AP23490796. Development of digital models of the production process based on multicriteria analysis of BigData management within the framework of technological preparation of production of machine-building enterprises. sc.sp. – Zhetesova G.S.

Actuality

Currently, industrial enterprises function in the conditions of a market economy, one of the main features of which is competition. Thus, in modern economic conditions, increasing the efficiency of the production process due to the optimization of its technological parameters is one of the primary tasks of an industrial enterprise.

The optimization of the technological process is based on a detailed model of the product manufacturing process, which describes the change in its state in the form of a set of parameters. On the basis of the digital model, the target indicators are optimized by changing the values of the control parameters in a given range of values.

From the point of view of the control process, the technological process of mechanical processing is a structurally complex object of control and represents a clear sequence of intermediate states of the product in the process of changing the structure and properties of the initial workpiece. The result of controlling this process is a set of optimal values of technological parameters that contribute to the achievement of intermediate states of the product that meet the specified requirements. In this case, the task is reduced to the formation of the best - optimal management strategy within the framework of a multi-level hierarchical system. The general target state of the control object is characterized by a balanced system of target indicators that determine the overall efficiency of the system.

Thus, optimization of the parameters of the technological process of mechanical processing is one of the main tasks at the stage of technological preparation of production, the solution of which contributes to increasing the efficiency of the industrial enterprise and maintaining its competitiveness.

The implementation of this project is aimed at the implementation of the main directions of increasing the efficiency of management of BigData machine-building enterprises based on the development of a digital model of the production process (digital twin), which allows determining the optimal values of technological parameters of the production process at the stage of technological preparation of production.

The relevance of the research topic is the digitization of production processes of machine-building enterprises based on the development of a structurally complex hierarchical model of the production process, which allows optimizing the technological parameters of the production process depending on the chosen optimization strategy, taking into account resource limitations.

Target project

Development of a digital model of the production process based on algorithms and mathematical models based on multi-criteria analysis of BigData management to determine the optimal technological parameters of the production process taking into account the chosen optimization strategy at the stage of technological preparation of production.

Expected and achieved results

1. A hierarchical model of optimization of the processing parameters of individual structural elements will be developed. Parameterized models have been developed that describe the process of implementation of the corresponding stages of processing for the corresponding elements of the investigated technological process (processing route, technological scheme, workflow).

2. According to the results of the optimization, the technological route of processing the group of holes and the used cutting tool are corrected. Changing the conditions of implementation of the process of processing a group of threaded holes was carried out on the basis of the analysis of the values of the target indicators, which make up the vector optimization criteria for each

control level, as well as on the basis of the analysis of the established optimization strategies for each structural element of the investigated technological process.

3. As a result of the optimization, the labor intensity of the group of threaded holes decreased by 18.3%, while the increase in processing error was 12.1%, and the increase in the surface roughness parameter was 13.2%. The obtained results are considered satisfactory, as they meet the optimization conditions, so it is possible to conclude that the goal of the work has been fully achieved.

4. Patent for a useful model of the Republic of Kazakhstan No. 10793 Method of optimizing the processes of forming parts on metalworking machines dated 27.06.2025
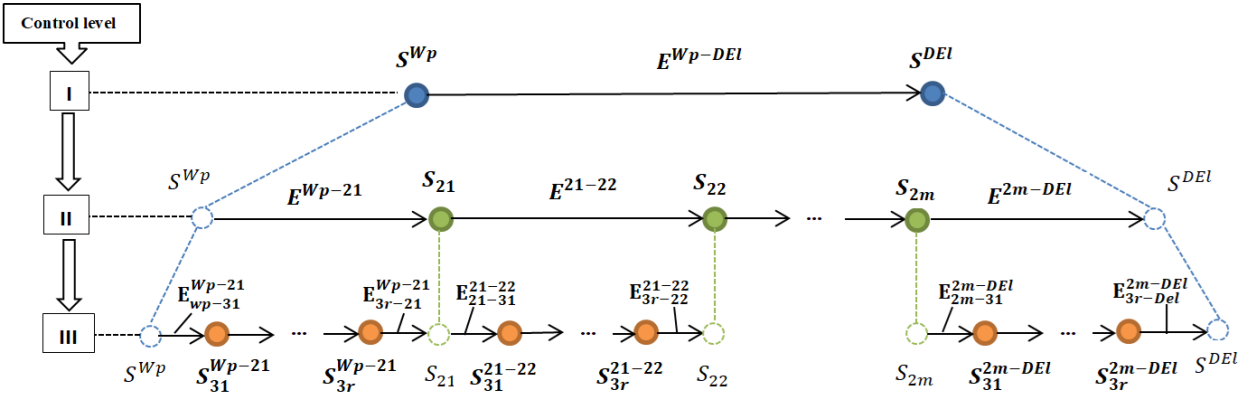
- Control level No. 1: technological route processing;
- Management level No. 2: technological transition;
- Control level No.3: working process.

