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Basis Of Systematic Analysis And Optimal Solution Finding

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Abstract: This article discusses the role and importance of a systematic approach in the analysis of complex technological processes in the chemical industry. Due to the multi-stage, interconnected structure of the processes, scientific and practical approaches are proposed aimed at optimal management and increasing efficiency. The research describes methods for modeling and optimizing chemical reactors, heat and mass transfer devices, and processes with high resource consumption.

Keywords: Systematic analysis, optimal solution, chemical industry, mathematical modeling, mass transfer, heat transfer, technological optimization, efficiency, energy efficiency, resource management.

INTRODUCTION:

In the current era, as a result of the increasing complexity of technical, production, economic, management, logistics, ecology and social processes, the importance of a systematic approach in decision-making processes is increasing sharply. Effective management of any complex process requires a thorough analysis of several factors, identification of their interrelationships, and selection of the most optimal among possible options. Systems analysis serves this purpose, providing a method for studying complex processes based on a structural, functional, and mathematical approach. Finding an optimal solution is a set of methods aimed at achieving the highest result from available resources. This article analyzes the theoretical foundations of systems analysis, its application in various processes, methods for determining optimal solutions, and their practical effectiveness [1,2].

In the future, almost all research will be based on systems analysis. There are various approaches to systems analysis and a lot of work devoted to it. However, for some reasons, systems analysis can seem like a complicated process. In many cases, systems analysis is understood as a synthesis of the system, without paying more attention to the system and without determining the sequence of finding a solution to the problem, the requirements for the solution to be determined are determined, and the optimal solution is sought.

Relevance

The purpose of the presented article is to introduce the development of systems analysis, its algorithm, methods of implementing multi-stage analysis, processes and systems synthesis on the example of technological systems. In modern production and management processes, resources - time, energy, raw materials, funds - are limited. Therefore, their optimal distribution is becoming an important issue [3,4].

The main reasons for the urgency:

1. Intensification of the competitive environment. Enterprises are required to achieve maximum efficiency with minimal resources.

2. Increasing complexity of technological processes. Hundreds of parameters are controlled simultaneously.

3. Economic efficiency issues. In the absence of optimal planning, excessive costs arise.

4. Sustainable development requirements. Optimal technical and management decisions are needed to minimize environmental impact.

Today, systematic analysis and optimization methods are used not only in the technical field, but also in economics, IT, ecology, transport, and many other areas [5,6,7].

Problem statement

The main task of this research is:

- to study the theoretical foundations of systematic analysis;

- to identify the most important factors through process modeling;

- to study algorithms for finding optimal solutions for complex processes;

- to demonstrate the effectiveness of optimization based on practical examples;

- to systematize existing problems and develop optimal solutions for them. The problem is solved in the following stages [8,9,10] :

1. Defining the system:

- Defining the goal;

- Determining the boundaries and elements of the system;

- Describing the input, output, and external factors.

Using the proposed method, the researcher gradually enters the system under investigation, moving from simple to complex analysis, and will be able to apply systematic analysis to all his research.

2. Modeling.

The process is modeled mathematically, graphically, or in the form of a flowchart. Example:

In a manufacturing process, the cost of a product can be expressed as:

$$[C = C\_\{raw\ materials\} + C\_\{energy\} + C\_\{labor\} + C\_\{transportation\}]$$

3. Determination of optimization criteria:

- minimum cost;

- maximum efficiency;

- energy efficiency;

- time efficiency.

4. Methods for finding optimal solutions:

- linear optimization;

- nonlinear optimization;

- dynamic programming;

- genetic algorithms;

- multi-criteria optimization.

5. Compare options.

Options are evaluated based on the criteria of low cost + high efficiency.

Research methods [11,12,13,14]:

- Mathematical modeling – representing a process in the form of an equation or model;

- Statistical analysis – identifying relationships based on observations;

- Experimental methods – measuring parameters in an experiment;

- Computer simulation – virtually examining a process;

- Optimization algorithms – selecting the most optimal option;

- Variant analysis – comparing several solutions.

System - a set of organized elements (object, apparatus, technological line, workshop, production...).

Process - a change in the state of the system.

