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DETERMINATION OF THE MAIN DIRECTIONS AND PRINCIPLES OF DEVELOPMENT OF CAD/CAM SYSTEMS IN THE PROCESSING OF WORKPIECES ON CNC MACHINES

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Annotation

Analyses and determinations of the main directions and principles of development of CAD/CAM systems when processing blanks on CNC machines are given in the article.

Keywords: CAD/CAM systems, interface, CNC program, “cloud”, high-speed processing, 3D model.

Introduction

Modern CAM systems in their development have reached the line where the main goal of developers is not to increase the functionality of a software product, but to simplicity of its applicability, intuitive interface for the user, and automation of the preparation of control programs. Since the moment when the most common CAM systems with their functionality began to cover almost all the needs of software engineers, a new requirement – decrease in the level of qualifications of engineers using these software tools has began to appear for them.

Some developers have started to actively simplifying the interface of their products. Therefore, in some systems, various so-called “masters” have appeared that can help the user quickly and accurately perform some actions, such as creating a blank, correctly orienting the part model in the coordinate system, determining the main elements of the model and selecting a tool for processing them, etc. Moreover, some software products initially contain methods or modules, with the help of which the user can master the basic functionality of the system and perform some simple actions guided by prompts. In this regard, to work in some CAM systems, at a certain level, training (from developers or sellers) may not be necessary at all.

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Main Part

One of the promising aspects of development of CAM systems is their CAD-component. At first glance, this topic seems insignificant, since it is more logical to build a product model in the CAD system, where there is all the functionality necessary for this. However, the CAM user simply cannot do without certain constructions. Most often, the programmer requires such functions as extending surfaces, "sewing" holes and pockets that are not subject to machining at this stage, building various contours to limit or refine tool paths, merging or splitting surfaces, creating a blank model, etc. Availability of such capabilities allows the CNC programmer, without resorting to designers, independently preparing a model to create correct control programs. Strange as it may seem, such training for a CAM user can take 30% or more of the total amount of time spent on writing CNC programs [1].

Naturally, the need arose to automate such constructions and improvements. Many CAM systems have such functions as creating points in the center of circles (or centerlines in holes), automatic creation of contours at the boundaries of surfaces, automatic creation of blank model with the necessary allowance in any direction, etc. Besides, many CAM systems acquire the ability to automatically recognize model elements, be they holes, pockets or planes. This allows the user selecting a specific group of structural elements of the product and assign general parameters for their processing. The most advanced CAM systems, with proper filling, are the so-called knowledge bases, are able automatically selecting the necessary set of operations and tools for processing certain elements of a product (or a group of elements).

More recently, there has been a trend among CAM developers to integrate their software into the most popular CAD systems. Such integration allows not only accurately transferring models from CAD in their "native" format, but also saving the construction tree of the model itself. Advantages of this approach are obvious: it allows attributing information about the tolerances for the dimensions of the model elements and the material of the part to the CAM, which in turn affects the automatically assigned operations and processing modes; it makes it easier for the CAM-system to define the structural elements of the model; the programmer has the opportunity to exclude unnecessary elements from the model without resorting to modeling or constructions [2].

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Since the moment crossing the digital frontier, software and knowledge have played an increasing role in production, and hardware is slowly but surely becoming an object of utility.

In the very near future, world production promises us the introduction of the "Industry 4.0" concept. The essence of this concept is that the usual production algorithms will be disrupted because of constant communication between products, systems and machines. This will allow the creation of smart automation systems in which machines and devices will be able to exchange data, acquire the ability to understand their environment and communicate via the Internet protocol. A key part of the concept is the information invested in the product, which, during the production process, will allow automated tracking of deviations from certain norms. The main driver of this concept is the development of information technologies, by means of which the exchange of data about the product will be carried out in the course of its creation.

One of the sides of this direction is cloud technologies, which are being implemented, if not in a comprehensive PLM system, then at least in CAM modules. Already, there are cloud services that allow creating OP without complex processing for almost all common CNC systems. However, the most promising direction of such technologies today is the creation of open databases, from which CAM systems will be able to use, to create OP, data such as cutting conditions, data about the tool itself in the form of 3D models that can be used for verification, etc. A huge plus will be that the filling of such databases will mainly fall on the shoulders of the manufacturers of the tool and equipment itself, and users, in the process of using them, will be able to modernize them and offer their own solutions [3].

Moreover, the task of the ability of cloud technologies to automate the selection of tools and recommended cutting conditions is very interesting, in response to a request from the CAM system, which carries information about the recognized structural elements of the 3D model of the blank, its material, etc.

Another possible area of application of cloud technologies is the promising areas of KBM and FBM. With their help, the CAM system is able not only to recognize the structural elements of the model, but also to automatically create various processing options for these elements, to assign appropriate processing strategies, etc. The role of "clouds" in this case is to create interacting databases, from which they will draw on solutions previously proposed by other users of the system. With the use of KBM modules, the user will only need to set the "zeros" of the

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part, assign the type of processing (milling, turning, etc.), start automatic recognition of elements and select the appropriate processing option from the proposed ones, and then start post-processing the OP.

