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Determination of Optimal Conditions of Forming of Surfaces on the Mechanical Processing of Preparations

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ABSTRACT: The mathematical model for determining the rational conditions for machining the working surfaces of the stamp on the final machining operations should be presented in the form of two independent modules describing the processes of turning and boring and round external and internal grinding of cylindrical blanks. The objective function and technical limitations for each of the above types of processing are reduced to a linear form. Mathematical models describing the listed processes can be obtained as a linear (target) function and the definition of rational processing conditions is reduced to a linear programming problem solved by a simple method or by using the graphical method.

KEY WORDS: optimization, technological process, mathematical model.

I.INTRODUCTION

Intensive development of engineering and energy is inextricably linked with the creation of new materials and progressive methods of their processing to obtain products of a given shape with the necessary operational properties. Among the most promising structural materials, allowing to significantly expand the operating conditions of modern technology, is new ceramics, which is defined as a new generation of ceramic materials derived from local raw materials.

Studies show that ceramic materials obtained from local raw materials, as compared with metallic materials, have pronounced advantages in terms of heat resistance and heat resistance, thermal insulation, electrical and many other properties. On the way to realizing the unique capabilities of ceramics, there is the problem of overcoming a number of its shortcomings: fragility, low reliability, and difficulty of processing.

Traditional ceramic technology based on sintering powders at high temperature does not always provide the required level of performance properties and sufficient accuracy of the products obtained, and subsequent mechanical processing is time consuming and expensive due to the high hardness of ceramics. An important problem of obtaining high-quality ceramic parts is to ensure the maximum density of the material to increase its reliability, crack resistance and toughness.

II. SIGNIFICANCE OF THE SYSTEM

Improvement and further development of mechanical engineering is increasingly pressing to technologists the task of strict classification of various types of technological processes, based on objective criteria, allowing to evaluate the capabilities and prospects of each of them in the manufacture of stamps.

The promising areas that provide an increase in quality and a reduction in labor intensity in the production of die parts should include the design of technological processes for their manufacture based on optimization principles. The most complete definition of rational processing conditions should be based on the choice of the most effective set of control parameters, including the type of machining, tool design, tool material mark or tool characteristic, cutting mode, etc.

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III. LITERATURE SURVEY

Comprehensive optimization for the entire technological process is a very difficult task. This is due to the need to create mathematical models for all possible processing options. In real conditions, in the process of machining, first, as a rule, the issue of structural optimization is solved, which involves the choice of one or another method of forming the surface that best meets the selected criteria at each stage of processing.

To evaluate the objective criteria, it is necessary to compare various methods of processing products. The best way for these purposes are indicators that estimate the energy costs necessary to carry out the technological operation under consideration, and the performance of the process at the same operation. However, these indicators themselves do not take into account the one-time area of distribution of the technological process, i.e. do not take into account the areas and volumes of blanks that are simultaneously exposed to energy impact, the quality of the surface layer and its durability.

The existing optimization methods at the stage of improvement and the development of technological processes for the manufacture of parts make it possible to increase the productivity and quality of processing, as well as to reduce the cost of their production. To develop new technological processes for the manufacture of parts on the basis of structural-parametric optimization is a very difficult task that can be accomplished with the presence of mathematical models. This in turn makes it possible to determine the optimal conditions for shaping under different conditions and processing methods. Therefore, optimization should first of all be carried out on operations that most affect the performance characteristics of the work piece.

When optimizing technological processes, the main ones are the type of processing, the machine model, the method of securing the work piece on the machine, the rigidity of the equipment system, the brand of tool material or tool characteristics, the design and geometry of the cutting tool, and other parameters affecting the controlled parameters.

IV. METHODOLOGY

The mathematical model for determining the rational conditions for machining the working surfaces of the stamp on the final machining operations should be presented in the form of two independent modules describing the processes of turning and boring and round external and internal grinding of cylindrical blanks. The objective function and technical limitations for each of the above types of processing are reduced to a linear form. Mathematical models describing the listed processes can be obtained as a linear (target) function and the definition of rational processing conditions is reduced to a linear programming problem solved by a simple method or by using the graphical method.

