Parametric Optimization of Technological Processes

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ABSTRACT

The article presents the definition of parameters of cutting conditions that optimize the main indicators of production efficiency, such as productivity, cost.

Keywords: Tool life, roughness, machined surface, product quality, finishing, roughing, feed, cutting speed

In the context of a multi-level choice of solutions at various stages of the design of the technological process (TP), the issue of structural optimization is initially solved. After selecting a certain structure of the processing route, operation, position, transitions or various types of technological equipment, the task of their parametric optimization is set. However, in most cases, this is difficult to do due to the lack of mathematical models that connect the structural components technological processes with a certain group of parameters that determine the technical and economic indicators of these processes.

Parametric optimization of the TP is usually performed after the selection of the transition structure and is expressed mainly in the determination of the optimal cutting modes (speed v, feed s and cutting depth t) from the standpoint of some criterion.

Parametric optimization can also include calculations: on the selection of the optimal geometry of the cutting tool (cutters, drills, milling cutters, etc.); selection of precision, power and strength parameters of machine tools; on the choice of physical and mechanical properties of cutting tools; to determine the optimal values of allowances and tolerances for the dimensions performed.

The task of determining the optimal cutting modes is one of the most massive and is found in the development of various types of TP machining of workpieces. Due to the different specific machining conditions, goals and objectives of optimizing the cutting process, there are different options for setting this task.

When describing the processing process, input and output parameters are distinguished, which are interconnected by complex functional dependencies. The totality of these dependencies is considered to be a mathematical model of the processing process. In general, the processing process is probabilistic. However, due to the complexity of constructing dependencies that take into account the random nature of the change in a number of parameters, deterministic models built on the basis of averaged process characteristics are now predominantly used.

In the tasks of calculating cutting modes, the input parameters are divided into searchable (controlled) and specified (uncontrolled). The task of calculating optimal modes is to determine such values that are the best (for some indicators) for the totality of output parameters at given values of uncontrolled parameters.

As the desired parameters in the calculation of optimal modes, the cutting speed *v* and the supply *s* are usually taken, sometimes the cutting depth t is used. It is also advisable to include in the category of the desired parameters the resistance and geometric parameters of the cutting tool, which can be controlled directly during the machining process. The degree of influence of individual controllable variables on the main indicators of the optimized process is different, therefore, when choosing and the construction of optimality criteria must take into account the most significant processing parameters.

In particular, it is known from the cutting theory that with external turning, an increase in cutting depth has a greater effect on increasing machining productivity at a constant area of the cut layer (*ts* = const). On the other hand, with a constant period of tool resistance, the increase in productivity is more strongly affected by the increase in feed *s* compared to the speed v. . Such a preliminary analysis allows, in some cases, to simplify the construction of algorithms for selecting the optimal processing modes.

In general, the formulation of the problem of optimizing processing modes includes:

- selection of the desired parameters;
- determination of the set of their possible values;
- selection of the analyzed set of output parameters of the process;
- establishment of functional dependencies between the search and output parameters with fixed values of uncontrolled parameters; selection of the objective function;
- assigning ranges of possible values of output parameters.

The set of desired parameters can be represented as a set **of**

$X = (x_1, x_2, ..., x_n)$. Then the problem of calculating the optimal cutting modes is reduced to the following problem of mathematical programming:

$$F(x) \rightarrow \min(\max)$$

$R_i(x) \leq \bar{R}_i$, где $i = 1, 2, ..., m$

where: F(x) is the dependence for the accepted optimality criterion;

R_i (x) is the value *of* the i-th characteristic of the cutting process depending on the values of the desired parameters *x* from some given set X;

R_i is the specified limit value of the i-th characteristic of the cutting process

Depending on the type and complexity of the representation, the functions $F(x)$ and $R_i(x)$ use different mathematical models for calculating cutting modes. These models can be classified according to the following characteristics:

- ✓ the composition of the set of x optimized variables;
- ✓ the composition of the process indicators to be taken into account;
- ✓ the accepted optimality criterion;
- ✓ виду функций $F(x)$ и $R_i(x)$, аппроксимирующих основные зако номерности процесса.

The use of various mathematical models leads to the need to develop a variety of methods and algorithms for solving the problem under consideration [1].