Development of CAM systems with respect to trajectories and machining strategies also has a promising direction in high-speed cutting. High-speed processing (HSP) is theoretically based on the so-called "Solomon curves", which are graphs of changes in the load on the tool in the process of increasing cutting speed, feed, and other characteristics. It was experimentally found that in a certain range of ultra-high processing speeds, the loads on the tool are significantly reduced, allowing, without sharp fluctuations in the processing parameters, to continue the cutting process. The main requirements for high-speed machining are small chip section, high spindle speed and high minute feed. Besides, for the use of HSP, a special tool will be required and it is desirable to carry out experimental treatments to adjust the cutting conditions when processing a certain material. The importance of the CAM system in the use of HSP is quite weighty, since there is a need to obtain such trajectories that would provide constant loads on the tool, minimizing their fluctuations, would minimize the number of tool penetrations into the blank, etc. Gradually, HSP solutions appear and in multi-axis machining. However, despite the fact that many CAM developers have already implemented new machining strategies in their products, not everyone can offer optimal cutting conditions for HSP machining [5].

After creating trajectories and generating a control program, a serious CNC programmer needs to check the result of his work for correctness. In addition to the correctness of the trajectories, the user is interested in whether a machine with a certain kinematics, using specific devices, can process the blank according to this control program. Indeed, often, especially when processing a part in several installations, the programmer has to carry out processing taking into account various equipment, which should be reflected in the part setup cards. In such cases, some CAM systems allow the user to create 3D models of the tooling, place them on the part right during the creation of OP, generate a machine program with the requirement for the machine to bypass the designated tooling. This, however, is not always enough. There is a danger that it is not the tool itself, its chuck or the spindle head that will collide with the tooling or part of the blank. In order to prevent such an outcome of events, the programmer can use the internal verification tools of the CAM system or a third-party software product.

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Since there is no full-fledged verification in most CAM systems, a separate group of programs has appeared that can carry out virtual processing of a blank taking into account the model of the machine, tooling, chuck, etc. Moreover, the existing verification modules in some CAM systems use not the final OP file, but an intermediate CL file, which may not produce the correct processing program if the postprocessor is incorrect. Third-party verification programs, using only the final software package, also solve this problem.

After virtual processing in the verification system, the final model can be seen for gouges. Many systems provide color highlighting of the residual stock on the blank model. Such data can be obtained by comparing the processed model with the finished product model.

In cases of multi-axis machining, the kinematic model of the machine is of great importance in the simulation. It can contain all the significant characteristics of the equipment, up to the elements of protective covers. With its help, the software performing the verification can automatically check all the elements of the machine for collisions, the possibility of performing this program on specific equipment in terms of dimensions, etc.

The final stage in creating a control program is post-processing. This process is the translation of intermediate CL (Cutter Location) files created by the CAM system into a program for a specific machine.

The postprocessor itself is a set of executable files that are capable of generating OP only for a specific machine. Previously, the process of creating postprocessors was expensive and time-consuming, because required a qualified programmer. Today, many postprocessors for the most common machine stands are freely available or bundled with CAM systems. Difficulties arise when using the most complex and specific equipment. However, even in such cases there is a way out [7].

The simplest solution is a universal postprocessor or postprocessor generator. The postprocessor generator is designed with an intuitive interface to facilitate the creation of a new postprocessor. In this case, to create a postprocessor, a good qualification of a technologist-programmer is already quite enough. However, in the created executable files, which are, in fact, a template, you usually have to make some changes that require the technologist to have a deep understanding of the kinematics of the machine and knowledge of the basics of the scripting language in which the main executable file is written. There are two types of

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universal postprocessors: independent, and working only with a specific CAM system (usually being its internal module).

In addition to all the above tendencies, one more tendency can be noted. It stands out from the foregoing by challenging classical machining by creating hybrid CNC machines. Hybrid machine tools as such have been around for a long time, but new trends promise us the introduction of additive technologies into traditional production. A multi-axis CNC machine, capable in one technological process, without removing the part from the machine, to make the necessary refinement of the product using 3D printing, promises, with proper use and sufficient workload, good profits. 3D metal printing, of course, has quite serious difficulties in application, and even more so on CNC machines. That, however, already in 2015 did not prevent some manufacturers of CAM systems from introducing modules into their products that allow combining milling, turning and 3D printing.

Conclusion

Making conclusion for the mentioned above, it is possible to determine the main directions and principles of the development of CAM systems:

- creation of cloud resources using knowledge bases that will allow the engineer to provide significant assistance in making decisions;
- creation of cloud services that allow automatically (or automated), through integration with the CAM, to select a tool and processing modes;
- further advancement of FBM and KBM into multi-axis machining;
- further and more in-depth integration of CAM systems into CAD systems;
- emergence of a new concept of post-processing and the use of the kinematic model of the machine for calculating operations;
- growing role of the software of machine "racks" in the competitive struggle of machine tool manufacturers;
- further simplification of the intuitive understanding of the interfaces of the control panels of CNC machines, which will allow employers to hire less and less qualified workers for the robot;
- integration of CAM systems into tablet computers, the emergence of new interfaces;
- development of rendering in the field of CAM systems;
- increasing the functionality of CNC systems in the role of CAM systems;
- development of additive processing operations support in CAM systems;

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- development of simulation modules using kinematic models of machine tools and the use of photorealistic graphics.

It is easy to notice that almost all areas of development, in any case, relate to the automation of production and the preparation of control programs for CNC equipment, in particular, its reliability and flexibility. High level of development in these areas, both today and in the future, will separate developed industries from those backward.

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