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SCIENTIFIC AND TECHNICAL INNOVATIONS IN TECHNOLOGICAL EQUIPMENT DESIGN AND AUTOMATION

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Purpose. The purpose of the work is to find and determine the optimal machine tools design parameters with the help of CAD elements with the active usage the experience in the design, manufacture and operation of tools in the current machine-building industry. Improving the methods of technological preparation of production, which are related to the design and manufacture of technological equipment for milling grooves, is very important and relevant. A significant reduction in the terms of designing technological equipment is connected with the automation of design processes on the basis of specialized CAD. **Methodology.** On the basis of three-dimensional modulation, libraries of structural elements and typical images of specialized CAD have been developed. The considered synthesis method of equipment designing for milling car bodies. **Findings**. Based on the analysis results of the machine tools power parameters for surface milling, the dependences of the calculations of unnecessary compression forces for different loading schemes of the workpieces, the wedge-plunger type of the transmission mechanism and the tangential stiffness of the tools were determined. **Originality**. An algorithm for finding the necessary clamping force of the workpiece during milling has been created. **Practical value.** Based on the algorithm, a software module for force calculation of the milling equipment was developed. The dependence of the clamping force on the cutting force, the processing method, the compressed air pressure, and the loading patterns of the workpieces are determined. **Conclusions.** Algorithms and software modules were developed for determining the power parameters of wedge-plunger transmission mechanisms and using them to form an information base of specialized CAD systems for equipment. According to established data and calculations, the algorithm was proposed. Obtained results prove the proposed method, but it is required to provide the proposed recommendations into real production.

Key words: technological equipment, automation, automated design systems, innovations, machine tools, technological process.

Work relevance. The main processes in mechanical engineering are mechanical processing and assembly, which account for more than half of the total labor machine manufacturing intensity. Automation of technological preparation (especially technological equipment) significantly shortens production preparation time due to engineering work automation. Project technological works related to the production of equipment occupy a large part of the work total volume on the preparation the production of new machines and equipment [1]. For just one part of the product in large-scale production, it is required to design an average of 10 devices, develop 150 processes for their manufacture, calculate about 1000 time standards, compile 10 material maps, 10 lists of necessary components, etc.

The development of automated design systems (CAD) for the technological preparation of production has been carried out for several decades, but a large part of the problems (including the technological equipment design) are still solved locally, both in terms of the issues scope and processing depth. The main reason hindering the complex CAD solution of technological equipment is the lack of comprehensive engineering design algorithms for the operational description of technological processes and the lack of many reference and normative data [2].

When designing automation, both local and general problems are solved. The first include calculations of the equipment accuracy of equipment, required clamping forces, transmission mechanisms, drives for them, details strength, economic efficiency of the equipment use. General tasks include the equipment design [3]. They can be solved at different levels: from the development of the simplest schemes to the drawing of general types, basic components and details, drawing up specifications.

The most effective means of reducing labor and material costs for technological preparation of production and increasing the level of production equipment is comprehensive unification and standardization of equipment assembly with further production specialization [4]. At the same time, not only parts and assembly units are considered, but also parts, parts elements that have a certain value (holes, grooves, grooves, stiffening ribs, seats of assembly units and parts, windows and cavities to facilitate the construction, etc.).

The development peculiarity of specialized CAD of machine tools is that the library of design elements is created on the basis of the actual production of a specific machine-building enterprise, using its experience in the designing machine tools field and their operation results [5]. This allows the most effective and characteristic constructions of equipment to be used as prototypes for the development of their analogues on the basis of the conducted unification, typification and normalization.

In our case, such an enterprise could be "Avto-Kraz" automobile plant, which has a large-scale production type and is a leading machine-building enterprise for the Kremenchuk region.

The use of real equipment designs as prototypes allows to significantly increase the efficiency of specialized CAD, to reduce the necessary memory volumes of the equipment for storing its information base due to greater "readiness" of its design elements, since they are practically used only as parts and assembly units. An important factor is the fact that the many years of experience in the design and technological equipment usage, accumulated at the plant, are stored and replicated. Structural elements of the part shape in the automated synthesis process of the technological equipment structure are used to correct the basic configuration of the part contained in the structural elements library. They also serve as the basis for machine synthesis of a special part through free design [6].

Materials and research results. Design automation involves work on organizing design elements, limiting their variety and nomenclature. It is necessary to establish standards for the configuration (types) of design elements and their metric characteristics [7].

On the basis of our analysis of the milling devices used at "KrAZ", an equipment for processing parts such as the gearbox housing of the rear axle of the KRAZ car was selected as a prototype.

Designs for machine tool equipment are distinguished by great diversity, multi-component and hierarchical structures, complex geometry of guide elements and a wide range of size changes, universality varying degrees and typification. The specific weight of typical equipment in the total volume of the created structures is low [8]. For these reasons, the method of their machine synthesis is established as the basis of the equipment automated design. The characteristic features of the equipment design synthesis method are the following:

1. A single design information model for the process of synthesis, documentation, technological preparation and manufacturing.

