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BASIC DATA FOR CONSTRUCTION OF CUTTING TOOL GENERATING REQUIRED CUTTING FORCE MODEL

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Summary

Article presents method of construction of special milling tool created for obtaining particular cutting forces system during usage of such tool. Developed machine tool solution can direct forces in direction that is significantly less flexible than other or in direction in which deformations will not effect significantly deviations in machined part. The method presented here combine aspect of the economic approaches to use commonly available cutting blades and fixing systems needed to develop tool construction. Article shows advantages of usage of commercial cutting blades and shows problems that are related with it, also trying to give solution for them.

Keywords: milling, special tools, milling tools, tools construction

Podstawowe założenia do projektowania specjalnego narzędzia skrawającego generującego wymagany układ sił skrawania

Streszczenie

W pracy przedstawiono metodykę projektowania specjalnego narzędzia frezarskiego wytworzonego w celu uzyskania określonego układu sił skrawania. Narzędzie ma na celu obróbkę przedmiotów podatnych na odkształcenie. Umożliwia ustawienie siły skrawania w kierunku mniejszej podatności przedmiotu lub w których odkształcenie nie spowoduje błędów obróbki. W opracowanej metodyce stosowano dostępne płytki ostrzowe oraz systemy mocowania. Uwzględniono kryteria ekonomiczne w konstrukcji narzędzi. Omówiono także zalety stosowania płytek dostępnych w handlu, występujące problemy i sposoby ich rozwiązania.

Słowa kluczowe: frezowanie, narzędzia frezarskie, narzędzia specjalne, konstrukcja narzędzi

1. Introduction

Classification of machining tools is based on different criteria, that concerns both possibility of acquisition of tool, and it's own construction and exploitation features. Concerning possibility of acquisition of cutting tool necessary for performing specified technological process there are distinguished normal and

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special tools. Standard tools, are called tools purposed to machine geometrically simple shapes (for example planes, inner or outer cylindrical surfaces) or surfaces with normal shapes (for example threads, gears). Such tools called also “commercial”, are serial or even mass produced (…) Special tools are called tools made for a specified machining process which would be hard to perform with normal tools. Special tools should only used in well grounded cases, cause their building is much more expensive than building of normal tools as mentioned in Górski, Harasymowicz [1].

Much effort has been put into improving machine utilization lead time efficiency through the improvement of both software and hardware. As mentioned by Grzesik [2]. Growth of possibilities of machining machines, their control systems and kinematics in connection with economic aspects causes that more of machining operations are made using commercially available tools. There are more and more operations that can be provided using chipper simple shaped tools using advanced cinematically machine instead of making special tools for the same operations performed with simple machining tools. Also tooling companies expand their offer of mass production of tools and tooling systems, what helps to achieve required shape and accuracy of machined part in as small amount of operation as possible. That makes machining more economically efficient. However still not everything can be made using widely available tools and for some operations it is necessary to create special tools. Even in this cases tool constructors achieve some help from tooling companies. Standards of machining tool clamps allows tool companies to prefabricate and sell tool bodies with fixed grip of required type for particular machine.

Some operations are still more efficient using shape tools. This case is taken under considerations in created technology of regeneration of track profiles of resilient wheelsets on wheel-turning lathes with friction drive. Those Lathes are commonly used for regeneration of heavy railway wheelsets and their kinematics is fitted to work with it. However regeneration of track profiles requires removing of large allowances what generates large forces what makes is technology not suitable for resilient wheelsets which are built with elastic parts that makes them flexible. New technology assume using newly designed shape milling tools for regeneration of resilient wheelsets on wheel turning lathes equipped with additional milling spindle. Presented article concern methodology of design of shape milling tool that generates forces that enable machining of resilient wheelsets.

2. Special tool design

Input data for construction of special tool are: part drawing that specifies shape of machined surface and material, also technological project that gives information of machining conditions, machining station, semi finished product and used devices and clamps as mentioned by Kunstetter [3]. This sentence is true regardless if constructed tool is modern or archaic. Aim of machining is to achieve desired dimensions and shape for machined part with assumed tolerances so it is necessary to know machined part documentation. Constructor has to know also the machining methods that are available so it is necessary to know technological data. Tools constructor does not have to be conches of machining possibilities of workshop so if he wouldn't know the technology he could for example design hobbing mill for a gear even if workshop is not equipped with a gear hobber. Also it is important to know the clamps and devices to create a tool that not collide with them during machining.

