ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 7, Issue 3 , March 2020

Structure of Design Model of Interlocking Side Mill for High-Efficient Treatment of Heat-Resistant Alloys

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ABSTRACT. The article presents formal models allowing preparing initial design and technological data array, based on which it becomes possible to go to the stage of design of the interlocking side mill for the concrete technological task of high-efficiency treatment

KEYWORDS: high-efficiency treatment method, form tool mill, hypergraph, replaceable polyhedral insert, structural model of interlocking side mill

I. INTRODUCTION.

The dominant trend in the development of modern branches of the mechanical engineering industry is the mechanical treatment of products made of materials with high physical-mechanical and operational-technological properties. Therefore, issues of highly efficient treatment methods (HETM) by cutting such materials become particularly relevant.

The implementation of such methods requires an integrated approach to the design of each of the elements of the technological system, as well as special approaches to the technological preparation of production. One of the most common types of machining is milling.

The main areas of HETM include:

1. High-speed machining (HSM), which uses mainly one-piece cutting tool, is characterized by high cutting speeds, small radial depth of cutting, relatively low temperatures and cutting forces at medium or medium-high values of feeds per tooth. This type of treatment requires high rigidity of the technological system, including the equilibrium of the tool system.

2. High-performance (or high-supply) treatment (HPT), in which the solid and prefabricated cutting tool is used. High and ultra-high feeds, small cutting depths, average cutting speeds, high cutting forces are characteristic for this treatment. Elementsof the technological system are required high stiffness, including stiffness of tool system.

Treatment by cutting of heat-resistant alloys causes certain difficulties connected with the low thermal conductivity of these materials, the tendency to surface hardening (cold working) during plastic deformation, which accompanies the cutting process.

Many heat-resistant alloys also tend to adhere to the tool material, intensively abrading the working surfaces of the treatment tool. High temperature in the cutting zone is often a limiting factor in treatment speed. Therefore, the treatment of billets from heat-resistant materials by cutting requires high rigidity and power of the equipment, as well as the use of special structures, both cutting elements and the tool as a whole.

The use operations of milling of parts having complex surfaces and made of hard-to-process materials, including heat-resistant materials, is relevant in solving many production problems in such important sectors as aerospace, energy, automotive, medicine, etc. Currently, there are a number of approaches to solving design and technological problems associated with the milling of parts with complex shaped surfaces.

It is known that the use of interlocking side mill with mechanically fixed in the tool body replaceable multi-faceted plates (RMPS) makes possible to significantly increase the stability of the mill, to increase the saving of hard alloy, to provide the necessary shape of the front surface due to the configuration of the cutting element, in comparison with solid or composite structures, which can be very advantageous from the economic point of view [3].

II. METHODOLOGY

The positioning of the cutting edges of the plates at the angle to the axis of the mill provides a number of advantages over their orientation parallel to the axis. These include improvement of milling uniformity, reduction of vibrations arising during cutting, increase of strength of cutting edge, reduction of forces acting during milling, increase of mill resistance, creation of additional conditions for chip breaking. The arrangement of the cutting elements on adjacent teeth with displacement relative to each other is not strictly helical. However, the plurality of cutting edges of the replaceable hard alloy plates form a common discrete cutting edge, which can be described as a helical line of variable (irregular) character. Mills of similar design can be used for machining of shaped billets made of hard-to-process (in particular, heat-resistant) alloys.

The design of cutting tools for surface treatment of complex profiles is one of the most important issues of tool production. With the widespread dissemination and implementation of computer-aided design and production (CAD/CAM) systems, the process of creating form tool cutters has become more efficient from both a technological and economic point of view.

A significant amount of previous studies allows identifying functional relationships between design parameters, manufacturing technology and operating conditions of the tool for HPT and its operational performance [2, 3]. Formally, these connections are conveniently represented in the form of a hypergraph (Fig. 1).

The vertices of this hypergraph are factors or indicators, and the edges are formalized or informal relationships between the corresponding factors and/or indicators. The edges describing the manufacturing technology of the body, the manufacturing technology of replaceable polyhedral plates (RMP), operating conditions and performance indicators, refer to the initial data for designing the design of the cutting tool for HPT. Fig. 2 shows a general classification of the milling tool according to the design and type of work surfaces.

