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METHODS OF IMPROVING THE CONSTRUCTION OF COMPOSITE CUTTING TOOL

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Abstract:
The article covers the methods of effective development of number of designs of composite end mills with diffusion fixing of carbide cutting inserts to insert-type knives.

Keywords: Composite cutting tool, heuristic method, prototype, technical solution, morphological method, object of improvement.

INTRODUCTION

Using methodology of searching design [1, 2, 3], iterative scheme (Fig. 1) for improving the composite cutting tool has been developed, which includes the following stages:

- choice of the object of improvement;
- establishing the defects of the object;
- determination of ways to overcome shortcomings;
- search and receipt of a technical solution;
- evaluation of the found solutions;

The object of improvement is understood as element of metal-cutting tool that performs its functions with low quality.

Searching process begins with the formation of a technical task (TT), which determines the area of acceptable values of indicators of the general list of requirements for metal-cutting tools.

The list of indicators and the values of the specified constraints are selected taking into account specific conditions to obtain solutions that are maximally approximate to the ideal.

The formulation of an ideal technical solution and the development of technical task are inherently similar procedures. The ITS shows the goal in the direction of the search, and the TT defines the specific parameters of the tool, upon reaching which the search can be stopped. For the search, it is advisable to use the methods of scientific and technical creativity aimed at increasing the activity of the designer. The choice of a particular method depends on the nature of the problems being solved, since each method has an area of its effective application.

MAIN PART

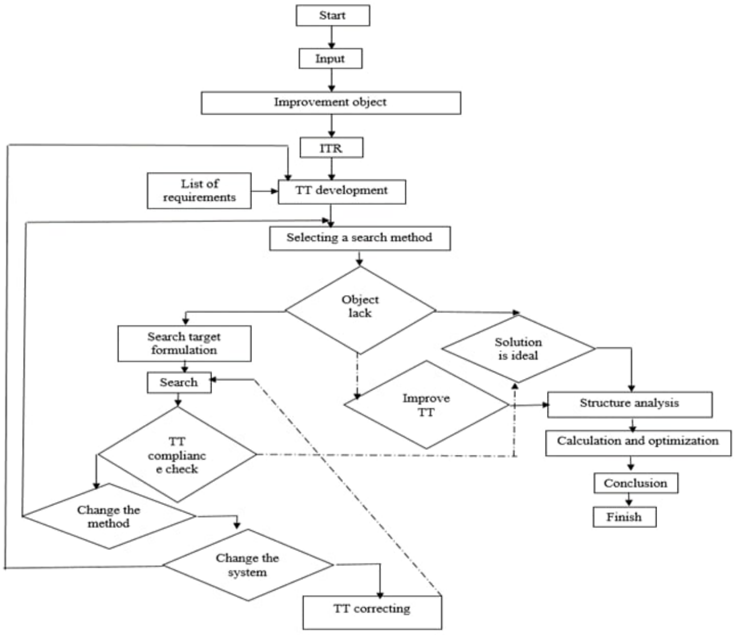

Fig. 1. Search design of composite cutting tool

Problems of a technological nature associated with improving the parameters of cutting tool, tooling, searching for new ways and methods of processing are most expediently solved by such methods of search design as the method of heuristic way and the method of morphological analysis and synthesis of technical solutions.

These two methods represent two approaches to the search for new technical solutions - changing an existing object in order to impart new properties and characteristics to it until it meets the TT and synthesizing a new technical solution with given properties.

METHOD OF HEURISTIC WAYS

This method is the most natural and easiest to use. Heuristic is understood such methods (rules) for solving engineering problems, which contain brief instructions (instructions) on how to change the existing prototype or in which direction to look in order to get the desired solution. Heuristic method usually does not contain a direct definite indication of how to transform a prototype, it only contains a hint that facilitates obtaining the desired solution, but does not contain (does not guarantee) its finding. Many heuristic techniques can be successfully used in various fields of technology. Over time, they do not become obsolete, and therefore turn out to be useful for other engineers. The method of heuristic methods has been developed and widely used in our country. About 10 of its modifications are known.

The method is based on an inter-industry fund of heuristic methods. This fund contains 180 separate methods, which are divided into 12 groups, an abbreviated version of the fund is given in the book "Fundamentals of engineering creativity" by Polovinkin.

The inter-industry fund of methods is universal, i.e. focuses on a wide variety of areas of technology. Heuristic methods have a generalized description.

