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Control of the lifecycle of a technological complex for the rectification of multicomponent mixtures under conditions of parameter uncertainty

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Abstract. Input parameter uncertainty is paid more attention among such parameters as parameter uncertainty, model uncertainty, choice uncertainty under variability, spatial variability uncertainty, temporal variability uncertainty, inter-site variability uncertainty. When the technological component changes, the control starts working again based on a new paradigm of internal and external circuits. The possibility of using the Monte Carlo method for the analysis and estimation of the uncertainty of input parameters is presented. In the analysis of the uncertainties of the input parameters, the simplification of the selection process and the probability density functions were used. Deviations from the normal distribution were represented by a matrix transformation. The technological function of the rectification complex is presented in an expanded form, the uncertainty of parameters and control actions are highlighted separately. The influence of the uncertainty of actions and the uncertainty of input parameters on the functions performed by the technological complex, the functions of planning and coordination is analyzed. It is argued that the impact of parameter uncertainty on these functions has a direct impact on the state of the complex in its lifecycle.

1 Introduction

Controling the lifecycle of complex technological processes and the complexes of technological devices that implement them remains one of the most urgent problems today. Technological parameters and their uncertainties are important in solving control problems. Accounting for uncertainties makes it possible to evaluate the accuracy of control. Uncertainties can be associated with other indicators, both with parameters and with models at the same time. With regard to the issue under consideration, uncertainties can be divided into the following types: uncertainty of parameters, uncertainty of models, uncertainty in the choice of values under conditions of variability, uncertainty in spatial variability, uncertainty in temporal variability, uncertainty in variability between objects [1]. The influence of these uncertainties on the lifecycle assessment of technological processes can be reduced using

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special approaches. It is necessary to take into account the presence of uncertainties when controling the lifecycle of complex technological processes and devices and when reflecting the results of their comparative assessment. In this case, the methods of uncertainty statistics are used [2]. In [3], stable algorithms for adaptive control and adaptation of uncertain dynamic objects are proposed based on reference models. It is shown that the work of the adaptive control system is to organize the control of the current state with the state of the reference models. The possibilities of the proposed control algorithms for uncertain dynamic objects are analyzed. The article [4] explores the development of robust stabilization algorithms for linear indefinite dynamic objects using iterative algorithms. Despite the fact that significant scientific achievements have been achieved in the cited works, none of them considered the issues of lifecycle management, taking into account the uncertainties of the parameters. All this shows the relevance of studying the issues of managing the lifecycle of complex objects and complexes, taking into account the uncertainty of parameters.

2 Parameter uncertainties in the lifecycle control of rectification complexes

When controling the lifecycle of technological complexes for the rectification of multicomponent mixtures, the operation of the rectification complex is simultaneously affected by uncertainties and control signals. This is a complex control process in itself. Uncertainties, in turn, affect the behavior of the rectification complex. Therefore, when considering the managerial impact on the lifecycle of the rectification complex, it is necessary to pay special attention to the technological functions of the complex (Figure 1).

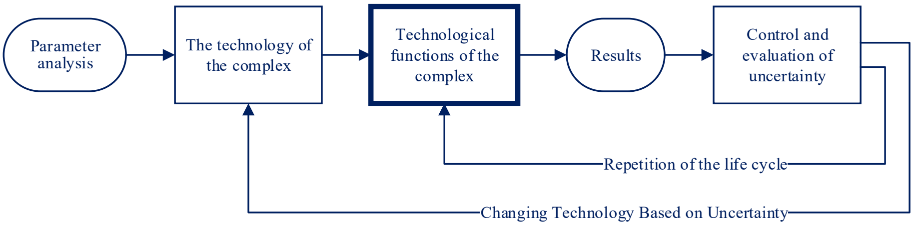

Fig. 1. Influence of uncertainty on technology, technological functions and lifecycle of the rectification complex.