Technological project includes also machining parameters and material data which have significant influence for cutting forces that have to be taken into account in calculations of tool's mechanical resistance and it's power requirement which have to meet power of used machines. Cutting forces Can also have influence on precision of machining especially when machined part is delicate Due to the specific character of the surfaces (very small width of the milled surfaces, small thickness of walls, small rigidity of the elements), the distribution of the machining forces and the way they load the processed elements should be noticed. As mentioned by Wencelis and Recmanik [4]. Presented tool construction also concerns object that is not stiff what requires taking closer look into cutting forces. In this article is presented construction of a shape tool which creates shape of machined object with shape of blades, what makes documentation of part especially important.

Shaped tools are created to machine complex surface on a simple machines which kinematics doesn't allow to create such surfaces with simple tools. As the shape of tool guarantees achieving wanted shape there is no need to use complex kinematics of machine. However production of shape tool is expensive and such tool is useless in any other operations except for the one that it was created for. Most shape tools are build of blades that shape is exact reflection of machined shape. That makes construction a bit simpler, but also makes some problems. If the machined surface is large such blade generates high cutting forces. Also there is a problem of production of such shaped blades. If the tool is made of high speed cutting steel (HSS) it is relatively not difficult to form it by grinding. Such tools are hardened in all volume even without coating they can work properly. However high speed cutting steel is not suitable for usage with hard and bad workable materials. Lately there is a large increase of production of cutting blades made of sintered carbides, and there is a lot of tools and cutting blades available to buy as a ready to use or semi manufactured tools. Machining properties of these materials makes them more suitable for hard part materials, but they are more expensive than HSS. There is a lot of tools and cutting blades that are commercially available and therefore they are relatively cheap. However creating special complex shape blades or tool of sintered carbides, especially for large surface, would be quite expensive. Such tools are not easy to shape with grinding in opposition to tools made of high speed cutting steel. Also most of them are equipped with coatings that would be damaged during attempt to machine coated blade, so it is not possible to change shape of such blade, it can only be ordered from tooling companies. However desired shape can be achieved using a number of simple shaped blades fixed to tool body in array that guarantees achieving of required shape during a turn of tool. This makes tool less expensive and enables replacing smaller parts of tools during it's wear, what makes process more economic Achieving of required shape may be in this case more difficult cause of imposed shape of blades inserts their fixing systems and it may be necessary to divide cutting edge into two or more blades that will machine all specified profile only after working of all of them (Fig. 1).

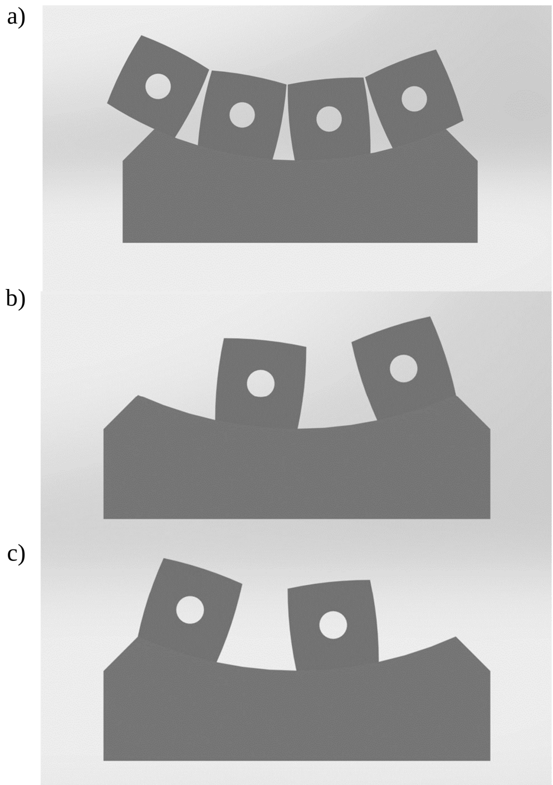

Fig. 1. Setting 8 arc edges blades for machining arc object:
a) shape of edges doesn’t allow to set edges in single row,
b) and c) the same shape fitted by two rows of blades