There are six sequential stages in the formulation and solution of engineering problems by the method under consideration:

1. When using the method, one can restrict oneself to a preliminary formulation of the problem. A deeper and more detailed search for a solution is usually carried out based on more precise formulation of the problem.
2. The solution to the problem itself begins with the selection of suitable heuristics. The initial information for this is the specific prototype that needs to be improved, the main drawback of the prototype that needs to be eliminated and the contradiction in the development of the prototype. Based on this information, the names of the groups of heuristic methods are looked through in the table and the most suitable groups are selected (mainly for intuitive reasons). In each of these groups, all heuristic methods that are of interest for the problem under consideration are reviewed. If it is difficult to select groups of heuristic methods, then the most appropriate heuristic methods are selected by looking at the entire fund.
3. The transformation of the prototype begins with the help of the selected methods, while the ideas for improving technical solutions are recorded in the form of a short description (simplified diagram).
4. Many improved admissible technical solutions were obtained only taking into account the main drawback or the main contradiction of development. In the future, these solutions are used as prototypes for the search for new improved technical solutions, considering other shortcomings and contradictions of development. The result is a new set of improved feasible technical solutions.
5. For the technical solutions found in clause 4, an analysis of their compatibility with adjacent and higher technical objects in the hierarchy is carried out. To facilitate the analysis, a table of two columns is made: in

the first - negative consequences that a new technical solution brings for a higher hierarchy or adjacent object. In the second, there are positive consequences. Next, the tables are analyzed (each solution has its own table).

6. Work items 2-5 for all prototypes and the best option is chosen.

The heuristic methods fund has a powerful property called heuristic redundancy. Let us note two varieties of this property. First, the simultaneous use of two or more heuristic techniques leads to their mutual effort in the sense of making it easier to find an improved solution.

Algorithm for using a specialized fund for improving the designs of the cutting tool is shown in Fig. 5.

At the first stage, the task of improving the design of the cutting tool is formulated. In this case, we can restrict ourselves to the preliminary formulation of the problem, which should contain two parts: "given" and "required".

Given:

a) qualitative or quantitative description of the functions of the elements of the cutting tool and restrictions on its design, manufacture and use;
b) list and description of possible prototypes and lists of requirements for them;
c) lists of shortcomings of prototypes.

Required:

In the process of solving the problem, change the prototype in such a way, find such a new solution that would implement the function of interest and would not have the disadvantages inherent in the prototype.

The second stage is devoted to the selection of suitable heuristics. The initial information for the choice of heuristic methods are: a specific prototype; its main drawback; the main contradiction in the development of the prototype. The selection of suitable heuristics begins by looking at the names of their groups and selecting (mainly for intuitive reasons) the most suitable groups.

The third stage is the transformation of prototypes using the selected techniques. At the same time, the idea of improved solutions is recorded in the form of a short description or a simplified diagram. Thus, with the help of separate techniques and sets of heuristics, many improved solutions are obtained. If at the same time it is not possible to obtain a satisfactory solution, then it is recommended to take the most promising of the found options as a prototype and repeat its processing again using suitable heuristic methods.

At the fourth stage, the obtained solutions are taken as a prototype and the search for an improved solution is repeated. The set of improved feasible solutions obtained only taking into account the main drawback or the main contradiction are used hereinafter as contradictions. As a result, a new set is obtained.

The fifth stage is devoted to the analysis of technical solutions for their compatibility with adjacent and higher in the hierarchy technical solutions.

At the sixth stage, a choice of solutions is made from the database formulated in the process of transforming prototypes. This procedure is carried out considering the main criteria for the development of cutting tools and their indicators

Heuristic methods significantly increases the possibility of obtaining an improved value.

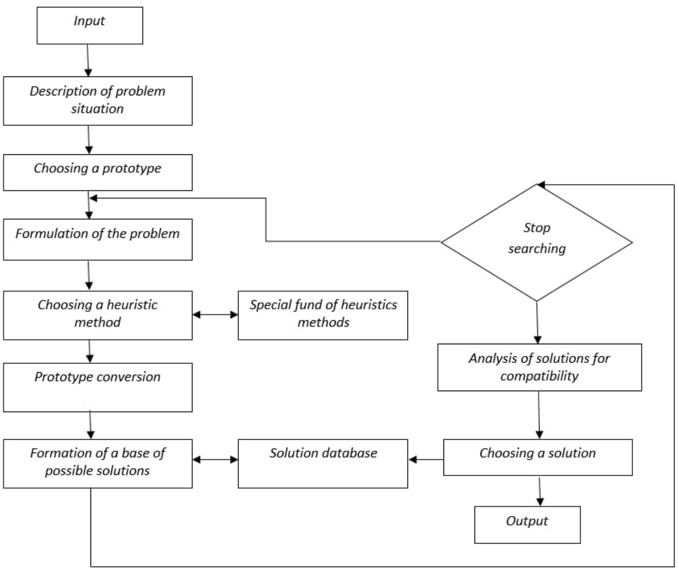

Fig. 2. Improvement of cutting tool designs based on a specialized fund of heuristic methods

