DELIVERING HIGH-TRANSITION PRODUCTIVITY IN FACE MILLING

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Annotation: *Determining errors that occur during the cutting of surfaces of parts in mechanical engineering remains the most important task. Before cutting the surfaces of the workpieces, it is necessary to study the working surfaces of the dies. This article provides information on methods for determining the geometric parameters of the surface when cutting with stamps on shaped surfaces, in particular on the structure of the cutting zone of shaped surfaces, the penetration of the cutter into the cutting zone and control conditions in the cutting zone.*

Keywords: *strength parameters, diagnostics, models, cutting area, strength, durability, stamping, stamping form, cutting parameters.*

INTRODUCTION

CNC B workbenches are carrying out extensive scientific and research work on studying the effect of the forces acting on the cutting tools on the quality of the details, accuracy and the wear resistance of the cutting tools through diagnostic systems during the mechanical processing of the complex-shaped details. In this direction, among other things, research on increasing the service life of cutters on the basis of reducing the amount of cuttings during the processing of complex-shaped details, on the basis of reducing the effect of radial forces affecting the processing surface is considered a priority. At the same time, the development of adaptive software for automatic selection of force diagnostic features and calculation of their limit values, taking into account the reliability of the state of the cutting tool, remains one of the urgent tasks of today.

Materials and Methods.

As noted in the first chapter, processing productivity is significantly determined by the number of processing stages necessary to achieve a given accuracy of a part from a workpiece of one or another accuracy. Due to the well-known property of the technological system associated with the heredity of part errors from the workpiece errors, the required number of stages for refining the workpiece depends both on the properties of the technological system itself and on the degree of spread of the input parameters of the workpiece and its processing modes. In its simplest form, this problem comes down to comparing the value of the processing error calculated using formulas (1) and (2) with the actual dispersion field of the workpiece. If the calculated value is less than the specified value, the part cannot be processed in one stage. In this case, the calculated tolerance value is taken as the required tolerance of the size of the intermediate workpiece and the required tolerance of the workpiece, which must arrive at the previous processing stage, is again calculated. The calculation stops when the calculated workpiece tolerance becomes equal to or greater than the actual tolerance of the existing workpiece. The number of calculation steps gives the required number of processing stages to obtain a given accuracy of a part from a workpiece of known accuracy.

However, as production experience shows, the required intermediate accuracy of the workpiece depends significantly on the rigidity of the technological system, the strength properties of the material being processed, the depth of cut and feed. Due to the fact that the last two parameters are part of the cutting modes, the question arises of determining their optimal values for each stage of processing, and then determining the number of stages or transitions that meet a given optimality criterion.

Determining the optimal number of processing stages

The required number of transitions in order to achieve a given accuracy is mainly determined by the amount of allowance for processing and the manufacturing accuracy of the part. The amount of allowance depends on the accuracy of the COOKING, characterized by the type of production, and the accuracy of the part depends on its service purpose.

An analysis of factory experience in designing operational technological processes for CNC machines showed that processing in several stages or many transitions is mainly characteristic of single and small-scale production. But for high precision parts, multi-step processing is used regardless of the type of production. To determine the required number of transitions, we will use the dynamic programming method based on the principle of optimality [1]:

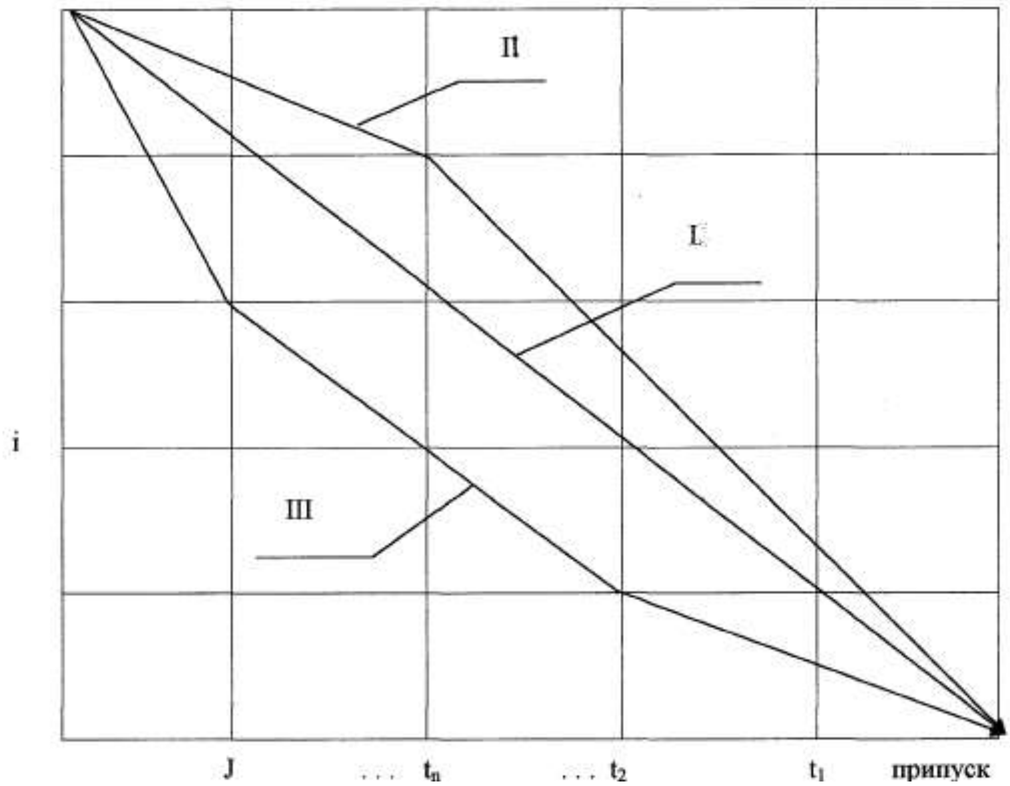
“Optimal behavior has the property that whatever the initial states and the decision at the initial moment, subsequent decisions must constitute the optimal behavior of the relative state resulting from the first decision.” In other words, for optimal control it is necessary that the control of the process at the 1st step be optimal relative to the state in which the control process found itself at the (i-1)th step. This method was first developed by Bellman [10]. The essence of the method is to find the best option using a directed search method using a graph of possible states of the workpiece (Figure 1).

Each state is characterized by an intermediate level of accuracy of the workpiece and the amount of allowance removed. Possible processing plans are depicted as a broken line passing through the vertices of the graph. The number of segments of the polyline means the number of transitions. Among a certain set of processing plans, the plan that gives the required value of the optimality criterion is selected.

One of the most complete criteria for optimality is the cost of a technological operation [1,53,86,90]. Its reduction is caused, in particular, by an increase in processing productivity, including due to:

Scheme for choosing the optimal option for constructing an operation.

Quality



I - processing in one transition

II - processing in two transitions

III - processing in two transitions

Figure. 1

minimizing the cycle time of automatic operation of the machine according to the program.

In general, the shortest path from the initial vertex to any vertex of the graph is determined by the recurrent equation: $T_{ij} = \min_{i<l<N}\{T_{l,k} + \tau_{l,k}^{i,j}\}$

Where T_{ij}- time of the shortest path from the initial vertex of the graph to the vertex with coordinates (i,j);

$\tau^{i,j}_{l,k}$- travel time from a vertex with coordinates (l,k) to a vertex with coordinates (i,j).

This equation is called the functional equation of dynamic programming. It represents a mathematical notation of the optimality principle for the specific process under consideration, reflecting the processing features during multi-transition milling.

Finding the optimal processing plan is carried out in the following way: based on the quality of the part and the quality of the workpiece, the number of possible processing plans is determined: one-transition, two-transition, three-transition, etc. Then, within each processing plan, based on the accuracy of the part and the workpiece, specific processing routes are selected in increments of one grade.

Then, for each of the steps (transitions) of a certain processing route, the required cutting depth and cutting conditions are calculated. After finding the cutting modes, the value of the goal function is calculated - the time of the automatic operation cycle of the machine according to the program. After which, the calculation of the cutting depth, cutting conditions and the value of the objective function is repeated for the next route of this processing plan and the route with the minimum value of the objective function is selected, and so on.

Then the next processing plan is selected, for which all calculations for the selection of routes, cutting depth, cutting modes, etc. are repeated. After which, from the available most productive routes, one, two, three transition routes, etc. processing plans, choose the one that has the minimum value of the goal function. A generalized algorithm for solving this problem is presented in Fig. 1.

As mentioned above, at each transition (section) of the processing plan (polyline), the cutting depth and cutting conditions are calculated. The depth of cut corresponds to the value of the allowance removed equal to the minimum permissible depth of cut, determined from the condition of removing errors from the previous processing and obtaining the specified accuracy [2,3]:

$$t_{min} = R_z + T_a + \rho + \varepsilon_y$$

Where R_z - surface roughness obtained at the previous processing stage;

Ta - the depth of the defective surface layer remaining after the previous processing stage;

ρ - total deviations of surface location;

εy - error of workpiece installation at this transition.

One of the restrictions on the depth of cut is the limitation on the maximum depth of cut allowed by the dimensions of the cutting tool plate, therefore part of those calculated according to Kovan V.M. cutting depths that turned out to be greater than 1max were discarded. Each of the state ordinates corresponds to a certain level of accuracy, and technologically feasible is only the transition that leads to the refinement of the workpiece, that is, in which the start ordinate is less than the end ordinate

Conclusion.

1. Based on the theory of coordinate relationships between the elements of the technological system and analytical force dependencies, a wide-range analytical accuracy model has been developed, reflecting the influence of part and workpiece errors on the processing accuracy, which, together with technical limitations, allows us to calculate cutting conditions at each transition.

2. Based on the study of the influence of technological factors on the number of transitions, numerical restrictions were obtained that allow, for given processing conditions, to determine the optimal number of transitions, according to the criterion of maximum productivity.

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