With parametric optimization, one of the following technical and economic problems of selecting the parameters of the cutting mode is usually solved, providing: 1) a minimum of costs associated with the processing process (typical for machining conditions on universal machines in mass production); 2) maximum productivity (typical for limiting positions of machine systems); 3) minimum costs at a given productivity (typical for machining conditions on machines and automatic lines in mass production). The solution of all the described optimization problems is based on the model of the cutting process, which reflects the dependence of the resistance of the cutting tool on the parameters of the processing mode.

In modern mechanical engineering, production is impossible without information support. To increase efficiency and competitiveness, it is necessary to optimize the machining parameters. One of the ways to improve production efficiency is to apply the optimal processing modes obtained by simulation modeling.

From the point of view of production optimization, simulation modeling is more versatile and less time-consuming compared to a physical experiment.

Problem Statement: the task of the study is to determine the parameters of cutting modes that optimize the main indicators of production efficiency, such as productivity, cost. Tool resistance, roughness of the treated surface.

As a workpiece, a shaft made of steel 45, GOST 1050-88 is adopted.

The research methodology consists in mathematical modeling, development of software and mathematical support for computers, the use of numerical methods for solving the optimization problem of part processing and experimental verification.

Development of a mathematical model.

Mathematical models and optimization algorithms have been developed that reflect the relationship of the parameters of cutting modes with quality criteria: productivity (P), cost (C), tool resistance (T) and machining roughness (Rz).

The dependence of criteria P, T, C, Rz on the parameters of cutting modes is taken in accordance with formulas (1), (2) [2] and are presented in the following form:

$$Rom = (1)\frac{\sqrt[0.4]{\frac{(0.25r^{0.15})^2}{x^{0.3}sin\varphi^{0.4}}}}{v\cdot 8r}$$

dde: r – radius at the top of the lathe cutter, mm; v – cutting speed, m/min; t – cutting depth, mm; φ – main angle in plan, deg.

$$P = \frac{\pi\cdot D\cdot n\cdot t\cdot S}{1+\frac{\tau_{\text{ст}}}{\text{T}}}\text{x}10^{-6}[M^3/\text{мин}] \quad (2)$$

dde: D – workpiece diameter, mm; n – rotational speed, rpm; S – feed, mm/rev; τ_{cm} T – resistance of lathe cutters, min.

$$T = (3)\frac{C_v k_v}{v\cdot t^x s^y}\ [\text{мин}]$$

where: C_V is the coefficient depending on the group of processed and tool materials; k_V is a coefficient depending on the strength and chemical composition, processed and tool materials, on the geometry of the cutting tool, the use of cutting fluid; x, y are the degree indicators depending on the brand of processed and tool materials, cutting conditions.

Substituting (3) into (2) and taking as a perturbation the change in the amount of allowance at constant t, we obtain the following function for P:

$$P = \frac{\pi\cdot D\cdot n\cdot t\cdot S}{1+\frac{\tau_{\text{ст}}\cdot v\cdot t^x s^y}{C_v k_v}} \quad [m^3/min], (4)$$

Mathematical models are represented as a set of parametric nonlinear functions. These functions are stored in the database and are used to form an optimization model and present in the required format.

To find the optimal value of the efficiency criteria, the "coordinate descent method" is used for many dimensional functions [3]. Constraints are the valid values of the source data.

Optimization is carried out by varying the initial parameters in the specified boundary ranges.

The optimal solution is given in the form of refined parameter values, at which the objective function takes an extreme value Fmin (or Fmax) for a given performance criterion.

The software for solving the tasks is developed in the Delphi programming environment.

One of the main requirements of this optimization is the quality assurance of the product (Rz), in accordance with this requirement, software has been developed that determines the roughness in a given range for 7 qualities.

In Fig. Fig. 1 shows the graphical form of the program for optimizing cutting modes. Which includes the following components: input of initial data determined by the range of parameters that were taken from the reference books, in accordance with the selected qualification and cutting mode. The following dependencies Rz(V), Rz(r), Rz(t), Rz(φ) dependencies are constructed, which clearly reflect the nature of the influence of each component. From the graphs it can be seen that the cutting speed has a greater effect on the roughness.

In our work, the optimization of Rz is carried out due to the cutting speed.

As a result of calculating the roughness from the values selected from the reference, the required value of Rz is not always obtained. In the next step, we optimize Rz by changing the Vz. Having received the required quality of processing, other economic indicators (P,T,C) are recalculated. The results of the dependency calculation are shown in Fig. 1.

