SECTION 15.
SYSTEM ANALYSIS, MODELING AND OPTIMIZATION

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STRATEGIC OBJECTIVES OF MODELING AN ENGINEERING OBJECT AT THE DESIGN STAGE

Development of a mathematical model for an engineering object at the design stage is a process of increased responsibility, as the success of the project implementation as a whole and the subsequent technical support throughout the object's lifecycle directly depend on the obtained results derived from the developed model. In general, the modeling process can be applied to both individual components and the entire engineering object. The methods and algorithms used for constructing the mathematical model may significantly vary depending on the circumstances.

However, in the context of parametric synthesis, the distinction between them is not essential. Therefore, let us consider the engineering object undergoing mathematical modeling, identifying it as the "modeling object" or, in the absence of unambiguous interpretation, the "engineering object" [1,2].

During the development of a mathematical model for an object with the aim of practical application in engineering, it is necessary to define specific requirements. One of the most important requirements is the adequacy of the information obtained based on the model regarding the technical indicators of the designed object. As arguments of the model, that is, as the domain of definition for the corresponding function (functional operator), primary parameters of the object are used. These primary parameters correspond to the parameters of component elements, physicochemical characteristics of materials, geometric dimensions of structural fragments, etc. In a general format, the model of an engineering object can be considered as an artifact (whether it is material or mathematical, i.e., virtual) that reflects the properties of this object using appropriate tools (which can also be material or mathematical). In turn, this model is carefully adapted for comprehensive and thorough examination of the object's operating modes under different conditions and the influence of the surrounding environment as a whole [3,4].

When studying a modeled object, we primarily have the following goals in mind:

Expanding knowledge about objects of a specific class is one of the objectives of studying the modeled object. The process of modeling an engineering object, as previously mentioned, is always aimed at creating artifacts. These artifacts can take the form of mathematical expressions (in the form of mathematical equations or algorithms) or material objects (such as prototypes or experimental samples). They reflect the essence of the modeled engineering object and help explore its possible operating modes.

Forecasting the technical condition of an object under the influence of external factors is an important aspect. The mathematical model developed for the design of an engineering object takes into account the physical processes that affect the formation of its functional properties. This model allows for predicting variations in technical indicators and operating modes of the object in the presence of external factors characteristic of the surrounding environment. The developed mathematical models of the engineering object become the primary tool for forecasting its technical condition during the operational stage and play a significant role in generating the necessary information for making decisions regarding further operation of the object, implementing control signals for its operating modes, and other aspects.

In the field of training specialists involved in the operation support of an engineering object, it is important to have a comprehensive training plan that encompasses both theoretical and practical components. Special attention should be given to the practical component, which involves simulating various situations, including abnormal operating modes and risky scenarios that could lead to a critical state of the object with negative consequences. Such practice enables the engineering and technical personnel to learn how to effectively respond in critical situations and avoid potential errors, thereby reducing the risk of accidents and mitigating their consequences.

The fulfillment of the aforementioned tasks is of particular importance in the context of the safe operation of engineering objects, as mentioned earlier. These tasks help enhance the qualification level of personnel and provide practical professional experience in decision-making and actions, both in standard operating conditions and in unforeseen circumstances that may affect the object. Solving these tasks requires an adequate model of the object, which typically belongs to the class of combined virtual-material models. Such models consist of two partial models: a mathematical model that reflects the functioning processes of the object, and a material model that represents its physical components. Special software is used to implement such a combined model, allowing for the simulation of various situations that may arise during the operation of the object, ensuring a high level of safety. Focus on these tasks is particularly relevant in the field of power engineering, as power engineering objects, being complex systems, belong to the category of high-risk engineering objects.

The mathematical model serves as the foundation for parametric synthesis. In practical engineering, the use of a mathematical model for the development of an engineering object during the design stage (especially in the initial stages) is extremely important and indispensable for this model. This determines many aspects of all subsequent processes that occur throughout the entire life cycle of the object [5]. The significance of this statement is evident, particularly when considering that during the early stages of a project, most of the components necessary for object development are absent (with the exception of standardized and unified components), and the formation of any material embodiment of this object (in the form of a model or prototype) requires information regarding initial parameters that define the schematic and structural embodiment of the considered object's components.

Conclusions. The above indicates that the mathematical (or combined) model serves as the sole and indispensable means and methodological basis for obtaining the necessary data by developers of the engineering object. This data is aimed at making effective schematic, technical, design, and technological decisions, significantly reducing the time typically spent on experimental investigations of the object during the design stage in the context of decision-making.

The development and practical application of a mathematical model for research with various objectives (such as component parametric synthesis or analysis of its functioning under different environmental conditions) involve considering certain peculiarities. The formation of the mathematical model of the designed engineering object is primarily aimed at taking into account a significant number of diverse factors that determine its functional characteristics and technical indicators.

However, this holds significant importance in engineering as mathematical models that account for "as many as possible" physical processes influencing the technical properties and indicators of the designed engineering object are characterized by considerable complexity. In the context of practical engineering, this means that the utilization of such models for virtual experiments, parametric synthesis procedures, simulation of operational situations, and other processes becomes problematic and often unfeasible. This necessitates the development of strategies and mathematical tools that, on one hand, preserve the essential positive properties of these described mathematical models and, on the other hand, enable their wide and effective application in engineering practice without significant limitations.

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