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Generalized Algorithm for Designing Composite Form-Milling Cutter with Replaceable Multifaceted Plates

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ABSTRACT: In article description of formal models and generalized block diagram of algorithm for designing innovative designs of composite form-milling cutters for specific technological problem of highly efficient processing of products made of modern structural materials have been presented.

KEYWORDS: formal models, prefabricated shaped cutters, replaceable polyhedral plates, cutting edge, high-performance processing, helix tool surface

1. INTRODUCTION

New lighter and stronger, but at the same time, tough-to-machine structural materials, such as high-strength metal alloys, composite materials and their hybrids, are aimed to reduce damage to environment. Among the world's leading manufacturers of cutting tools, such as ISCAR, SandvikCoromant, Seco, the concept of environmental sustainability is understood much more than just recycling worn-out cutting inserts or regrinding tools. In the very near future, sustainability should become part of the culture of manufacturing companies, the integral part of the product chain. The environmental program is accepted in European Union countries, the main goal of which is to replace raw materials with recycled materials. In this regard, the development of special approaches to the implementation of all stages of the life cycle of products in the tool industry, including their design, is urgent scientific and technical problem.

There is certain range of production tasks associated with the processing of shaped blanks and requiring the use of shaped cutters with non-overlapping replaceable multifaceted plates (RMP) in modern industry. Such tasks include, in particular, the processing of guide details of complex shape, wheel pairs of locomotives, large-sized parts used in construction, automotive and aviation industries, etc.

The concept of setting cutting edge of composite cutters is used to denote composite cutters, in which the cutting edge of the tooth, conjugated with the original tool surface and forming the producing surface, consists of set of replaceable multifaceted plates (RMP). As a rule, the RMP on different teeth of such cutters are located with mutual displacement relative to each other.

Cutters with a set cutting edge are widely used in roughing operations, as a rule, in heavy duty, when machining high shoulders, deep cavities and grooves. They are often used for milling edges and edges of large work-pieces. In addition, cutters with set cutting edge include composite form-milling cutters. The complex shape of the generatrix of the original tool surface of composite form-milling cutters determines the variable (irregular) character of the helical surface, which is formed by the cutting edges of the plates located on one tooth.

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II. MATERIALS AND METHODS

Analysis of previous research allows identifying functional relationships between design parameters, manufacturing technology and operating conditions of composite form-milling cutters for highly efficient processing of modern structural materials. The representation of functional relationships and the design of the cutter in the form of graph models was given in articles [1, 2, 4]. Based on this information, a generalized system of initial data was formed for the design of composite form-milling cutters with RMP, presented in the form of an oriented graph (Fig. 1). The vertices of this graph are groups of initial data, and the edges show the directions of information flows that are implemented in the design of the tool. In the presented diagram, data about the processed product and data about the designed toolcan be selected. In turn, product data contains general design data, data on possible shaping schemes for this product, as well as general operating data. Tool data includes general design data, the list of which is the same as for the product, supplemented by a set of special design data specific to the cutting tool. Tool data also includes general operating data similar to those listed for the product, supplemented by specific operating data specific to milling the product.

For the synthesis of optimal tool designs, it is necessary to determine the area of possible solutions. The general scheme for designing a cutting tool contains two large subsystems

1) subsystem for determining the initial tool surface and clarifying the type of the designed cutting tool;
2) subsystem of transformation of the body, limited by the original tool surface, into a workable cutting tool, i.e. design of a given type of cutting tool. The enlarged diagram of the subsystem for determining the type of the designed cutting tool includes a block for selecting the kinematic scheme of shaping.

