[2] Autar Kaw, "Tsai□Wu, Failure Theory", in *Introduction to Composite material*. Florida, USA: University of South Florida, Tampa, 2015.

UDC 681.5:519.711

MODELLING OF AUTOMATED PRODUCTION SYSTEMS' WORKING

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The problems associated with the optimization of production systems are quite relevant today. This is due to the high intensification of modern production, the complex structure of production systems, the need for rapid reorientation of production to produce a new type of product. In such difficult conditions, it is necessary to have a methodology that would allow you to quickly and easily model the production system, check its efficiency, give appropriate recommendations for optimizing the construction of the system. Currently, when modern computer technology is widely used, the most rational and promising methods of modeling of production systems is simulation, which allows you to quickly formalize and process large flows of information that occur in modern production systems, easily model the relationship between components system, perform work optimization. Therefore, taking into account all the above factors, there is a need to develop an effective apparatus for mathematical modeling of production systems.

To do this, it is necessary to theoretically substantiate and practically implement mathematical methods of modeling production systems, prove the adequacy of the mathematical model, as well as choose a rational optimization method and create appropriate software that would implement the chosen method in practice.

Typically, a production system is a defined set of blocks (elements), united by some set of connections to achieve a common aim. In production systems, this aim is to perform a given set of works. Each job consists of a number of different operations performed by the respective blocks. The system as a whole provides a consistent passage of each work through certain blocks, a set of operations in which ensures the performance of this work. We believe that the operation is the smallest, indivisible part of the work. In this regard, in the study of production automated systems, quantitative characteristics (parameters) of operations must be specified. These parameters can be set by a matrix, the elements of which are the quantitative effect of the corresponding operation in a particular work. These values can mean either the cost of time, resources, or income, and so on. The specific content of these values affects the formulation of problems for studying systems. The parameters express the quantitative characteristics of the production system as a whole.

The functioning of an arbitrary system is a set of rules that determines what the system must do to achieve its aim; these rules do not necessarily use the knowledge of building a system. In general, according to the level of abstraction adopted in the study of the system, its operation can be described by more or less detailed rules.

Under the structure of an arbitrary system we understand the set of blocks (elements) and a set of connections between them. The structure of the service system is usually represented by a digraph, in which the vertices denote the blocks (elements) of the system, and the arcs - the directions of works' movement from block to block in the process of their execution.

To quantify the degree of achievement by an arbitrary system of the aim set before it, various characteristics of its functioning are introduced. Each individual characteristic evaluates one side of the system, and only together they allow to assess how the system has achieved its goals. Unfortunately, today there is no single method of modeling production systems in general, ie those that would adequately and with sufficient accuracy describe the parameters of production systems of different structures, so to model a specific type of system, or at least several similar types of structures use different mathematical models.

The analysis of methods modeling for production systems for the purpose of their work's optimization has allowed to establish that the structural-logical method of technological systems' research and the methods based on representation of production structures by means of Petri nets have the greatest interest.

The use of structural-logical approach to modeling and optimization of production systems has the following advantages:

a) unification with the help of logical determinants of computational procedures in the study of systems leads to the fact that all calculation and analysis' tasks, as well as synthesis of complex systems are reduced to the calculation of certain logical determinants, ie are the same from a computational and mathematical point of view;

b) obtaining analytical conditions for the optimality of the work's order in the system and on their basis - the procedures for the synthesis of complex systems' some classes have a reduced calculations' complexity;

c) the use of the branches and boundaries' procedure, which is used in the complex systems' synthesis to improve its accuracy and speed, allows to intensify the clipping of unpromising options by additional use of information contained in the optimal conditions and the conclusion of more accurate estimates. in addition, it has reduced computational complexity.

The above advantages of using infinite logic and logical determinants are realized within the structural-logical approach to the study of production systems, which involves structural representation of the studied system and expression of its characteristics through the characteristics of subsystems using infinite logic and logical determinants.

One of the promising approaches to the optimal use of production systems is the mathematical models' development based on computer technology using Petri nets. Petri nets allow to display parallelism, asynchrony, hierarchy of modeled objects by simpler means than when using modeling means, such as methods of mathematical programming, methods of classical optimization, application of traditional queuing systems, etc.