III. EXPERIMENTAL RESULTS

The diagrams shown in Fig. 1 and Fig. 2 make possible to form a structural model of the high-efficiency interlocking side mill in the form of a hypergraph (Fig. 3) [1]. On this column, the edge $l0$ represents the complex of technological and operational parameters (CTOP). Edge $l1$ combines cutting part CP (vertex $x1$), secondary elements of working part SEWP ($x2$) and adjusting-fastening part AFP0 ($x3$). In turn, the CP consists of vertices $x11$... $x15$ joined by an edge $lx1$ and representing, respectively, the main cutting edge MCE, the auxiliary cutting edge ACE, the front surface FS, the main rear surface MRS and the auxiliary rear surface ARS.

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

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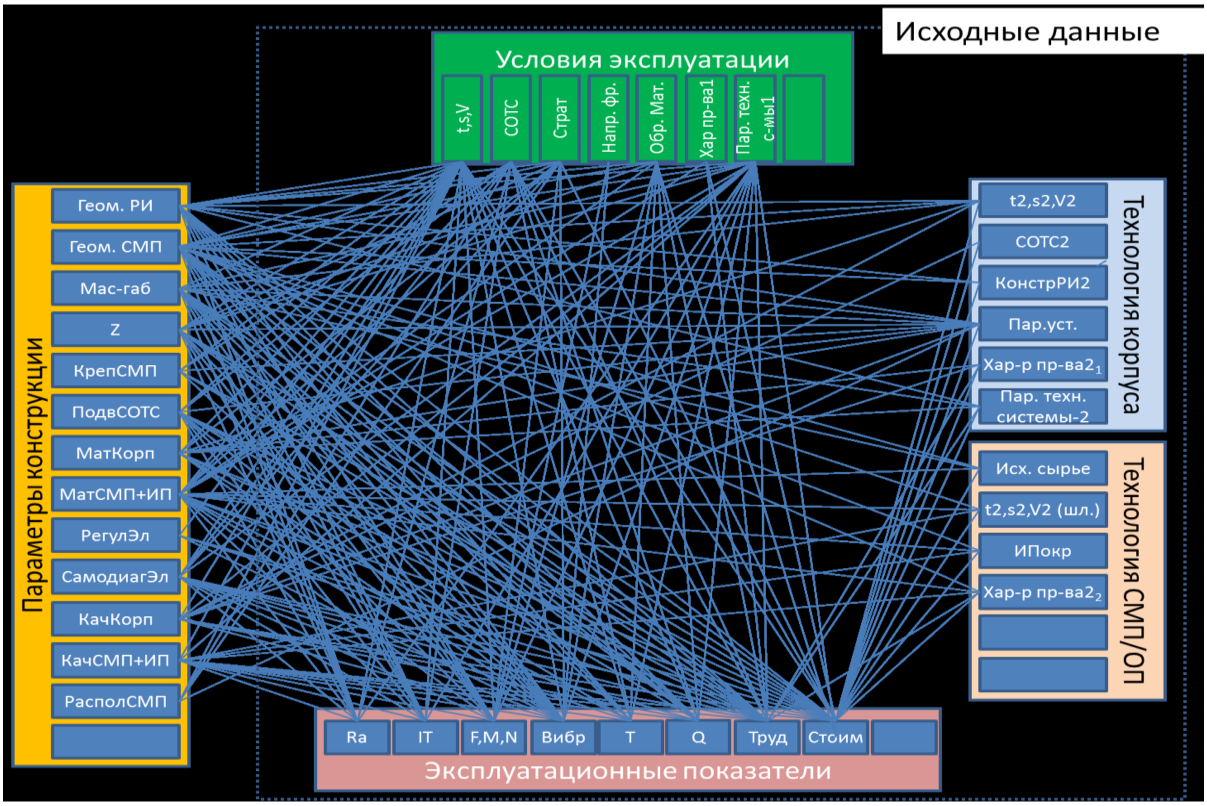

Figure 1. Functional interactions among design parameters, manufacturing technology and operating conditions of the tool for HPT

