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Research Article

FUNDAMENTALS OF COMPUTER-AIDED DESIGN CONSTRUCTION OBJECTS

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Bozarov Farkhod Samadovich
The senior teacher of University of Economics and Pedagogy, Non-governmental educational institution, Uzbekistan

ABSTRACT

The article explains the essence of the design process and a systematic approach to the task of computer-aided design. Design tasks are also outlined. The main purpose of the article: to show the essence of the design process, design principles and the basic design principle - a systematic approach. In this article all the information was translated from Russian into English by author.

KEYWORDS

Essence of the design process, complex multi-stage process, synthesis procedure, Methodology, computer-aided design;

INTRODUCTION

Essence of the design process - The essence of the design process lies in the development of structures and technological processes for construction, which must, with minimal cost and maximum efficiency, perform their prescribed functions under the required conditions.

The design of any technological object is the creation, transformation and presentation in the accepted form of the image of this object that does not yet exist. The image of an object or its components can be created in the human imagination as a result of a creative process or generated in accordance with some algorithms in the process of interaction between a person and a computer.

Design includes the development of a technical proposal and (or) terms of reference (TOR), reflecting these needs, and the implementation of the TOR in the form of project documentation.

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The result of the design, as a rule, is a complete set of documentation containing sufficient information for the manufacture of an object in the given conditions. This documentation is the project, more precisely, the final description of the object. Therefore, design is a process that consists in obtaining and converting the initial description of an object into a final description based on the implementation of a set of research, calculation and design works.

Discussion. The design of complex objects is based on the application of ideas and principles set forth in a number of theories and approaches. The most general approach is the systems approach, the ideas of which permeate various methods of designing complex systems.

Design is a complex multi-stage process, which can involve large teams of specialists, entire institutes and research and production associations, as well as customer organizations that will operate the developed equipment.

From the point of view of the content of the tasks to be solved, the design process is divided into the following stages:

- System design, in which design goals are selected and formulated, the initial data are substantiated and the principles of system construction are determined. At the same time, the structure of the designed object, its constituent parts, which are usually functionally completed blocks, are formed, energy and information connections between the constituent parts are determined. As a result, private technical specifications for the design of individual components of the object are formed and formulated;
- functional design, aims to implement the components of the system (complexes, devices, nodes). At the same time, parameters are optimized (structural and parametric synthesis is carried out) in terms of ensuring the best functioning and efficient production;
- design, also called technical design, solves the problems of layout of circuits and placement of elements and nodes. At the same time, they strive to optimize the decisions made in terms of constructive, technological, economic and operational indicators. At this design stage, the technical documentation necessary for manufacturing and operation is developed;
- technological preparation of production ensures the development of technological processes for the manufacture of individual blocks and the entire system as a whole. At this design stage, technological documentation is created based on previous results.

Each stage of design is reduced to the formation of descriptions of the designed product related to various hierarchical levels and aspects of its creation and operation. Design stages consist of individual design procedures that end with a particular design solution. Typical design procedures are the analysis and synthesis of descriptions of various levels and aspects. The analysis procedure consists in determining the properties of a given (or selected) description. Structural analysis can serve as an example of such a procedure. The analysis allows assessing the degree of satisfaction of the design solution with the specified requirements and its suitability.

The synthesis procedure consists in creating a design solution (description) according to the given requirements, properties and restrictions. In this case, in the process of synthesis, the structure of the object can be created (structural synthesis) or the parameters of the elements can be determined that provide the

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required characteristics (parametric synthesis). The procedures of analysis and synthesis in the design process are closely related, since both of them are aimed at creating an acceptable or optimal design solution.

A typical design procedure is optimization, which leads to an optimal (by a certain criterion) design solution. The optimization procedure consists in repeated analysis with a target change in the circuit parameters until a satisfactory approximation to the specified characteristics. Optimization ensures the creation (synthesis) of a design solution, but includes a phased assessment of characteristics (analysis). Design procedures consist of individual design activities. For example, in the process of analyzing mathematical models, one has to solve differential and algebraic equations and perform operations with matrices. Such operations may be of a separate nature, but in general they form a single design procedure.