To perform the technological functions of the complex, the parameters necessary for the implementation of the technology, the parameters of the state of the complex, the design and technological parameters of the devices in the complex and the uncertainties in them are taken into account. All of the above parameters are important for all stages of the lifecycle of the complex. Process functions designed with parameter uncertainties can be reused many times until they become unstable. If parameter uncertainties can be "monitored and assessed", the rectification plant lifecycle is guaranteed to be successful and profitable. The implementation of the technological functions of the complex is thus considered as an internal lifecycle control contour, and events in it occur with measurable uncertainties. As a result of monitoring and evaluating the uncertainties of the parameters, accepting them as real uncertainties for a given complex, that is, unmeasured uncertainties, requires changes in the technology components implemented in the complex. As soon as the change is made, the rectification complex implements the rules of its new technology in the "inner contour" in accordance with the new paradigm.

In cases where the function of controlling the parameters of the rectification complex technology is poorly formed, this makes it difficult to perform operations on them. The only reason for this is the complexity of the heuristic representation of the content of such parameters. At the same time, the action function, the resource function, the planning and coordination function, and the control function can be well represented in the rectification complex. When performing complex technological functions, the output signals of some of them are accepted as input signals for others (Figure 2).

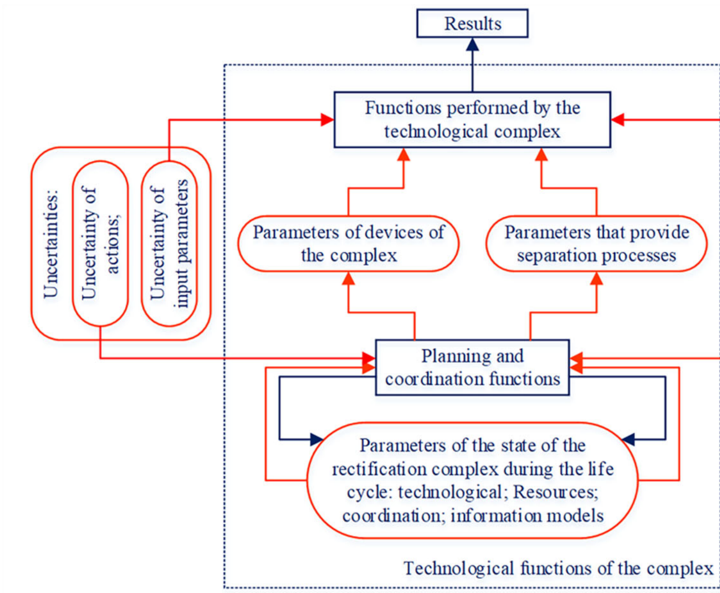

Fig. 2. Technological functions of the rectification complex.

Let us emphasize the uncertainty of actions and the uncertainty of input parameters when performing the technological functions of the complex for rectification multicomponent mixtures. The uncertainty of actions is expressed by the situation that arises during the implementation of the lifecycle stage. In this case, the situation may be somewhat unpredictable a priori, but observable a posteriori.

The influence of the uncertainty of input parameters on the lifecycle management of the complex can be characterized by the Monte Carlo method [5]. This method makes it possible to stochastically estimate the output indicators when controling complex technological processes and the lifecycle of the rectification of multicomponent mixtures in rectification complexes. The data is generated for each of the input parameters based on the values of the technological parameters of the devices of the complex and the values of the parameters that ensure the efficient operation of the rectification process in accordance with the functions performed by the technological complex. The main steps of the Monte Carlo method are to choose the value of the probability density function for each input parameter X_i and take into account its deviations from the norm. In this case, the deviation from the uniform distribution changes to a random deviation from the distribution. Then the output values of the constructed model of the rectification process are calculated. The output z values of the model are expressed by the following equation:

$$z = \sum W_i X_i; \quad (1)$$

where W_i – sensitivity factor; X_i – input parameters; z – output values.

Input parameters X, sensitivity coefficients W and output values z are described by the following expressions respectively:

$$X = \begin{bmatrix} x_1(1) & \cdots & x_n(1) \\ \vdots & \ddots & \vdots \\ x_1(N) & \cdots & x_n(N) \end{bmatrix}; \quad (2)$$

$$W = [w_1 \dots w_n]; \quad (3)$$

$$z = (w^T \cdot X^T)^T, or \begin{pmatrix} w^T \cdot \overrightarrow{x(1)} \\ \dots \\ w^T \cdot \overrightarrow{x(N)} \end{pmatrix}; \quad (4)$$

where N – number of iterations.