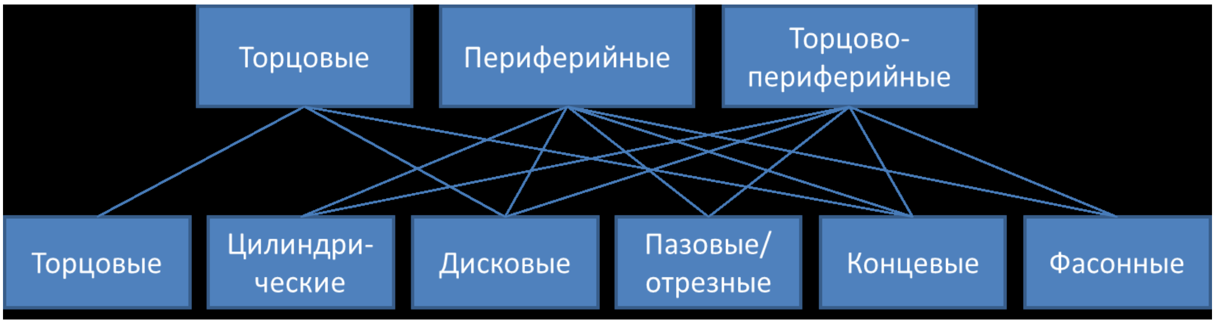

Figure 2. General classification of the milling tool

Design parameters of each of the vertices *x*11…*x*15 are represented on the graph by edges *lx*11…*lx*15, which enclose a set of vertices. The SEWP integrates the edge *lx*2 of the vertices *x*21…*x*23 – the outer surface of the secondary part OS, x22 - the inner surface of the secondary part IS, and the supporting element SE. The structural parameters of the secondary part are enclosed in the edges *lx*21…*lx*23. The adjusting-fastening part includes the vertices *x*31…*x*33 describing the elements of fastening of the cutting part to the secondary part of the tool CP-SEWP, the elements of fastening of the cutting tool to the auxiliary tool CT-AT, as well as the elements of fastening of the cutting part to the fastening part of the tool CP-FP. Corresponding design parameters are represented by edges *lx*31…*lx*33.

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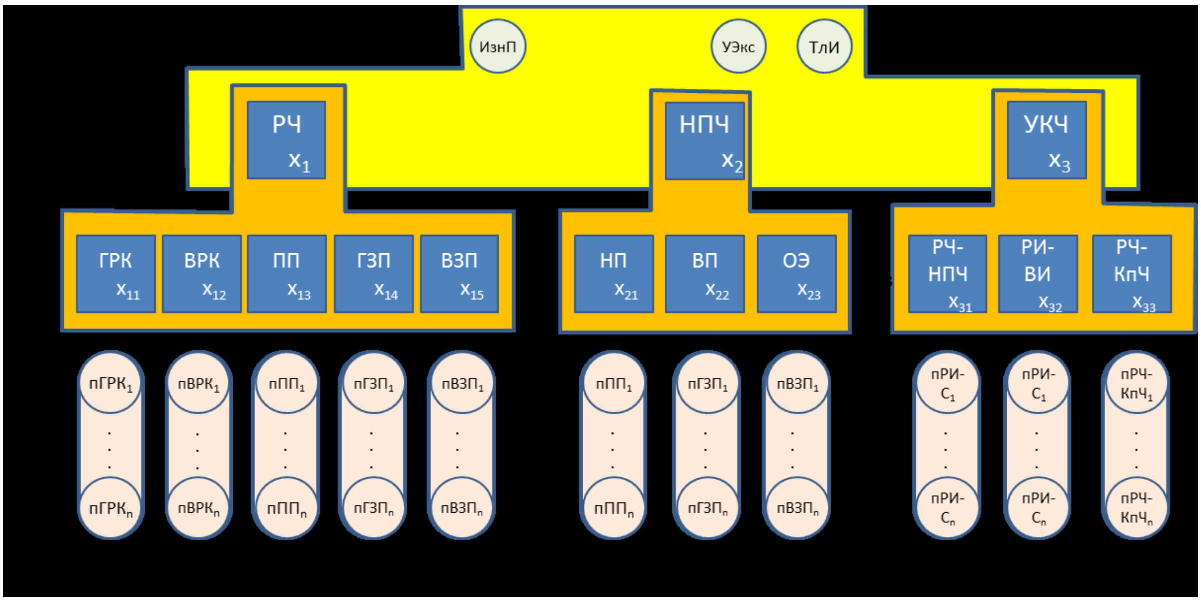

Figure 3. Structural model of interlocking side mill for highly efficient treatment.

IV. CONCLUSIONS

The presented formal models allow preparing an array of initial design and technological data, based on which it becomes possible to proceed to the design stage of the construction of interlocking side mill for a specific technological task of highly efficient treatment.

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