Design procedures and operations are performed in a specific sequence called the design route. Design routes can start from the lower hierarchical levels of descriptions (bottom-up design) or from the top (top-down design). There is a deep relationship between all stages of design. Thus, the definition of the final design and the development of all technical documentation often cannot be completed until the technology development is completed. In the process of designing and developing technology, it may be necessary to correct the circuit diagrams, the structure of the system, and even the initial data. Therefore, the design process is not only multi-stage, but also repeatedly corrected as it is completed, i.e., the design is iterative.

In the design process, it is necessary not only to create an object that will provide the specified functioning, but also to optimize it for a wide range of functional, design, technological, operational and economic indicators. At separate stages, for certain particular problems, optimization can be carried out on the basis of the developed formal mathematical methods. Often at the design stage it was difficult to foresee some of the requirements arising from the operating conditions.

The development of design is based on a systematic approach and improvement of design processes using mathematical methods and computer technology, integrated automation of labor-intensive and routine design work, replacement of prototyping and full-scale modeling by mathematical modeling, the use of effective methods of multivariate design and optimization, as well as improving the quality of design management.

Methodology of the system approach and analysis to the problem of designing complex systems: A systematic approach allows finding the optimal, in a broad sense, solution to the design problem through a comprehensive, holistic consideration of both the designed product and the design process itself, and can lead to truly creative innovative solutions, including major inventions and scientific discoveries. The main means of design automation are computers and other technical means controlled by them, which create the necessary basis for the full realization of the potential of the system approach.

The systems approach is gaining ground in design and management. The essence of the system approach is that the object of design or control is considered as a system, i.e. as a unity of interrelated elements that form a single whole and act in the interests of realizing a single goal. The system approach requires considering each element of the system in interrelation and interdependence with other elements, revealing the patterns inherent in this particular system, and identifying the optimal mode of its functioning. The

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systematic approach manifests itself, first of all, in an attempt to create a holistic picture of the investigated or managed object. The study or description of individual elements is not self-sufficient, but is carried out taking into account the role and place of the element in the entire system. A methodical means of implementing a systematic approach to the study, design or management of a complex process is system analysis, which is understood as a set of techniques and methods for studying objects (processes) by representing them in the form of systems and their subsequent analysis.

System objects are the parameters of the system under study: input, process, output, goal, feedback, and constraints. The action of system objects is understood as the quality of object parameters. Properties allow you to describe objects quantitatively, expressing them in units inherent in them, which have a certain dimension. If the elements impose mutual restrictions on the behavior of each other, this indicates that there is a connection between them. The presence of a connection between elements and their properties is a condition for the existence of a system. System analysis involves a systematic approach to the study of relationships between elements, between subsystems and the system.

The process of functioning of a complex system occurs at many levels. The system is divided into subsystems, which are the components necessary for the existence and operation of the system. The central stage of the system analysis methodology is the definition of goals. It is important for designers to have a clear idea of what is required from the future control system, what results are desired. Therefore, it is necessary to have a certain set of requirements for the system, i.e. a clearly defined design goal. Already at the very first phases of understanding the problem, it is necessary to have an idea of the goals that are expected to be achieved as a result of the design of the technological process, as a result of its management.

The formulation of goals creates the possibility of choosing the criteria associated with them. In systems analysis, a criterion is understood as a rule according to which certain means of achieving a goal are selected. The criterion in the general case complements the concept of the goal and helps to determine the effective way to achieve it. In the case when there is a clear unambiguous relationship between the goal and the means of achieving it, the criterion can be specified in the form of an analytical expression. This situation is typical, for example, for "simple" design or control systems, when a criterion given in the form of a functional allows one to find control actions that provide a given goal. Therefore, in such situations, the concepts of goal and criterion are not distinguished. In complex systems with a high degree of uncertainty, when the goals are of a qualitative nature and it is not possible to obtain an analytical expression, it is necessary to distinguish goals from criteria, characterizing the means of achieving the goal.

