Imitation modeling of textile production processes

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Abstract. Intensification of any modern production is accompanied by the creation and implementation of new complex systems of technological equipment, characterized by significant changes in the organization and design methods. In modern conditions, one of the main tools at the research stage and at the stage of building such systems is modeling and comprehensive study of the projected objects on a computer. Imitation modeling is currently an effective tool for studying technological processes and industrial productions. The study of technical-technological subsystems of industrial processes using the simulation method has an analogy with the full-scale experiment. In this case, the computer experiment is carried out using a computer that automates the modeling process and provides the required number of tests in a shorter period. The article discusses the development of an imitation model of the textile industry. It was created on the basis of the structural approach proposed by N.P. Buslenko. Herewith takes into account the stochastic character of the technological processes of textile production. Applied programs, modeling cotton spinning and weaving processes have been developed that allow real-time monitoring of the system status and its parameters.

1. Introduction

Intensification of any modern production is accompanied by the creation and implementation of new complex systems of technological equipment, characterized by significant changes in the organization and design methods.

In modern conditions, one of the main tools at the research stage and at the stage of building such systems is modeling and comprehensive study of the projected objects on a computer. Imitation modeling is currently an effective tool for studying technological processes and industrial productions. The study of technical-technological subsystems of industrial processes using the method of imitation modeling has an analogy with the full-scale experiment. In this case, the computer experiment is carried out using a computer that automates the modeling process and provides the required number of tests in a shorter period.

Currently, imitation methods of modeling are widely used in virtually all industries. Various sources [1-7] provides examples illustrating the usefulness of imitation modeling methods and gives an idea of the problem areas in which imitation is the real part of the decision-making process.

Important point in the development of a specific simulation model for industrial applications is that it can be built using different approaches [1, 3, 4]. These approaches differ in manifold of technological
systems; various cyclicity of production processes and the conditions of their progress of the process; multi-variants schemes of placement and use of equipment; the purpose of modeling; evaluation criteria and a list of restrictions; the chosen language of formalization and programming.

2. Object and methods of research
Objects of imitation, describing such complex systems as textile production, require the development of new and improved approbated approaches to the implementation of imitation methods. The possibilities of modeling complex textile production systems will be examined using the example of mechanized cotton spinning and weaving lines.

The basis for constructing verbal models of the objects of the production systems under consideration is the data of literature sources [3, 8] devoted to the description of the functioning of these systems, which are supplemented by qualitative and quantitative statistical characteristics obtained as a result of timekeeping observations of the work of technological equipment of specific objects of imitation [3].

The principles of imitation, which are the basis for the developed models of the systems under consideration, are the decomposition and hierarchy of the description of objects proposed by N. Buslenko. [2].

A complex hierarchical system can be represented as a collection of a finite number of functionally simpler parts [2, 3]. The obtained parts are broken up until we get elements suitable for mathematical and algorithmic description.

As a rule, in imitation, modeling time is the main independent variable. Therefore, when calculating and modeling complex systems on a computer, it is expedient to use abstract models that process information with discrete time slots [3]. Other variables that appear in the simulation model are functions of time (dependent variables). With discrete imitation, the dependent variables change discretely at certain moments in the simulation time, called the moments of events. As a rule, in discrete models the values of dependent variables do not change in the intervals between the moments of committing events.

3. Results of the research and their discussion
The use of the above principles as applied to the processes of functioning of objects of imitation of textile manufacturing makes it possible to identify a number of technical and technological subsystems of textile manufacturing at the level of structural elements: a system of mechanized cotton spinning line; system of mechanized weaving line and others. Each subsystem within source systems corresponds to technological process performed by particular equipment. At the same time, the connections that ensure their interaction remain.

The processes of functioning of complex systems of textile production can be represented in the form of connected graphs [3]. The nodes of graphs correspond to functional states of technological equipment of mechanized lines of cotton spinning and weaving. The orientation of graphs edges reflects the direction of the operations and their interrelationship.

Mathematical models and algorithms of modeling are developed on the basis of the constructed graphs of functional states of technological equipment [3].

The experimental basis for creating models was the study of statistical regularities in the distribution of random quantities of the implementation of basic and auxiliary processes of production, time to failure, time elimination of technological and technical failures for the different species and types of equipment.

In the development of models and subsequent modeling, the experimental-statistical data obtained are used to determine constants, variables, random and indicator functions. The values of quantity listed are used to select the direction of the imitation modeling process in accordance with their mathematical representation. The choice of the modeling direction is carried out in logical comparison blocks.

Despite the similarities obtained graphs, mathematical models and algorithms for the simulation of textile production, they differ in name used variables, constants, random and indicator functions. When implemented modeling algorithms in program level, these differences are more significant due to the
nature of said information stored in the various elements of the reserved data arrays and some clarification (detailing) of simulated processes.

Synthesis of cotton spinning and weaving subsystem models provides a generalized mathematical model simulating the functioning of objects in the form of systems of logic equations that describe the conditions of the transition from one technical and technological subsystem to another. At the same time, it is taken into account that the technical-technological subsystems of the highest level include subsystems of the lowest level.

The summation or joint functioning of the obtained modeling algorithms of technical and technological subsystems is not sufficient for constructing reliable program models of the systems under study. A description of the schematic diagram of the algorithm for modeling a complex system is additionally required; analysis and accounting of the relationships identified at the stage of creating mathematical models of all levels; as well as the development of auxiliary modules, which will reflect the relevant relationships, interdependencies and part of the functions not implemented in the models of subsystems. These include: 1) management program-monitor; 2) random number generators; 3) modeling reliability parameters; 4) determination of down time.

In addition, the features of representation of models of complex systems on a computer should be taken into account when developing software to implement a simulation model.

By combining the main subroutines-modules that simulate the processes occurring in the technical and technological subsystems of textile production, as well as the auxiliary and providing modules in the schematic diagram of the applied program (Figure 1), we obtain the structure and configuration of the software simulation model of the process of functioning of complex cotton spinning and weaving systems. The presented structure of the model provides its flexibility, the ability to change and add new modules practically without adjusting the rest.

![Figure 1. The schematic diagram of the application program.](image-url)

Applied programs for modeling the systems of mechanized lines of cotton spinning and weaving developed according to the presented in Figure 1 correspond to the chosen modeling ideology, having differences in the interface part. Elements of visualization at imitation of work of each unit of the process equipment allow observing in a mode of real time behind proceeding of technological processes of spinning and weaving. This allows you to make the necessary adjustments in the process of the machine experiment.

The application of the developed application programs simulating the operation of all technical-technological subsystems of mechanized spinning and weaving lines allows us to obtain a number of dependences of the main indices of the spinning and weaving technological processes on the input parameters of the initial data: the productivity of each machine and the entire mechanized line from the
intensity of the raw material input for processing; loading machines for a given time of line work (simulation time); loading of machines with a given amount of produced products; the throughput of the mechanized line and other indicators (Figures 2, 3).

**Figure 2.** Results of modeling of the technological process of cotton spinning.

**Figure 3.** Results of modeling of the technological process of weaving.
4. Conclusion
The methodology described in the article is an effective tool allowing imitating any technological processes in the textile industry and others in industries. In the authors' opinion, the considered methods of formalization, computer simulation, analysis and synthesis of simulated objects on a functional-structural basis allow qualitative and quantitative assessment of various technological processes, as well as choosing the optimal parameters for the functioning of machines and equipment that implement these processes.

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