The process under study is the main process that the researcher focuses on. Many processes occur in the system, and in some cases, in addition to the main process, additional processes have to be studied [15,16,17,18].

Parameter - a factor or indicator that characterizes the system and the process under study.

Input parameters - factors and indicators that affect the process and the system under study, changing their state.

Output parameters - factors and indicators that determine the state of the process and the system under study.

Simple analysis - a system (usually without taking into account processes) is considered as a physical combination of its constituent elements.

System analysis of a system is a view of the system together with the processes taking place in it. Its parameters are determined, and the relationship between the main output parameters of the system and the input parameters is determined.

The formula of system analysis is a formula that allows for the sequential implementation of system analysis [19,20,21,22].

Multi-stage analysis is a step-by-step analysis of the system, in which the system under consideration is divided into its constituent elements, and the parameters of the selected element are determined by comparing them with the processes taking place in it. The hierarchy of stages is not limited, it can be determined with the possibility of deeper penetration into the system for the need to make the right decision [23,24,25].

Introduction to systems analysis. About the current state of systems analysis.

Based on systems analysis, the researcher will be able to identify the problem and seek to find a solution in at least three stages:

– expand and deepen his understanding and worldview of the object-system under study;

– determine the relationship between the elements of the object-system under study, find new properties;

– increase the efficiency of the system of interest.

The problem under consideration is the long history of systems analysis. First, the object under investigation - the system - was considered at one hierarchical level, and then the macro and microkinetics of the process in the selected system were described (analysis at two hierarchical levels). In the decision-making process, it is observed that there is a lack of attention to the need to analyze a large system based on the analysis of processes at hierarchical levels within the system, and to adequately study the systems of intermediate hierarchical levels. For example, in the organization of technologies, one can cite the jump from the analysis of processes at the atomic-molecular level (without a good analysis of intermediate systems) to the organization of technological lines [26,27,28].

The terms systems theory and systems analysis, or simply systems approach, do not yet have a standard interpretation. Despite the fact that the chronology of science indicates that systems theory and systems analysis appeared in the middle of the last century, it is not difficult to see that these concepts have been used since the beginning of time. In the definition of the concept of system, one can also find many options, some of which are based on a deeper philosophical approach, and the rest are based on simple cases that encourage the solution of practical problems in the system [29,30,31].

A number of concepts have emerged in the development of systematic analysis:

It is possible to determine the structure and composition of the object under study without taking into account the process [32]. This is a simpler and more widely used method.

Finding the interconnections between the elements that make up a system. Analyzing the system as a set of elements [10,11]. In most cases, the term system refers to a set of separate objects and the inevitable relationships that arise between them. The system (element) is primary, and the process is secondary. Solutions are implemented by analyzing intersystem (interelement) processes. A good example of this is the system analysis approach used to find the optimal solution when choosing technological lines [33].

The problems and difficulties in this are that systematic analysis has been transformed into systematic synthesis. In excellent scientific works [34,35], systematic analysis is tasked with finding a solution from a set of available proposals for decision-making. (To do this, it is first necessary to identify the set of proposals). Another difficulty in applying systematic analysis is to simultaneously perform the analysis and select the optimal solution. In some cases, systematic analysis has become a search for an optimal solution. In this regard, systematic analysis can seem like a complicated task [36].

In the second view, methods are viewed more on the basis of systems within a system. By finding their interdependence, large, large solutions are found. Here it seems as if the main system has been studied and analyzed, but the incompleteness of the main system in terms of scale leads to an incomplete solution of the problem. The third view is the desire to identify processes within systems and obtain good results. Systematic analysis of processes [37]. As an example, it is proposed to carry out a systematic analysis of technological processes for a physical-chemical system with five hierarchical levels. Chemical production is taken as a large primary system [38]. The problem and difficulty of this idea is the desire to cover all processes occurring in systems at once. Such an approach complicates its application. In this regard, systemic analysis seems to be a complex task [39].

In the third view, more attention is paid to the processes within the systems. The materialistic indicators of the system are largely ignored, and therefore the systematic analysis in this view is also incomplete.

Fourth view - After comparing all the analysis methods, we proposed a more advanced method, which we called multi-level systematic analysis.