The criterion must meet a number of requirements. It must, firstly, formulate the main, and not the secondary, goal of the functioning of the controlled system, and secondly, it must reflect all the essential aspects of the system's activity, i.e., be sufficiently representative. Thirdly, the criterion must be sensitive to significant changes that occur during the functioning of the controlled system.

For design and control, it is always desirable to have a single optimality criterion, which facilitates decision making and allows solving the optimization problem mathematically. A systematic approach requires tracing as many connections as possible - not only internal, but also external - in order not to miss really

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significant connections and factors and to assess their impact on the system. When developing production process control systems in connection with the use of computers, one inevitably has to consider, first of all, such issues as improving the management structure, methods of preparing and making decisions and, accordingly, the formation of goals and criteria used in the design process.

An essential place in the concept of a system is occupied by the principle of integrity, according to which the relationship and interaction of objects generates new, systemic properties of an object that are not inherent in its individual elements. From the point of view of a systematic approach to design automation, the design process is a multilayer hierarchical procedure with optimization of solutions in each layer. The principle of hierarchy in design and management, as well as the principle of integrity, necessitates the construction of a system of criteria, when particular criteria intended for solving problems of the lower level of management (subsystem) logically coincide with the criteria used at a higher hierarchical level.

In the process of design and control, output quantities are compared, i.e. the result of the functioning of the system, with a criterion. Consequently, the criterion in a controlled system is a sign by which the most effective way to achieve the goal is chosen. It is the value that needs to be maximized or minimized when managing the system in accordance with the purpose of its activity. Thus, the system is a rather complex object that can be divided into constituent elements or subsystems. Elements are informationally connected with each other and with the environment surrounding the object. The set of connections forms the structure of the system. The system has a functioning algorithm aimed at achieving a specific goal.

System approach to the task of computer-aided design: A systematic approach to computer-aided design tasks requires the implementation of joint design of an object or process (CAD) and an automated control system for this process (APCS). In this regard, in recent years, we are no longer talking about solving individual problems, but about the joint design of these two processes.

The traditional separate consideration of the tasks of designing and manufacturing products no longer satisfies the needs of today, since it cannot guarantee either a high quality of design or an appropriate level of organization of production processes that ensure their implementation.

However, it is in the design process that a significant part of the information used to organize production is generated. A new concept has appeared: an automated technological complex (ATC). Jointly functioning CAD systems and the process control system that controls them constitute an automated technological complex (ATC).

Stages of designing complex systems - Consider the main stages of design from the standpoint of information processing technology. Traditionally, the design of complex technical systems is divided into the following stages or stages of development:

- terms of reference for the projected object;
- research work;
- preliminary design;
- technical project;
- working draft;
- manufacturing technology and testing of the designed object (prototype or batch), making corrections (if necessary).

CONCLUSION

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In summary, the use of computer technology in construction has broad prospects, given the volume of construction, information flows, and the variety of participants in this process. The deployment of computer technology is one of the effective ways to overcome the problems of using solutions on construction sites.

Automation of a construction company leads to an increase in business efficiency, its competitiveness, and strategic coordination of all aspects of the business. It also contributes to business optimization, including the integration of business, human resource and information technology management capabilities to improve overall performance.

Considering the advantages provided by the introduction of computer technology, an increasing number of construction companies seek to automate not only the accounting of business operations, design, but also the management of business processes. In response to the increasing demand from consumers, the number of various software products offered by various development companies is also increasing. In addition, the emergence of new Western systems and the further development of domestic developments make the computer technology market more saturated.

Some analysts predict a peak in interest in computerized enterprise management systems in the near future. Many of these software products have similar characteristics, which in turn raises the question of choosing the most appropriate corporate information system for the enterprise.

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