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The Tasks of Optimal Design and Research of Systems for Cleaning Gas Emissions of Industrial Enterprises

[1]Mirzarakhimov Mirsolikh Sultonovich, [2]iskandarov Jakhangir Ravshan Ogli, [3]umirzoqov Azamat Abdurashidovich, [4]Suvanov Farrukh Ravshanovich

[1]Doctor of Technical Sciences, Professor, Department of Life Safety, Faculty of Mining and Metallurgy, Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan
[2] Doctoral student of the department "Objects of oil and gas processing" of the Faculty of Geology-backlight, Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan
[3] PhD scholar of the department of Mining, Tashkent City, 100095, Tashkent State Technical University named after Islam Karimov, E -mail: a_umirzoqov@mail.ru, tel: +998977207202
[4] Network center for training and training of teachers at the Tashkent Institute of chemical technologies software engineer, Tashkent, Republic Of Uzbekistan, E-mail: suvanovfarrux@mal.ru

Abstract: *The problem of protecting the environment from the harmful effects of industrial gas emissions has now become truly global. One of the effective ways to solve it is the development and implementation of non-waste and low-waste environmentally balanced technologies in which significant importance is attached to the purification of industrial gas emissions from harmful impurities. However, reliable, scientifically sound methods for calculating and designing processes for cleaning gas emissions from harmful impurities, choosing catalysts, and implementing optimal technological schemes are still not sufficiently applied. Naturally, to a significant extent this is a consequence of the lack of a general theory of catalysis, but it is even more due to the small use of modern research methods in the field of processes and apparatuses of chemical technology, mathematical modeling and optimization.*

Keywords: gas, chemically, mechanism, purification, removals, operating mode, sorbent.

I. INTRODUCTION

However, reliable, scientifically grounded methods of calculating and designing processes for purifying gas emissions from harmful impurities, choosing catalysts, and implementing optimal options for technological schemes are still insufficiently applied. Naturally, to a large extent this is a consequence of the absence of a general theory of catalysis, but to an even greater extent due to the small use of modern research methods in the field of processes and apparatus of chemical technology, mathematical modeling and optimization [1].

In this regard, it is especially important to note the necessity and perspective of the strategy of system analysis, the essence of which is the decomposition of a complex physicochemical system into subsystems and then a detailed study of the catalytic system as a whole and at various levels of its hierarchy.

II. MATERIAL AND METHODS

The problem of creating apparatuses for the purification of gas mixtures, fully meeting the conditions of high efficiency, the possibility of utilizing the captured products and substances, requires complex scientific research related both to the development of direct processes and technologies for gas cleaning, and to the creation of efficient devices for these purposes with a simultaneous deep study of the issues of their automation and optimal control [2].

For local gas cleaning systems, it is advisable to consider tasks at two levels of the hierarchy - local cleaning schemes and individual processes. In this case, as a criterion, the maximum degree of extraction of a certain substance (or its minimum content) should be used:

$$R = min\breve{y},\ \breve{y} = f(x, B),\ x_H \le x \ge x_B \quad (1)$$

where x - controlled process variables;
B - coefficients of the process model; хн, хв - restrictions.

III. RESULTS

For plant-wide gas cleaning systems, it is advisable to formulate the optimization problem at three levels of object decomposition [3]. At the first level, where the fundamental problem of choosing an effective gas cleaning scheme is solved, the technical and economic criterion for the minimum of reduced costs is used:

$$\Pi = min\Pi_v, V = \overline{1,1}, \Pi = C_V + E_Y * K_{3,V}, \quad (2)$$

where 1 is the number of possible gas cleaning schemes;
CV and K3, v - prime cost and capital expenditures for all gas cleaning methods.
For each v-th cleaning scheme, restrictions must be met:

$$P_{V,i} \geq P_i^T, i = \overline{1,n} \qquad (3)$$

where n is the number of standardized impurities in the purified gas stream;
Pv j, PiT - calculated and required degree of purification for the i-type of impurities.

This problem can be solved by enumerating options if there are relationships connecting Cv and K3, v with the system performance, and if the number of gas cleaning methods connected in series is small.