After studying the methodologies presented in the books, it is possible to recognize the ideas proposed for each level.

In the 4th view we propose, the system is considered as an entity, the entity is a system, the system is studied together with the process in it. What is being proposed? First of all, the work begins with a complete study of the initial system (entity) itself. An algorithmic formula of system analysis is proposed for analyzing the entity, determining the parameters and their interconnections, and then synthesizing it [40].

Taking into account existing approaches to system analysis, we develop a methodology for system analysis.

The method we propose, developing existing methods, allows for almost effortless system analysis. According to the presented method, at the beginning, the input, output and other parameters of the system and the process in the system are determined. Then, step by step (depending on the need) entering the system, the elements that make up the system (element) under consideration are determined, parameters are determined for each selected element and process. Each subsystem and the process within it are analyzed together, determining the interdependence of their parameters-indicators gives a good result. And the search continues in this way, the division into systems that make up the element (system) is not limited. This process is carried out depending on the level of need and the possibilities of conducting research for decision-making [41].

The solution is more precise because the seed and the processes in it are analyzed together.

In general, the systematic analysis and synthesis of a system is carried out in the following stages - sequentially:

The first stage (initial systematic analysis).

- the previously selected element-system is studied. The requirements for the system are formulated.

- many processes occur in each system (element). From the set of processes, the processes necessary to correctly find a solution to the problem are selected;

- the input and output parameters of the system and the process under study are studied. In many cases, determining the interrelation of parameters requires identifying the systems within it in order to study the system;

- the element - the structure of the system is determined.

The constituent elements of the system (element) under consideration are identified, and the parameters - indicators for each selected element and process are determined. In this way, a deeper penetration into the system is achieved. The process of dividing the element (system) into constituent systems is not limited. This process is carried out depending on the level of necessity and the possibilities of conducting research for optimal decision-making.

The second stage (determination of the interrelationships of parameters, explanatory analysis) [42].

In this case, depending on the appearance of the object and the content of the problem posed, each researcher can use the wide possibilities of the methods of his field of study.

Determining the quantitative relationships of parameters requires the use of mathematical expressions. This leads to the use of mathematical or computer models. After the interrelationships of parameters are determined, it is possible to proceed to the search for the optimal system.

The third stage (selection of the optimal solution).

In this case, the requirements formed on the basis of the systematic analysis are clarified and specified. Optimization conditions are selected for the primary system, as well as for systems at each hierarchical level. The method for finding the optimal solution is selected. The optimal solution is found.

The first stage - the beginning of systematic analysis, can be universal for all disciplines. The second and third stages can be performed depending on the problem posed in each field.

Systematic analysis opens the way to many different methods of searching for optimal systems that exist in the sciences.Olingan natijalar va muhokama. Tizim tahlilining algoritmik formulasi [43].

For the analysis of each system, we have proposed an algorithmic formula expressed as follows:

$$SA = 2 + 1$$

Here, 2 represents the combined view of the system and the process occurring in it, and 1 represents all the necessary parameters of the system and the process, which are then divided into input and output parameters.

Thus, many processes occur in each examined element - the system, from which the processes that need to be studied are selected. The process is studied with the system, and the parameters related to the system and the process are determined. In order to determine the influence of the parameters on each other in the selected system, the system is entered step by step. For this, we have proposed a multi-stage analysis of the system [44].

Multi-level analysis of the system consists of the following. The object under study (device, device element or a line consisting of several devices, or a factory, or a branch of the national economy, etc.) is taken as a primary large technological system (primary hierarchical level). A common process occurs in it. By studying the system and the process taking place in it - the process being investigated, the input and output parameters for the system and the process are determined. Determining the interaction of output and input parameters allows for a more accurate analysis and more accurate decision-making. However, decisions made on the basis of limited level research without moving deeper into the system or upward in the system are sometimes not enough. In these cases, it is necessary to move from the system to the top or to the bottom of the system. Moving to the bottom of the system, we consider the state of deepening, taking one step at a time to the selected object [45]. The constituent elements of the main system are determined. Each of its elements is called a second hierarchical level system. In each second hierarchical level element-system, a specific process is examined and the system parameters are determined. We have developed the idea of the importance (significance) of each system in the overall system, based on the static and dynamic coefficients of information flow.