Analytical or graphical solution of the obtained systems of linear equations for the studied machining processes, with given defining and controlled parameters, will allow determining the working conditions and cutting conditions for turning and boring operations and round outer and inner grinding. This, in turn, makes it possible to evaluate the productivity of the process under consideration and reasonably choose the optimal processing conditions and will allow us to consistently meet the technical requirements for the quality of processing for a given operation.

On the basis of the obtained mathematical models, algorithms were developed and programs written in the Delphi language for calculating rational cutting conditions for finishing turning and boring operations, as well as round external and internal grinding of the punch and die matrix. The joint use of programs for these technological processes, which are separate modules, makes it possible to carry out structural - parametric optimization in the design of the final operations for the manufacture of parts. These programs can also be successfully used to perform parametric optimization on the corresponding operations of the technological process. The basic procedures for solving a system of equations-inequalities and finding the optimal solution are almost identical for both programs.

We will create a mathematical model and a program to determine the optimal processing conditions for turning and boring the punch and die matrix.

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$$\begin{cases} x_1 + y_v x_2 + x_v x_3 \le b_1; \\ (1 + z_{P_z})x_1 + y_{P_z} x_2 + x_{P_z} x_3 \le b_2; \\ z_{P_z} x_1 + y_{P_z} x_2 + x_{P_y} x_3 \le b_3; \\ x_2 + x x_3 \le b_4; \\ z_\theta x_1 + y_\theta x_2 + x_\theta x_3 \le b_5; \\ x_1 \ge b_6; \\ x_1 \le b_7; \\ x_1 \ge b_8; \\ x_1 \le b_9; \\ x_2 \ge b_{10}; \\ x_2 \le b_{11}; \\ x_3 \ge b_{12}; \\ x_3 \le b_{13}; \end{cases} \tag{1}$$

$$f_0 = c_0 - x_1 - x_2 - x_3;$$

where $x_1 = \ln n_3$; $x_2 = \ln(100S)$; $x_3 = \ln(100t_p)$;

$$b_1 = \ln\frac{318 C_v k_v * 100^{(x_v + y_v)}}{T_p^m D_3};$$

$$b_2 = \ln\frac{N\eta * 60 * 1000 * 318^{(1+z_{P_z})} * 100^{(x_{P_z} + y_{P_z})}}{C_{P_z} D_3^{(1+z_{P_z})}};$$

$$b_3^I = \ln\frac{318^{z_{P_y}} * 100^{(x_{P_y} + y_{P_y})} * k_3 * \delta_p}{2C_{P_y} * D_3^{z_{P_y}} \left|\left(\frac{1}{j_{заг}} + \frac{1}{j_{cm}} + \frac{1}{j_p}\right)\right|};$$

$$b_3^{II} = \ln\frac{318^{z_{P_y}} * 100^{(x_{P_y} + y_{P_y})} * \left[k_3 \delta_p - 2\left|(\Delta_{\theta p} - \Delta_{из.p})\right|\right]}{2C_{P_y} * D_3^{z_{P_y}} \left|\left(\frac{1}{j_{заг}} + \frac{1}{j_{cm}} + \frac{1}{j_p}\right)\right|};$$

$$b_4 = \ln\frac{C_3 * Rz^y * r^n * (90 + \gamma)^{0.15} * \alpha^{0.25} * 100^{(x+1)}}{(\varphi\varphi_1)^z * h_3^{0,2}} * k_s;$$

$$b_5 = \ln\frac{\theta_{kp} * 318^{z_\theta} * 100^{(x_\theta + y_\theta)}}{C_\theta * D_3^{z_\theta}};$$

$$b_6 = \ln\frac{1000 * v_{пр.наим.}}{\pi * D_3}; \quad b_7 = \ln\frac{1000 * v_{пр.наим.}}{\pi * D_3};$$

$$b_8 = \ln n_{cm.min}; \; b_9 = \ln n_{cm.max}; \; b_{10} = \ln(100 * S_{cm.min});$$

$$b_{11} = \ln(100 * S_{cm.max}); \; b_{12} = \ln(100 * t_{p.min}); \; b_{13} = \ln(100A);$$

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$f_0 = \ln f_m; \ c_0 = \ln 10000 * l_m * A;$

The research allowed us to obtain a system of linear inequality constraints (1) and the linear function f_0 represent a mathematical model for determining the rational cutting conditions for longitudinal turning and boring blanks with one cutter.