When designing optimal schemes for cleaning gas emissions from harmful impurities (the second level of the system), an approach based on solving the classical problem "calculating equations of material and heat balances - choosing equipment" and a simulation method for optimizing options for chemical technological systems is effective [4]. In accordance with (2), for each generated version of the cleaning schemes, the reduced costs are estimated, which serves as a criterion for choosing an effective system.

When optimizing individual devices, it is advisable to use such criteria as the optimum design indicators of devices, a minimum of the time indicator of the device's operation and others, which have the form (1).

The constraints xн and xв can take integer values, for example, {+1; -1} if optimization is performed in the area of the hypercube of the planned machine experiment. Due to the nonlinearity of the target function in optimization problems of this level, it is advisable to use search methods [5].

One of the most effective methods of making decisions in conditions of uncertainty is the method of expert examinations. Assessment of the quality of examinations is based on the selection of subgroups from the group of experts and analysis of the degree of consistency of their opinions. In the case of multi-criteria design decisions, it is advisable to implement an iterative procedure that takes into account additional information from the group's preferences [6].

An algorithm using the method of potential functions is very effective for making decisions on the design characteristics of gas cleaning devices. If there is initial information about the types of devices in the form of a matrix $|x_{i,j}|$, where i is a certain class of the device, a j - signs of this class, a procedure for accumulating experience on the belonging of devices to class A or B in terms of potential functions is organized.

The solution of optimization problems of systems for cleaning industrial gas emissions from harmful impurities can be made even more effective if we build a unified methodological and mathematical support for the research and design stages, especially at the junction of these stages [7]. The logical sequence of the tasks to be solved and the system of experimental tasks at both stages form a certain imitation system, and in conjunction with the decision procedures - a dialogue system. This allows us to fulfill the main requirement - to achieve the solvability of design problems as a necessary requirement for optimization as a whole.

IV. DISCUSSIONS

1. The conceptual scheme for the implementation of the information system for calculating the properties of substances and compounds of gas emissions from industrial enterprises has been substantiated.

2. A multifunctional information system for calculating the properties of components and optimizing the processes of cleaning gas emissions from harmful impurities has been developed.

3. Modern methods of extracting technological information from the thermodynamic calculation of the equilibrium transformation are considered. The influence of some factors on the degree of equilibrium transformation is analyzed [8]. Various semi-empirical methods for obtaining the initial thermodynamic characteristics of chemical compounds are given, as well as some methods of statistical processing of the results at separate stages of the calculation.

4. The basic system principles of the analysis of technological schemes for the purification of gas emissions from harmful impurities have been formulated.

5. The main stages of technological design of systems for the purification of gas emissions from harmful pollutants are disclosed and information support of the design system of the technological scheme of gas purification is substantiated.

6. Reflected the coordination of multilevel tasks for the optimal design of systems for cleaning gas emissions from harmful impurities.

7. The substantive formulation of the tasks of the optimal design of systems for the purification of industrial gas emissions has been completed.

8. A solution to the applied problem of optimization of the thermal regime of a reactor with a stationary catalyst bed is given.

V. CONCLUSIONS

The solution of the optimization problems of systems for cleaning industrial gas emissions from harmful impurities can be made even more effective if we build a unified methodological and mathematical support for the stages of research and design, especially at the junction of these stages [9]. The logical sequence of the tasks to be solved and the system of tasks of the experiment at both stages form a certain imitation system, and in conjunction with the decisive procedures, form a dialogue system. This allows you to fulfill the basic requirement - to achieve the solvability of design problems as a necessary optimization requirement as a whole.

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An analysis of search methods (generation) and choice of options (decision making) indicates that for the time being the generation of structures of chemical-technological systems for gas purification are still unformalized methods that take into account the knowledge of specialists (in the form of heuristics) and their assessment in accordance with the theory expertise. To generate the functional modes of the systems for cleaning gas emissions of industrial enterprises from harmful impurities, it is most expedient to use simulation methods. One of the most effective decision-making methods under the conditions of uncertainty is the expert examination method. Assessing the quality of examinations is based on the selection of subgroups from a group of experts and an analysis of the degree of consistency of their opinions. In the case of multi-criteria design solutions, it is advisable to implement an iterative procedure that takes into account additional information from the preferences of the group.

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