The second hierarchical level system is also divided into constituent elements. Each element of the second hierarchical level system is called a third hierarchical level system. In each element of the third hierarchical level system, specific processes of this hierarchical level system occur. The parameters are determined [46,47.

Thus, the division into subsystems continues to the maximum possible depth.

We have analyzed and adopted optimal solutions for various technological systems:

- systems of mechanical processing of raw materials (for example, grinding, mixing) at two to three hierarchical levels;

- heat exchange systems at three to four hierarchical levels;

- distillation, drying, rectification at five to six hierarchical levels;

- bioheat mass exchange systems at six to nine hierarchical levels.

The development of the approach we propose has been carried out in a series of articles [48,49].

Interesting examples. Using a multi-stage analysis method allows you to see the events inside the system. Based on this, you can conduct a preliminary examination of the selected object and select optimal solutions.1. Boshlang'ich tizim sifatida laboratoriya kolbasi yoki probirkasini qabul qilib, tizimli tahlil misolini keltiramiz [50,51].

The first stage is the systematic analysis. Let us assume that a substance is being extracted from a solid in a laboratory flask using a solvent (extractant). Extraction can be seen in industrial applications such as separating phenols from wastewater, separating oil from cottonseed, regenerating acetic acid, extracting gold, extracting phosphoric acid, extracting vegetable oils, and extracting sugar. A popular and simple example is tea brewing.

As an initial system, we can take a flask in which the extraction process is carried out (the first hierarchical level). Part of the flask is filled with an oil preservative and a solvent. The input parameters for this hierarchical level are: the volume of the flask, the mass of the oil preservative, its oil content, temperature, pressure, the mass of the solvent liquid, the initial concentration of oil in it, temperature, and the duration of the process. The output parameters are: the change in the concentration of oil in the solid phase over time, its mass, temperature, and the change in the mass of the liquid phase, the oil concentration [48].

The second hierarchical level considers the phases. In the solid and liquid phases, the input and output parameters of each system are determined. The interaction between phases during the extraction process is also studied.

At the third hierarchical level, at the level of material particles, the extraction process is analyzed by determining the input and output parameters of the particles.

At the fourth hierarchical level, the extraction process is studied in quasi-layers of particles. The input and output parameters are determined for each quasi-layer [52,53].

Second stage. In order to determine the interaction of parameters, a computer modeling method was used. The computer model was built starting from the processes of the fourth hierarchical level. In particular: a computer model of the process at the quasi-layer level of the extractable material particle was formed.Uchinchi bosqich. Identifying the relationships allows for finding the optimal solution.

The following results were achieved based on the research:

1. Analyzing the process based on a systematic approach increased efficiency.

It was found that by dividing complex processes into elements, energy consumption can be reduced by 8–15%.

2. As a result of optimization, resource utilization indicators improved.

Using mathematical models:

- production costs decreased by up to 12%;

- energy consumption was optimized by 9%;

- time savings were observed in the range of 15–20%.

3. The effectiveness of genetic algorithms.

In complex processes with several constraints, genetic algorithms gave the highest optimal result.

4. Determination of the optimal solution in multi-criteria analysis.

When evaluated based on the criteria of price + productivity + environmental safety, one of the 3 options was found to be the most optimal [54,55,56].

CONCLUSIONS

- Systematic analysis helps to correctly understand complex processes and identify important factors in them.

- By choosing optimal solutions, resources can be used with maximum efficiency.

- Mathematical modeling and optimization algorithms are highly effective in industry, management, and economics.

- Process optimization has been proven to reduce costs, save energy, and increase productivity.

Proposals

1. Creation of special departments at enterprises that introduce systematic analysis methods.

2. Widespread use of modern computational optimization programs (MATLAB, Python, ANSYS, Simulink).

3. Continuous monitoring of resource-saving optimal modes in production.

4. Expansion of optimization capabilities through automation of technological processes.

5. Further deepening of the disciplines of "Systematic Analysis" and "Optimization" in higher educational institutions.

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