2. The presence of an information field of discrete weak design solutions that change, in the form of elements, on the basis of which the synthesis process is carried out.

3. The existence the synthesis space defined by a set of three-dimensional system of rectangular coordinates associated with elements of different hierarchical levels of structure dismemberment.

4. The dominant role of the main coordinate system in the space of synthesis, the location of which is related to the location of the technological bases of the processed part in the fitting.

5. Hierarchy of synthesis models, the presence the large number of private models reflecting decision-making processes in a wide variety of different design situations that arise during the construction of structures at all its hierarchical levels.

6. A single design information model for the process of synthesis, documentation of technological preparation and manufacturing.

The hierarchy of synthesis models, the presence a large number of private models reflecting the processes of adopting solutions in a wide variety in different project situations that arise during the construction of structures at all its hierarchical levels [9]. Fig. 1 shows a diagram with the synthesis space of the equipment for milling the body.

The information model of equipment designs is a system of parameters that are used to describe tools in the computer in the process of their automated design. There can be several ways of presenting information models of structures. However, all of them should be built based on the understanding of the equipment design as a set of spatially ordered and metrically defined structural elements, each of which has certain geometric, physical, functional, structural, technological and other properties.

According to [10], assuming that the properties of a structural element can be represented by one generalizing parameter – the code of the element E, for the structure K, which consists of n elements, it is possible to write

$$K=\{E_1^*,E_2^*,\ldots E_n^*\}=\{E_n^*\}^n_{i=1}, \qquad (1)$$

where the segment above E indicates the spatial order of the element, and the asterisk indicates its metric determination.

The spatial arrangement of the structural element informs the vector of its spatial position ψ, i. e.

$$E_i^*=(E_i^*,\psi^*). \qquad (2)$$

The vector ψ has three linear (X,Y,Z) and three angular (α, β, γ) coordinates given in the right rectangular spatial coordinate system:

$$\psi_i=(X_i,\ Y_i,\ Z_i,\ \alpha_i,\ \beta_i,\ \gamma_i,), \qquad (3)$$

The metric determination of the structural element is expressed using the vector υ and its dimensional characteristics:

$$E_i^*=(E_i^*,\upsilon_i), \qquad (4)$$

where $\upsilon=(\upsilon_1,\ldots,\upsilon_q)$; $\upsilon_1,\upsilon_{2\ldots}$- dimensions, q – the dimensions number characterizing this element.

If we denote the set of coordinates deviations of the vector ψ with the spatial position of the structural

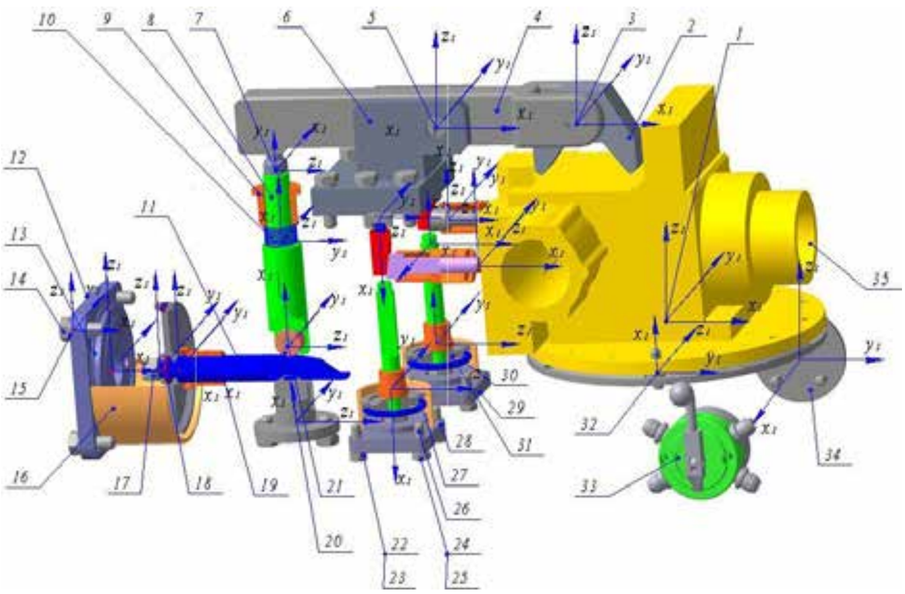

Fig. 1. Synthesis space

element by $\Delta\psi$, and the corresponding set of deviations of the vector dimensions v by Δv and carry out the corresponding substitutions in the above expressions, we get:

$$K=\{E_i, X_i, Y_i, Z_i, \alpha_i, \beta_i, \gamma_i, \Delta\psi, v_i, \Delta v_i\}^{n}_{i=1}. \quad (5)$$

The last expression represents a generalized information model of equipment design. Digital arrays built in a computer according to this information model describe a specific structure and are the result of its software synthesis from structural elements.

The information model of the design reflects the composition and structure of the designed device. It contains information about the elements, their properties, relationships of mutual location and connections.