By reducing the system (1) with three unknowns to a system with two unknowns, the solution of the problem can be simplified, as a result of which the analytical and graphical solution of the problem can be carried out in two-dimensional space. For the transformation, we express x1 from the constraint – inequality associated with the cutting properties of the tool, which are largely determined by its resistance.

$$x_1 = b_1 - y_v x_2 - x_v x_3;$$

We substitute the obtained values into all other inequalities of system (1). When turning one of the main limitations associated with the cutting properties of the tool. As a result, we get a new system containing two unknowns, x_2 and x_3:

$$\begin{cases} (y_{P_z} - y_v - z_{P_z} y_v)x_2 + (x_{P_z} - x_v - z_{P_z} x_v)x_3 \le b_2 - (1 + z_{P_z})b_1; \\ (y_{P_y} - z_{P_y} y_v)x_2 + (x_{P_y} - z_{P_y} x_v)x_3 \le b_3 - z_{P_y} b_1; \\ x_2 + x x_3 \le b_4; \\ (y_\theta - z_\theta)x_2 + (x_\theta - z_\theta x_v)x_3 \le b_5 - z_\theta b_1; \\ -y_v x_2 - x_v x_3 \ge b_6 - b_1; \\ -y_v x_2 - x_v x_3 \le b_7 - b_1; \\ -y_v x_2 - x_v x_3 \ge b_8 - b_1; \\ -y_v x_2 - x_v x_3 \le b_9 - b_1; \\ x_2 \ge b_{10}; \\ x_2 \le b_{11}; \\ x_3 \ge b_{12}; \\ x_3 \le b_{13}; \end{cases} \quad (2)$$

$$f_0 = c_0 - b_1 - [(1 - y_v)x_2 + (1 - x_v)x_3];$$

Under the conditions of a specific problem, c0-b] is a constant value, then in such cases the objective function f0 will reach the minimum value when in the equation of the objective function reaches the maximum value the value enclosed in square brackets, that is, the unknown x2 and x3 will maximum permissible values satisfying the system of constraints (2).

Before starting to solve the problem, it is necessary to bring the system of linear constraints-inequalities to a joint form. To do this, you need to correct the source data and technical limitations.

Program to determine the rational processing conditions for turning and boring blanks the task of determining the optimal processing conditions for turning and boring is carried out on a computer by means of a simplex method, i.e. all possible pairs of linear inequalities are solved together, and the joint solution of a system of two such equations gives the intersection point of these two lines, and the points of all vertices of the region of optimal solutions are obtained. From this set of points that satisfy all the constraints, a point is selected that corresponds to the minimum of the objective function.

V. EXPERIMENTAL RESULTS

The block diagram of the main module of the program is shown in Fig. one.

The program consists of two main parts: input of initial data, viewing and analysis of the solution obtained. The initial parameters can be divided into three logical groups:

- Parameters related to the machine on which the machining is performed and the coefficients that determine the cutting speed are displayed;

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- Parameters related to the cutter, with the help of which the treatment is carried out, select the cutter material, the geometrical parameters of its cutting part and holder;
- Parameters related to the work piece, where the material of the work piece, its condition and geometrical parameters, requirements to the quality of processing, type of cooling, coefficients determining the temperature in the cutting zone are indicated.

Due to automatic loading from the created database of various parameters and coefficients necessary to solve the problem. The input of the initial data has been significantly simplified. The parameters and coefficients have been entered into the database, which allow determining rational cutting conditions when processing various steels, ceramics as well as titanium and aluminum alloys. Many coefficients used in empirical dependences for calculating temperature and surface roughness were obtained experimentally by calculating the coefficients of the system by the equations after entering all the input parameters.

- Each row of the table indicates the limitation of these factors, as well as the color that will show the limiting line of the corresponding limitation.
- According to the results of the analytical solution, its graphical interpretation is built. Each technical constraint-inequality is represented by a boundary line, which defines a half-plane, where the existence of solutions of a system of inequality constraints is possible. Intersecting the boundary lines form a solution polygon, inside which any point satisfies all inequalities. From this area, select the optimal parameters that determine the cutting conditions.
- Convenient means are provided to the user to view the graphical solution (moving the area, changing the scale, highlighting the selected direct limit, etc.). This method provides a visual representation of the impact of technical limitations on processing conditions, allows you to analyze, due to which in this particular case, you can increase the productivity of the process.

