The construction of the system of automation of designing of load-lifting cranes of bridge type

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Abstract. The hierarchical structure of load-lifting cranes of bridge type is considered as a complex dynamic system, on the basis of which the entire object is represented by six levels of ranks of elements. Based on the proposed hierarchical structure, the design process is represented by phases of closed design work. As a result, the main stages of modeling the process of designing a load-lifting cranes of bridge type, on the basis of which the algorithm of design automation is built, are identified. Thus, the use of modern modeling tools will allow to abandon field experiments, take into account the maximum number of measured parameters, that ultimately significantly reduces production expenses, reduce time and labor costs, achieve optimal characteristics.

1. Introduction

The crisis of the 90s had a negative impact on the state of the Russian crane fleet and the production of crane equipment. In this regard, it is necessary to promptly upgrade the crane fleet, which will allow the introduction of automation at all stages of production: from design to maintenance during operation. The direction of development of design of cranes can be divided into two points:

- creation of national standards, and the use of international standards, as until now such standards in the Russian crane industry are absent;
- elimination of shortcomings and further development of automation systems for crane design.

Over the last 10-15 years of automation design have come a long way of development from the point of view of functional extension, ensuring reliability and reducing the cost.

The widespread use of modern computer technology and the emergence on the software market of modern CAD and SAE systems, which led to significant changes in the design processes and accelerate the research of various structures, including engineering. And the use of modern methods of calculations implemented in CAD systems makes it possible to study the various characteristics of the designed objects, which allows you to change the design of these objects without creating experimental samples and not to resort to a long and expensive procedure of field research.

Therefore, further development and implementation of design automation systems will be carried out by simplifying and eliminating existing shortcomings.
2. Formulation of the problem

The load-lifting crane of bridge type is a complex dynamic system (figure 1), consisting of a variety of mechanisms and structures, which moves along a complex trajectory, the nature of which is determined by the translational motion of the center of mass of the crane, the rotational movement of the bridge crane.

![Diagram of the hierarchical structure of the load-lifting crane of bridge type.](image)

**Figure 1.** The hierarchical structure of the load-lifting crane of bridge type is a complex dynamic system, where M - subsystems of the first rank, B - aggregates of the second rank, U - nodes of the third rank, F - elements of h rank, d - the simplest functional elements, conventionally r-rank, L - hierarchy of ranks of elements.

near the trajectory of the center of mass of the crane and of the relative elastic oscillations of individual elements of bridge, travelling mechanisms and cargo. In accordance with the works [1-4], the crane should be considered, in terms of its design, production and operation, as a complex multi-level, hierarchical structure that can be represented, in accordance with the commonly used General approach to modeling complex technical systems using graph theory. Graphs are diagrams consisting of dots and connecting them with straight line segments or curves [2].
Any technical scheme can be represented by a graph, intermediate nodes, which correspond to the ranks of the elements of different levels of detail. In figure 1, different levels of hierarchy are presented: lifting crane, which is a set of subsystems, subsystems, aggregates, nodes, and functional elements - primary structural objects. Thus, the design process is inextricably linked with the creation of a technical system and is one of its stages. Hence, as proposed in [1, 2], the design process can be represented as a hierarchical structure expressed by phases of closed design work (figure 2).

3. Theory
Construction of the algorithm of the design automation system (figure 3) bridge cranes: at the initial
stage, the designer is faced with the task of determining the needs and problems, as well as the formulation of possible solutions, after which a geometric model of the crane is created, which is analyzed by analytical modeling and experimental studies.

As noted in [3-6] when designing a bridge crane, it is necessary to take into account the process of movement of the bridge crane, taking into account the dynamic characteristics, since the elements of movement, such as crane beams, rails, running wheels, etc. are subjected to intensive wear, and the determination of the optimal modes of operation of the electric drive, allows to achieve better technical characteristics.

At the initial stage, the design of the crane is determined: its geometric dimensions are set, the weight of the load is determined, etc., at this stage it is important to determine the choice of the components of the movement mechanism: electric motor, drive, frequency Converter, for this there are many techniques [7]. Then, enter the input parameters, such as acceleration, driving force, etc.

4. Results
Modeling of the design process of the load-lifting crane of bridge type can be represented by the following stages [8]:

- Create Assembly models that consist of elements that have real-world parameters. It uses a library of standard crane parts and a standard range of cranes from information support to design automation systems.
- Setting dynamic links, input parameters of the system.
- Calculation with the help of mathematical support of design automation systems: calculation of system parameters.
- Visualization of simulation results. User in the mode real time, can track system change and output characteristics.

Further, depending on whether the results meet the technical requirements, is the design documentation, or adjusted input parameters for re-calculation.

5. Summary and conclusions
It should be noted that this design automation algorithm is applicable for various software products of design automation systems that have advanced mathematical software and a graphical editor that allows to model the object in 3D mode [7]. It is programs such as Solid Works [8, 9], ANSYS [10, 11] etc. Thus, Solid Works is a powerful tool for 3D modeling [8] and computer-aided design of complex products for various purposes [9]. In fact, this is a complete set for the design of products in digital form, which contains a lot of additional tools that allow you to make a model of virtual technical tests.

In ANSYS complex it is possible to perform calculations of static processes and transients [10], forced oscillations and natural oscillations [11], as well as stability of the system.

Subjects of research can be thermal and stress-strain state of structural elements, stability and frequency characteristics of objects, dynamic response, fatigue, electromagnetism, high-frequency analysis, dynamics of liquid media. Most of the problems are solved in the nonlinear formulation.

Thus, the use of modern modeling tools will allow to abandon field experiments, take into account when designing the maximum number of parameters, and eventually reduce costs, reduce time and labor, to achieve optimal characteristics.

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