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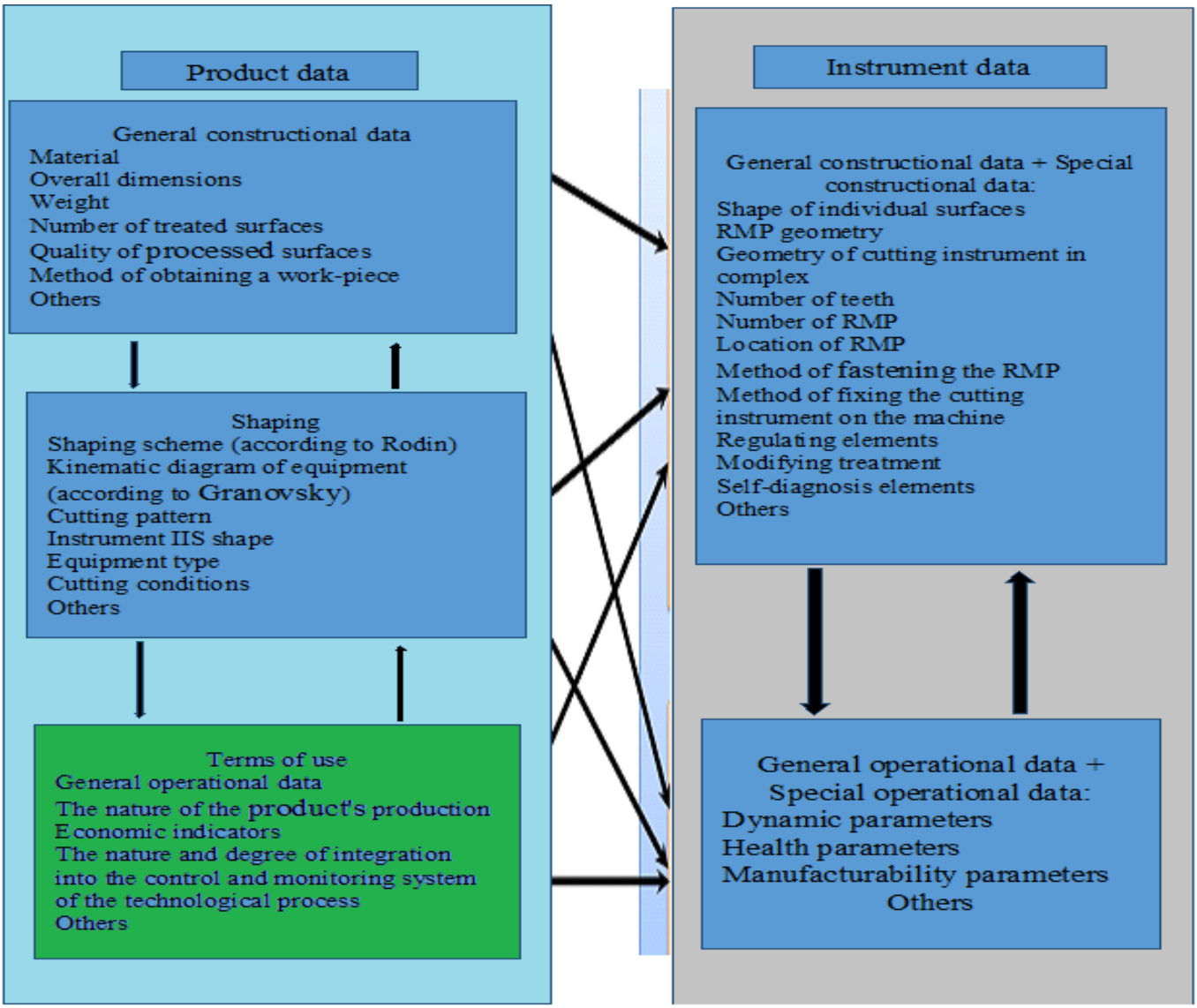

Fig. 1. Generalized system of initial data for the design of composite form-milling cutters with RMP

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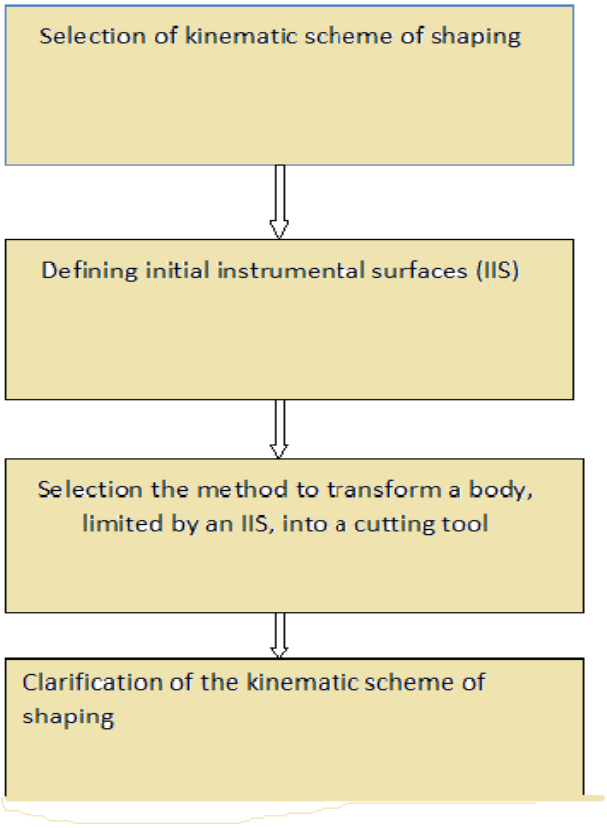

Fig. 2. General scheme for designing a cutting tool

III. RESULTS AND DISCUSSIONS

A. Determination of the shape of the original tool surface of the composite form-milling cutter with RMP

The shape of the initial instrument surface (IIS) of the composite form-milling cutter with the RMP, which make up the inlaid cutting edge, can be different. There are four main options:

1) IIS in the form of a plane, typical for end mills;
2) IIS in the form of rotary body. Most of the peripheral and face-peripheral milling cutters have such IIS;
3) IIS in the form of a helical surface, typical for some gear and thread mills;
4) IIS of variable radius. Milling tools of this type are designed for special tasks: processing surfaces of double curvature, processing shafts of variable cross-section (for example, RC-shaped), etc. [3].

Complex cutters with a stacked cutting edge can have various options for the location of the cutting plates in the body. In general, the whole variety of options for placing the RMP is come to the following schematic diagrams:

1) along a straight line parallel to the axis of the IIS cutter;
2) along a straight line inclined at some angle to the axis of the IIS of the cutter;
3) along a helical line (in the general case, having an irregular character), lying on the IIS cutter;
4) along the combined line, combining the sections of the lines indicated in paragraphs 1-3.

In addition, the orientation of the plates in the housing can be realized using three diagrams: