OPTIMIZING THE TECHNOLOGICAL PROCESS

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Annotation
The most important thing in development of the optimal technological process is to justify the purpose and evaluate the effectiveness of technological operations or its individual elements. Various methods and criteria were analyzed in the article, which, from the point of view of matching optimal solutions at different levels, it is preferable to develop processes from the most general issues to their detail.

Keywords: iterative method, nonlinear programming, stochastic method, structural and parametric optimization, parametric optimization, linear programming, technological process.

A number of tasks are solved in design of the technological process (TP), which are multivariant. These tasks include the choice of equipment, the calculation of cutting conditions, the choice of cutting tools, etc. In the designed technological process, even for simple parts, a large number of different combinations of transitions, basing schemes, processing methods and arrangements of operations are possible, and in more complex their number is many times greater. Different variants of TP for manufacturing the same part due to differences in the structure, equipment used, tools, cutting conditions, etc. have different output indicators: productivity, cost, metal consumption, equipment loading, etc. [1].

The availability of several options for solution of the problem (options for TP) leads to the problem of choosing the best option. In our case, this will be the TP option, which ensures the fulfillment of all the requirements of the part drawing under specific production conditions and gives the best value of output indicators. Such a technological process is called optimal. Therefore, the task of TP design is an optimization task [2].

Optimization (from Latin optimum, i.e. the best) is the process of finding the extremum of a certain quantitative value (parameter) of the designed object, represented as a function (functional). If this function characterizes a positive property of an object, then its maximum value is sought, if it is negative, then its minimum value.

The widespread use in all areas of engineering activity of various optimization methods and modes, which are based on a certain mathematical instrument, has allowed forming a whole area of applied mathematics, called “operations research”.

Optimization theory in the modern view includes a set of fundamental mathematical results and numerical methods focused on finding the best options from a variety of alternatives and avoiding a complete enumeration and comparison of possible options.

Optimization methods, depending on the type of goal function and constraints, are divided into the classical method of differentiation, linear, quadratic, convex and dynamic programming.

From the point of view of the optimum search strategy, there are four groups of optimization methods, i.e. analytical, recursive, iterative, stochastic.

Analytical methods find application in solving classical tasks and problems with constraints in the form of equations. To solve problems without restrictions, methods for studying the derivative of a function are used. By equating the derivative to zero, extremum points are found, and then the points are examined using the second derivative to find the maximum. In this way, simple technological problems are solved, for example, cutting conditions are calculated, the parameters of the cutting tool are selected, etc.

Recursive methods refer to methods that allow determining one variable in one calculation operation. The solution of the entire problem is carried out by alternately determining the variables. The most common among these methods is dynamic programming. This method can be used in the analysis of multi-stage decision-making processes, for example, in the optimization of route TP. However, the dynamic programming method is effective with a small number of restrictions introduced into the mathematical model, so it has not yet become widespread in solving technological problems.

Iterative methods combine the largest group of optimal search methods. These include ways to calculate a goal function at one or more probability points to determine the “best” point. The calculation is performed until the assigned criterion is approached at a distance less than a certain predetermined value. These methods allow only local optima to be established, but they can be used in cases where optimization is carried out at different starting points. The optima determined by this method represent an accurate solution relative to the absolute optimum.

There are two large classes of iterative methods: methods of linear and non-linear programming.

Linear programming is used to solve linear problems when the purpose and constraint functions are linear and all variables are continuous functions. This programming is based on the assertion that the optimal point of the objective function is located at one of the vertices of a convex polyhedron that defines the area of possible solutions. The simplex method is the most known iterative method for solving linear problems.

Stochastic methods of optimization (methods of random search for solutions) include procedures for the accumulation and processing of information, in which an element of randomness is deliberately introduced. The advantages of these methods are their simplicity, reliability, sufficient accuracy, and ease of programming. As a result, random search methods have become one of the most effective optimization methods.

Stochastic methods of optimization are used for various tasks of technological design of parts manufacturing processes in the presence of a large number of random factors that cannot be described in a traditional mathematical form.

To set the task of optimizing the technological process, it is necessary to form a mathematical model of the processing of a part (assembly of a product), which should include the following components:

1. Criterion (criteria) of the optimality of the TP.
2. Target function.
3. System of restrictions.
4. Clearly defined input, output and internal parameters.
5. Controlled (variable) parameter or controlled (variable) parameters that stand out from among the internal parameters.

When developing an optimal technological process, the most important thing is to substantiate the goal and evaluate the effectiveness of technological operations or its individual elements, for example, cutting modes.

In tasks that occur under the conditions of TP optimization, the optimality criteria may be different, but they must all meet certain requirements: have sufficient completeness of the description of the object; have a certain physical meaning; be quantitative and be expressed unambiguously by some number; have a simple mathematical form; be determined with acceptable accuracy.

Depending on the type and level of optimization tasks (calculation of cutting conditions, design of an operation and a technological process, or evaluation of the operation of an enterprise as a whole), the main used optimality criteria can be divided into the following types:

1. Economical: minimum prime cost; the lowest reduced national economic costs; the lowest reduced self-sustained costs; the highest profit; profitability; he minimum level of production costs (minimum costs for electrical and other types of energy, for basic and auxiliary materials, for the wage fund, etc.).
2. Technical-economical: maximum productivity; the smallest piece time; main and auxiliary time; equipment efficiency; reliability of the equipment system or its individual elements; machine-tool capacity of the product; stability of technological process of processing.
3. Technological: accuracy of product manufacturing; surface quality indicators of the product (roughness, waviness, micro-hardness, residual stresses, etc.); physical and chemical properties of products; tool life;

4. Operational: wear resistance; fatigue strength; contact stiffness and other indicators of product durability.

5. Other: psychological; aesthetic; ergonomic.

In solving problems of optimization of technological design, the most widely used are economical-technical and economic optimality criteria. This is because of the development of any technological process or the solution of a more particular problem, for example, the calculation of cutting conditions, is based on two principles: technical and economic [3]. In accordance with the first principle, the technological process must guarantee the fulfillment of all requirements for the manufacture of the product. The second principle defines the conditions that ensure the minimum labor costs and the lowest production costs. The first principle is most fully reflected by the minimum cost from the group of economic criteria, and the second - by the maximum productivity from the group of technical and economic criteria.

In these cases, the problem arises of evaluating and comparing various design solutions with the so-called vector efficiency criterion. For this purpose, generalized criteria are used, which are scalar functions of particular criteria and consider the degree of achievement of all goals in the aggregate, reflecting the relative importance of each criterion separately.

References

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