After selection of cutting blade inserts it is required to build tool body with blades fixing that are compatible with selected blades, Tool body is usually built of construction steel, that is cheaper and easier to machine that tool materials. Some inserts can also be used with so called cassettes that are simple shape housings for one or few inserts. Simple shape of cassettes makes production of tool body easier but as they incorporate fixing of blades cassettes at larger than inserts what may cause problems with tools strength. In opposite it is simpler to control geometry of blade in tool coordinate system by changing cassette than machining complex blade fixing in tool body what may sometimes be impossible.

While creating new blade lots of data has to be taken into consideration to calculate proper tool geometry, or to find most economic cutting parameters for part material and blade material. Such data is often based on experimental values established in large and expensive research. Tooling companies perform such research so they recommend specific blades for machined part material, and gives recommended parameters for machining with these blades. Also if its decided to create a tool using commercially available blades instead of calculation of geometry and parameters it is necessary to find blades of desired shape (or shapes) designed to work with specified material and set recommended parameters for such machining. Of course machining parameters and methods also have to meet the workshop possibilities.

While constructing a tool it is important to establish a cutting forces that this tool will generate while working. It determines required mechanical resistance of tool and also determines required power of machining tool used for operation. On values of forces in cutting process influences lots of factors, and taking all of them is not practically possible. Therefore calculated forces have only approximate values. In a mechanical model, the determination of cutting forces involves the type of material and cutting conditions [5-8]. Calculating of cutting forces is based on experimental data, which are achieved in different conditions that those that calculation is applied to (even though formal identity). Therefore results of calculation are always aberrated with deviation and should be treated as approximate. Estimating of value of deviation is hard; it depends on reliability of input data and in some part on experience as mentioned by Olszak [6]. Producers of tools usually gives factors and formulas for calculating approximate forces values for the tools working in specified conditions. Such calculations are precise enough to establish tool minimum strength or its power requirement. However if it is necessary to determine exact forces values and directions this data are not sufficient. One of such case is definitely attempt of construction of tool generating specific cutting forces. Such tool can be used for machining flexible parts when it can direct forces in direction that is significant less flexible than other or in direction in which deformations will not effect significant deviations in machined part.

As the precise calculation of cutting forces is very difficult or even impossible best way to achieve complete and precise data of cutting forces generated with specific blade while machining specific material is to measure those forces during test machining. Forces measurement allows to investigate forces for required parameters like feed or cutting velocity and also to check specific areas of cut that are expected to obtain during machining. It is also possible to check how values and directions of forces change while manipulation of inserts set up in tool. This enables selecting arrays of cutting blades that’s resultant cutting forces system will be similar to required.

Proper performing of such research would give possibilities to set blades in way that helps to achieve satisfactory forces system while machining with such tool. Achieved results also give a base to precise establishing minimal tool body mechanical strength and requirement of power for driving tool designed this way. Also gathering results of measuring of forces gives lot of data necessary for construction of special tool.

After completing all necessary input data it is possible to create a tool body that guarantees setting chosen blades insert in array that will create desired shape while machining. This body is a set of nests for inserts positioned in desired way. In many cases geometry of nest for commercial inserts may be obtained from inserts producer. Tool body may be produced as completely new part in workshop but it can also be made from pre-fabricated parts that includes grip that is made according to norms requirements.

3. Summary

Construction of special shape tool can be performed using commercial inserts. This makes usually expensive tool more economic but also brings some problems. There is lack of precise information about blade geometry that cannot be fitted individually by tool constructor while using ready existing blades. However there is a lot of kinds of inserts and it is possible to find blades that approximately meet the required geometry or blades that are designed to work with specific materials.

As data for calculating cutting forces are not precise enough to manage forces system on blades in appropriate way it is simpler to perform test machining with specific blades to achieve complete and precise necessary data.

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