MORPHOLOGIC ANALYSIS AND SYNTHESIS OF SOLUTIONS

Considered morphological method is based on combinatorial analysis. Its essence lies in the fact that in the product or object of interest, a group of basic structural or other features is distinguished. For each feature, alternative options are selected, that is, possible options for its execution or implementation. By combining them with each other, you can get many different solutions, including those of practical interest. At the same time, a morphological table is drawn up, in which signs and alternative options for their use or implementation are entered. The most suitable and best solutions are selected from the many combinations of options obtained. There are several modifications of the method. The most common modification is based on a functional approach: the functions of the elements of the object (product) are taken as features, and as alternatives, various ways of implementing each function are taken. The solution of the problem begins with its preliminary formulation. In addition to this, a quality criterion is selected, i.e. the most important quantitative indicator (parameter) for evaluating technical solution options. A quality criterion is usually taken as a development criterion or other most important indicator. The choice of the development criterion is carried out taking into account the accepted classification.

Development criteria:

- Functional: performance, accuracy, reliability, etc.
- Technological: labor intensity of manufacturing, technological capabilities, use of materials, dividing the object into elements
- Economic: costs of materials, energy costs, costs of preparing and obtaining information, overall dimensions of the object
- Anthropological: ergonomics, aesthetics, safety, environmental friendliness

After setting the problem and choosing the quality criterion, a constructive functional diagram of the prototype is built. Such a scheme is a directed graph, the vertices are the names of the elements of the object and the objects of the environment, and the edges are the functions of the elements. Such a diagram shows (gives) a visual (integral) representation of a technical object from a functional point of view.

The morphological method allows any element to be considered as a separate object; this is done in cases where, along with the improvement of the object as a whole, the task of improving the elements is considered.

Morphological table is built based on a constructive functional diagram, the number of columns is equal to the number of functional elements, and the column headings are functions of the elements. It is recommended to arrange the columns of elements in the table in such a way that the most constructively related elements are in adjacent columns.

Problem of decreasing N arises, which is done in two stages:

1. Sequential discarding of the least effective and promising options in each column
2. Reducing the number of columns

At the same time, among all functional units, the main ones are distinguished, which decisively affect the efficiency and quality of the product.

In the shorted table, a sequential synthesis of technical solution options is carried out and their comparison among themselves

This approach, despite its simplicity, is very laborious. An economical procedure for reducing the number of options is proposed.

CONCLUSIONS

Based on the methods described above, a number of designs of composite end mills with diffusion bonding of carbide inserts to insert-type knives have been developed.

The main requirement of the technical specifications for the synthesis was formulated as "Providing vibration resistance when plunging"

The procedure for synthesizing the structures of prefabricated cutters was carried out as follows:

1) morphological matrix has been compiled (Table 1)

The following subsystems and elements of the composite cutter were selected as morphological features: body material, cutting plate material, method of fastening the cutting plate to the insert-type knife, axial arrangement of insert-type knives in the body, angular pitch of insert-type knives in the body, radial arrangement of insert-type knives in the body, the law of the location of the insert-type knives in the body, the dynamic parameters of the teeth, and controlled parameters

2) using a specialized fund of heuristic methods, alternative variants of its implementation were found for each morphological feature.

Table 1
Morphologic matrix

No.	Signs	Alternatives of signs			
1	Body material	Steel	Cast iron	-	-
2	Material of cutting plate	Carbide	High-speed cutting steel	STM	-
3	The method of fastening the cutting plate to Insert-type knife	Mechanical	Soldering	Diffusion	Glue

4	Axial arrangement of insert-type knives in the body	Single stage	Two stage	Multi stage	-
5	Angular pitch of the insert-type knives in the body	Uniform	Uneven	-	-
6	Radial arrangement of the knives in the body	On one circle	On several circles	-	-
7	The law of the arrangement of the insert-type knives in the body	In a circle	In a spiral	In two spirals	-
8	Dynamic parameters of the teeth	Constant	Different for each tooth	Different for the group of teeth	-
9	Controlled parameters	Oscillation amplitude	Oscillation frequency	AFC	-

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