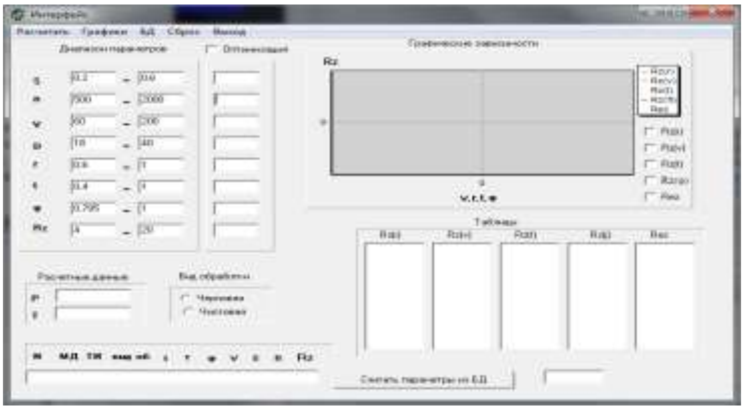
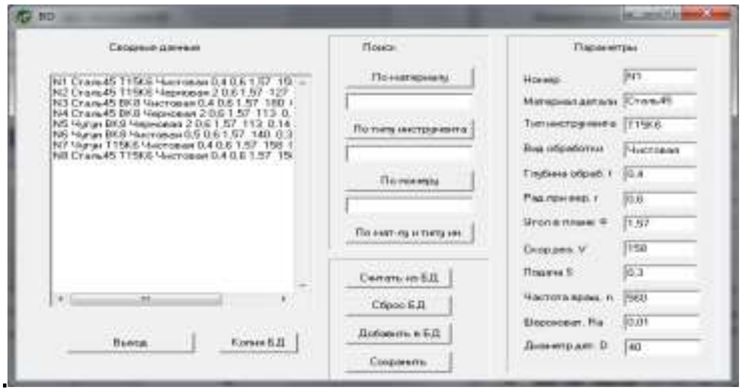


Fig.1 Source form.

Figure 2 shows a database made up of reference books on cutting modes, taking into account various initial data.



Rice. 2 Database.

After entering the initial data, we make a calculation, and we get the following results, the results for rough processing are displayed in Fig.3, for finishing in Fig.4

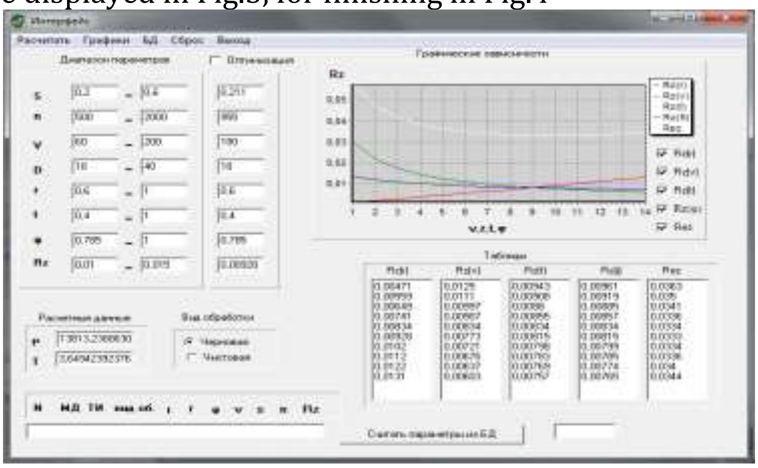
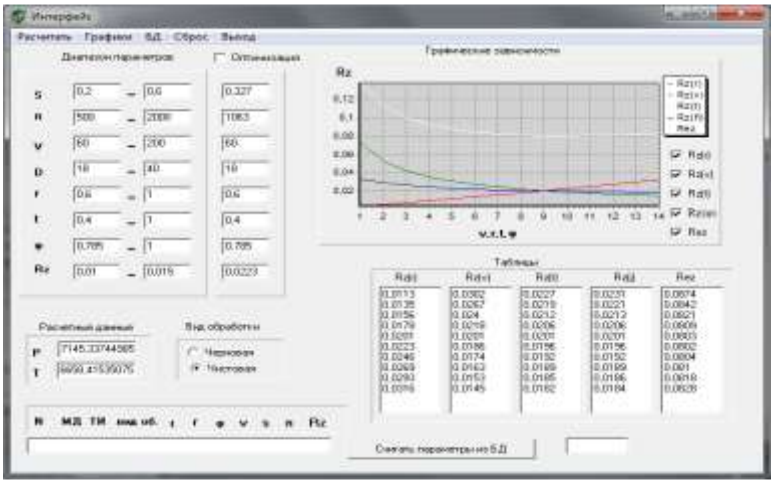


Fig.3. Calculation for rough processing.