When using Petri nets to model production systems in instrument-making production, the issue of increasing the production systems' efficiency can be solved by improving the methods of managing the work of technological and transport and warehousing equipment.

At the level of the production complex, the actions of receiving, storing, moving and transforming are carried out by the receiving, warehousing, transport and converting complexes, respectively. Each of these complexes according to the accepted hierarchy, in turn, is a technological complex, and on each of them the corresponding technological process is realized. Thus, it is possible to allocate: the receiving technological complex, a warehouse technological complex, the transport technological complex which will transform a technological complex. In the General case, the number of required technological complexes of different types can be any and depends on the characteristics of the implemented production process. The host technological complexes at the enterprise may have logistics and supply services. Warehouse technological complexes at the enterprise are a system of warehouses for storage of materials, blanks, semi-finished products, tools, equipment, etc. The transport technological complex at the enterprise is represented by a transport department or other service that provides transportation on the enterprise territory of materials, blanks, tools and other objects and labor's means. Transforming technological complexes at the enterprise include departments of the basic production (procurement, machining, thermal, assembly).

At the level of the transforming technological complex, the actions of obtaining are performed by the department's supply system, storage actions are performed by the department's warehouse system (for example, department's warehouse of blanks, warehouse of tools, warehouse of devices, etc.), actions of moving are performed by the transport system. and tools for workplaces), conversion actions - a conversion system (for example, a workplace or an automatic line). Each of these systems, according to the accepted hierarchy, in turn, is an operating system. That is, you can select the holding operating system, warehouse operating system, transport operating system and converting operating system, and each of them implements the corresponding operation. The number of required operating systems of different types can be any and depends on the characteristics of the implemented process.

Similarly, you can structure the host, warehouse and transport technology complexes. They also perform actions to retrieve, save, move, and convert, and therefore have the appropriate elements. For example, in a warehouse technological complex designed to store tools, the actions of receiving are performed by the relevant service, the actions of storage are performed by the warehouse itself, the actions of moving - warehouse transport systems, the actions of transformation - tool department. The article shows that increasing the efficiency of instrument-making production can be achieved by modeling and optimizing the equipment load of production systems.

The analysis of production systems modeling methods showed that in solving this problem it is expedient to use modern methods of mathematical and simulation modeling based on the use of structural-logical approach to mathematical modeling of systems and their simulation modeling by Petri nets.

Methods of infinite logic and logical determinants allow to describe the mathematical model of the production system and its characteristics, and the method of branches and boundaries - to optimize its work. The main provisions of infinite logic and ordinal determinants, which are based on the structural-logical approach to the study of complex systems, which include production systems in instrument making, allow to create a mathematical model of the arbitrary structure's system.

The these methods' actual application of modeling production systems can reduce non-production losses of time, thereby saving production resources without the use any other measures of administrative or technical nature.

Keywords: production system, mathematical modeling, optimization, structural-logical method, Petri nets.

УДК 621.391

КОНТРОЛЬ ТА КЕРУВАННЯ ПРОЦЕСОМ ОБРОБКИ ДЕТАЛЕЙ ПРИЛАДІВ В АВТОМАТИЗОВАНОМУ ВИРОБНИЦТВІ

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Комплексна автоматизація приладобудівного виробництва, його перехід на безлюдні технології потребує використання сучасного обладнання: верстатів з числовим програмним керуванням (ЧПК), багатоцільових оброблюючих центрів, гнучких виробничих модулів. Таке технологічне обладнання дозволяє забезпечити високу якість поверхні деталі, точність виготовлення деталей, а також підвищити продуктивність та знизити собівартість виготовлення деталей приладів. Створення на базі цього обладнання автоматизованих виробництв ставить задачу контролю та керування процесом обробки в умовах «безлюдної технології» [1].

Дослідження процесу різання на мікроструктурному рівні показує, що процес стружкоутворення являє собою в'язке руйнування, пов'язане з явищем пластичної деформації. Таке руйнування супроводжується переходом елементарних часток зі стану з великим значенням енергії в стан з меншим значенням енергії, при цьому вивільняється на першому етапі взаємозв'язку частина енергії у вигляді електричних сигналів. Тому контроль обробки деталей приладів повинен бути заснований на вимірюванні, природно виникаючих при різанні, змінної складової електрорушійної сили та потужності різання [2].