied to the branches of the chemical and petrochemical industry to improve their productivity.

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İZOBUTANIN İZOBUTİLENƏ DEHİDROGENLƏŞMƏ PROSESİNDƏ REAKTOR–REGENERATOR QOVŞAĞINI OPTİMAL İDARƏETMƏ ÜSULU

R.Ə.Məlikov

Kontakt qazının sıxlıq, istilikkeçirmə göstəricilərinin, katalizatorun temperatur və sərf parametrlərinin və prosesin riyazi modelinin iştirakı ilə optimal idarəetmə üsulu tövsiyə olunmuşdur.

Açar sözlər: sıxlıq vericisi, istilikkeçirmə vericisi, prosesin riyazi modeli.

СПОСОБ ОПТИМАЛЬНОГО УПРАВЛЕНИЯ РЕАКТОРНО–РЕГЕНЕРАТОРНЫМ УЗЛОМ ПРОЦЕССА ДЕГИДРИРОВАНИЯ ИЗОБУТАНА В ИЗОБУТИЛЕН

Р.А.Меликов

Разработан способ оптимального управления химическими процессами с учетом данных плотности, теплопроводности контактного газа, параметров процесса – температуры, расхода катализатора, а также математической модели, заложенной в компьютер.

Ключевые слова: датчик плотности, датчик теплопроводности, математическая модель процесса.