The purpose of parametric optimization is to ensure the quality of the resulting Rz surface by determining the parameters of the cutting modes. Ranges of permissible values for the main cutting parameters are taken from the reference books, as a result of the calculation of the average values, we get some deviations from the specified Rz, in order to obtain the required roughness value, it is necessary to investigate the effect of parameters on roughness. We have conducted research and developed a model and program for optimizing Rz.



Rice. 4. Calculation for finishing.

Next, we use the "optimization", and we get the following parameters, the data is displayed in Fig. 5 - for roughing, in Fig. 6 - for finishing.

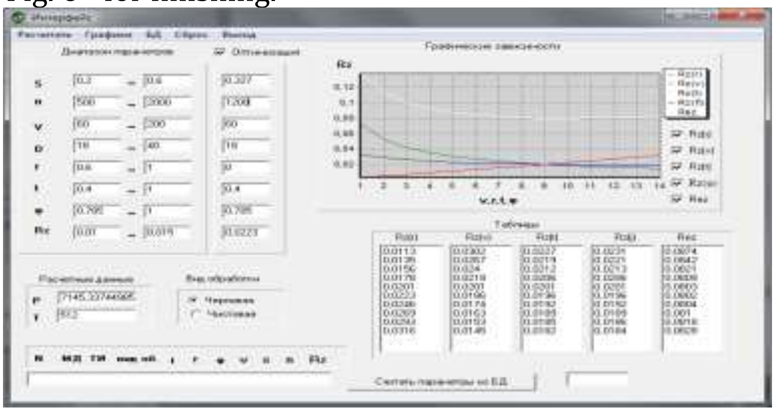


Fig.6 Optimization results for rough processing.

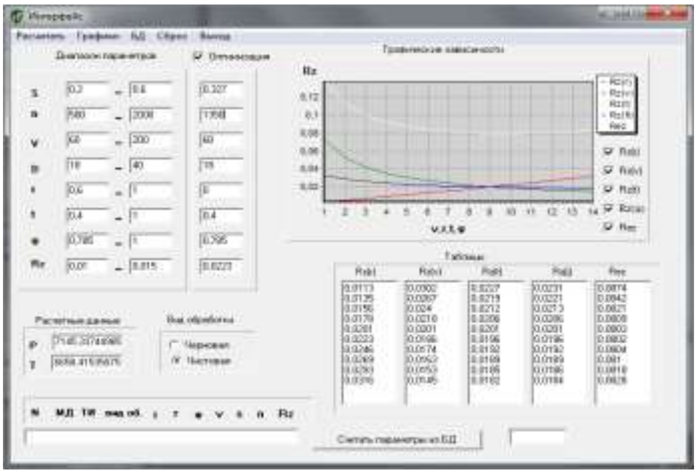


Fig. 7. Optimization results for finishing.

The output data includes the results of calculating the criteria P, T, C, Rz, presented as dependencies P=f(v), T=f(v), C=f(v), Rz=f(v).The results for the calculation are made for the average value S = 0.57 mm / v. The unit of measurement P in the graph is given in^{m3}. Data for other S values within a given feed range is calculated similarly according to the appropriate methodology. From the graphs, it is possible to determine the current values of criteria P, T, C, Rz, when the cutting speed *v* changes between 19 and 195 m / s.

Literature.

1. CAD of technological processes, cutting tools and devices. Ed. by S.N. Korchakov, M.: Mashinostroenie, 1988.-350 p.
2. Klyuev A. S. Optimization of systems of technological control and automation: Inform. approach / A. S. Klyuev, A. T. Lebedev. - M.: Energoatomizdat, 1994. - 96 p.
3. Mudrov A. E. Numerical methods for PC in the languages of BASIC, Fortran and Pascal.- Tomsk: MP "Pasco", 1991.-272 p.