Modeling the uncertainty of input parameters based on the stochastic approach is an improved case of the variant considered by B. Maurice et al. [6]. To simplify the use of the method in the analysis of the uncertainty of the input parameters, it was used to simplify their selection and evaluation of the probability density functions. The evaluation was carried out using pairwise comparison [7] and matrix transformation. The problem of developing control models for stochastic processes of separation of multicomponent mixtures based on fuzzy logic was studied in the article [8], but the uncertainties of the parameters were not taken into account.

Figure 1 shows the technological functions of the mixture rectification complex, which can be described in detail in Figure 2 for a clear idea of what it consists of and what functions it performs.

We single out two main factors that affect the technological functions of the complex for the rectification of multicomponent mixtures, these are: uncertainty and control. Uncertainty consists of uncertainty of actions and uncertainty of input parameters. Both uncertainties are independent uncertainties. For this reason, it is possible to use methods to eliminate them independently of each other. And control consists of the control of technological parameters and parameters of the control action. Control influence is directly assigned to the functions of planning and coordinating the technological process of rectification and operation of the complex.

The task of the planning and coordination block is to control the parameters of the rectification device and regime parameters that are important in organizing the rectification process, and transfer the results to the technological function of the complex. During the lifecycle of this block distribution complex, it makes decisions taking into account the functions that reflect the state of the complex, namely the technological function, resource function, coordination function and information models, as well as specific characteristics of uncertainties.

3 Conclusion

Taking into account the uncertainty of parameters in the control of the lifecycle of multicomponent rectification complexes provides a basis for setting and solving control and optimization problems. Among the uncertainties, attention is paid to the uncertainty of the parameters, and their control and evaluation serve to improve the accuracy of the technological operation of the rectification complex. The use of the Monte Carlo method in estimating the uncertainty of input parameters makes it possible to simplify the procedure for choosing a large number of parameter values when analyzing the uncertainty of input parameters. If the rectification of uncertainties and control effects that affect the technological function of the complex allows us to analyze the main effects on the technological function, then the functions of planning and coordination have an impact on improving the quality of the lifecycle management of the complex. In general, taking into account uncertainties in the control of the lifecycle of technological processes and complexes of multicomponent rectification serves to improve the quality of control and increase the efficiency of mixture rectification.

References

1. Mark A. J. Huijbregts, The International Journal of Life Cycle Assessment **3**(**5**), 273-280 (1998). https://link.springer.com/article/10.1007/bf02979835
2. A.M. Beltran, V. Prado, D.F. Vivanco, P.J. Henriksson, J.B. Guinée, R. Heijungs, Environ. Sci. Technol. **52**, 2152-2161 (2018) https://www.doi.org/10.1021/acs.est.7b06365
3. N. Yusupbekov, H. Igamberdiev, U. Mamirov, CEUR Workshop Proceedings **2965**, 296-302 (2021)
4. N. Yusupbekov, H. Igamberdiev, U. Mamirov, Lecture Notes in Networks and Systems **307**, 225-232 (2022). https://www.doi.org/10.1007/978-3-030-85626-7_28
5. C.Y. Baek, K. Tahara, K.H. Park, Sustainability **10**, 922 (2018). https://www.doi.org/10.3390/su10040922
6. B. Maurice, R. Frischknecht, V. Coelho-Schwirtz, K. Hungerbhler, J. Clean. Prod. **8**, 95-108 (2000)
7. C.Y. Baek, K.H. Park, K. Tahara, Y.Y. Chun, Sustainability **9**, 1676 (2017)
8. Yu.Sh. Avazov, Journal Advances in Intelligent Systems and Computing (Switzerland, Springer Nature, 2021) **1323**, 364-376 (2021). https://doi.org/10.1007/978-3-030-68004-6_48