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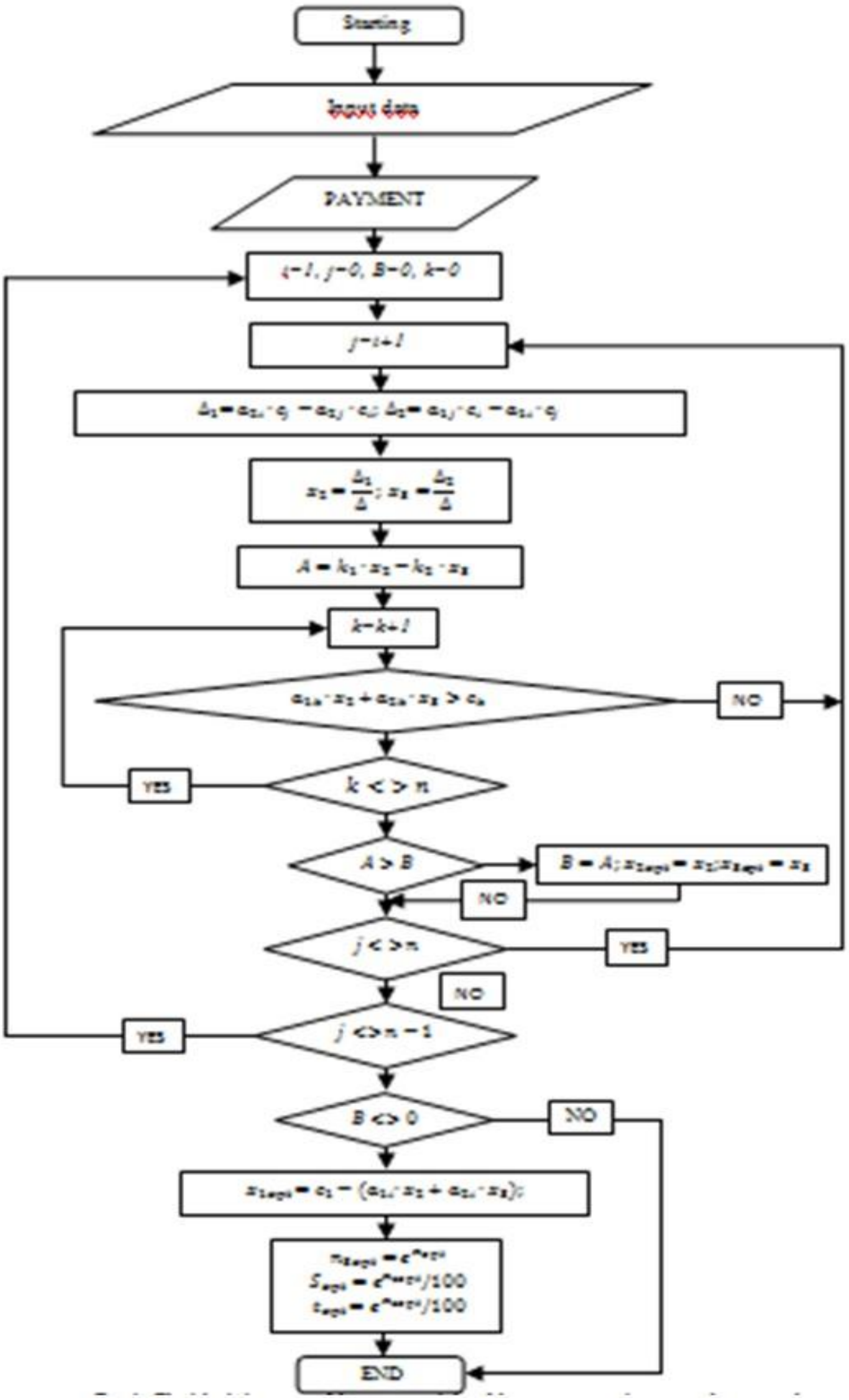

Fig.1. The block diagram of the main module of the program to determine the rational processing conditions for turning and boring.