According to the specified scheme of the synthesis space (Fig. 1), an information model of the device is created, on the basis of which its synthesis is carried out.

K={20000100001*,20000200001*,20000300001*,10000011501*,10000000501*,10600000001*,10000000701*, 40000000801*,10000900001*,10001000001*,20001100001*,20001200001*,20000001301*20001400001}=
$=\{E_{14}^{*}\}^{14}_{i=1}$

K={
01 000 100 00 6 48.545 -134.538 000 0.785 0.785 000 000 000
01 000 100 00 1 89.508 -29.363 000 0.785 0.785 000 000 000
01 000 100 00 2 89.508 -29.363 000 0.785 785 000 000 000
…………………………………………………………………
………………………………………………………………
01 000 100 00 2 -419.742 -302.090 000 0.785 0.785 000 000 000
01 000 100 00 2 -332.624 -204.026 000 0.785 0.785 000 000 000
01 000 100 00 2 -423.847 -254.198 000 0.785 0.785 000 000 000
01 000 100 00 6 -478.581 -183.957 000 0.785 0.785 000 000 000
01 000 100 00 6 -365.008 -204.482 000 0.785 0.785 000 000 000
01 000 100 00 6 -329.431 -195.360 000 0.785 0.785 000 000 000
01 000 100 00 6 -310.731 -184.869 000 0.785 0.785 000 000 000
01 000 100 00 6 -310.731 -184.869 000 0.785 0.785 000 000 000
01 000 100 00 6 -293.398 -196.728 0.785 0.785 000 000 000 000
01 000 100 00 6 -293.398 -196.728 000 0.785 0.785 000 000 000
01 000 100 00 6 -293.398 -196.728 000 0.785 0.785 000 000 000
01 000 100 00 6 -281.996 -206.306 000 0.785 0.785 000 000 000
01 000 100 00 6 -252.348 -247.813 000 0.785 0.785 000 000 000
01 000 100 00 6 -266.488 -271.074 000 0.785 0.785 000 000 000
$\} = \{E_{35}^{*}\}_{i=1}^{35}$

The synthesis of the adaptation should be considered as a process of data accumulation in the information model, which reflected the change in the spatial image of the structure over time. Synthesizing a structure means establishing a spatial-nominal connection of structural elements in any one or several reference systems and displaying this result in the information model of the device. The beginning of this process is the moment of completion of the formation of the canonical model of the processed part, and the end – receiving the result in the form of a digital description of the equipment.

The algorithm for solving the above problems largely depends on the generalized geometry of processed parts equipped class, the synthesized functional group of structural elements, the structural elements used library, processing operations type, the specifics of technological conditions and production traditions for which the system is created, etc. Therefore, algorithms for the machine synthesis of equipment require the use of a large number of different special approaches to solving the problems that arise. At the same time, the task of creating invariant software synthesis modules that would be generalized and suitable for any automated design system is relevant.

Conclusions. The issue of equipment normalization for the purpose of their more effective use in the development of an information base of specialized CAD devices was considered. The obtained data and coefficients as well could be considered during the technological equipment design and development and could directly influence on the possibilities in standardization of CAD systems.

Developed algorithms and software modules for determining power parameters of wedge-plunger, wedge and lever transmission mechanisms and using them to form an information base of specialized CAD devices.

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НАУКОВО-ТЕХНІЧНІ ІННОВАЦІЇ У ПРОЄКТУВАННІ ТА АВТОМАТИЗАЦІЇ ТЕХНОЛОГІЧНОЇ ОСНАСТКИ

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Метою роботи є пошук і визначення оптимальних конструктивних параметрів верстатних пристосувань за допомогою елементів САПР із використанням багаторічного опиту проєктування, виготовлення та експлуатації пристосувань діючого машинобудівного виробництва. Удосконалення методів технологічної підготовки виробництва, які пов'язані з проєктуванням і виготовленням технологічного оснащення для фрезерування пазів, є вельми важливим і актуальним. Істотне скорочення термінів проєктування технологічного оснащення зв'язано з автоматизацією процесів проєктування на базі спеціалізованих САПР. На підставі тримірного модулювання розроблено бібліотеки конструктивних елементів та типових зображень спеціалізованої САПР. Розглянуто метод синтезу проєктування пристосувань для фрезерування корпусів автомобілів. За результатами аналізу силових параметрів верстатних пристосувань для фрезерування поверхонь визначено залежності розрахунків необхідних зусиль стиснення для різних схем навантаження заготівок, клиноплунжерного типу передаточного механізму та тангенціальної жорсткості пристосувань. Створено алгоритм із находження необхідного зусилля затиснення заготовки під час фрезерування. На підставі алгоритму розроблено програмний модуль силового розрахунку фрезерного пристосування. Визначено залежності зусиль затиснення від зусилля різання, методу обробки, тиску стислого повітря, схем навантаження заготівок.

Ключові слова: технологічна оснастка, автоматизація, системи автоматизованого проєктування, інновації, верстатні пристрої, технологічний процес.

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