Figure 1 – Initial information for choosing the optimal option for performing technological operations

In the course of research, the task of optimizing the technological parameters of the process of forming a group of threaded holes M12x1.5-6N (6 pcs.), included in the detail "Flange" (picture 2) made of heat-resistant steel 14X17N2, was solved.
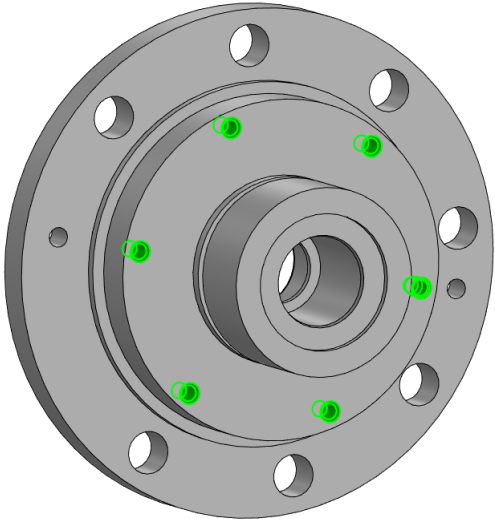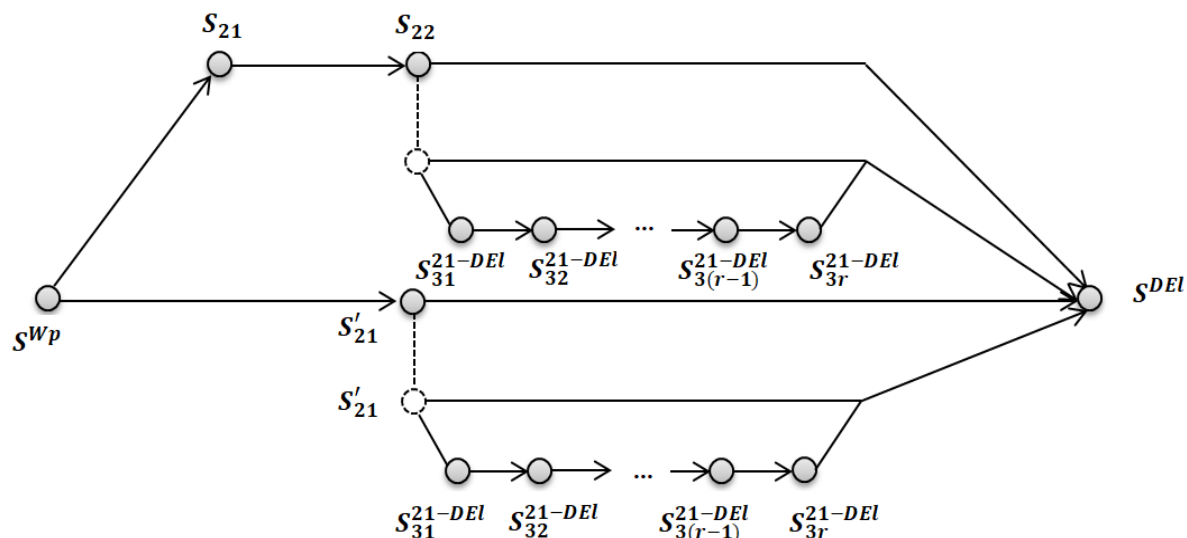

Figure 2 - Full model detail "Flange"

The graph of expedient variants of technological routes for the formation of the investigated group of holes is presented in Figure 3.

S^{Wp} – state of the threaded hole before realization of the technological processing route (workpiece); S^{DEl} – state of the threaded hole after realization of the technological processing route; S^{21}, S^{22} – state of the threaded hole after realization of the 1st - 2-th technological transition; $S_{31}^{21-DEl}, S_{32}^{21-DEl}, S_{3(r-1)}^{21-DEl}, S_{3r}^{21-DEl}$ – state of the threaded hole after 1st...r - one working stroke.

Figure 3 – Structural-hierarchical model of the process of processing a group of holes M12×1.5-6H

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List of publications

1. Жетесова Г.С., Жаркевич О.М., Хрусталева И.Н., Кожанов М.Г., Шахатова А.Т. Анализ методов многопараметрической оптимизации для механической обработки деталей //Труды университета, №3 (96), 2024, 73 - 79

2. Zhetessova G.S., Zharkevich O.M., Shakhatova A.T., Khrustaleva I.N., Shkodyrev V.P. Additive Optimization Method for Choosing CNC Machines for Technological Preparation of Machine-Building Production //Material and Mechanical Engineering Technology, №3, 2024, 32 – 37.

3. Zhetessova, G.; Khrustaleva, I.; Shkodyrev, V.; Zharkevich, O.; Kanatova, A.; Kozhanov, M.; Tattimbetova, G.; Abdugaliyeva, G. Model of Optimization of Process Parameters for Machining of Separate Design Elements of the Product. Appl. Sci. 2025, 15, 5395. https://doi.org/10.3390/app15105395

Information for potential users

Development of a digital model of a structurally complex production process (digital twin) will improve the efficiency of technological preparation of production through multi-criteria analysis of various scenarios for the implementation of the technological process and the selection of the optimal option, which helps reduce labor intensity and the cost of manufacturing the product, as well as improve its quality.

Application area

Technological processes of mechanical engineering production, as well as any technological processes of industrial production.

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