

CAD/CAM-system module for the design of automatic production

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Abstract: Automated production becomes a new reality of the industry, one of the important points in the construction of such production is a more accurate and quick design of technological processes for processing and assembly of parts. Analysis of computer-aided design systems shows the inadequacy of their capabilities to achieve this result. Significant improvement of CAD / CAM systems is required, for which it is necessary to establish close relationships between the part, tool, machine tool, technology, as well as digitize world experience and build an advanced algorithm that independently takes many different decisions, such as grouping part elements into operations and grouping transitions for their processing.

Keywords: CAD/CAM-SYSTEM, AUTOMATED PRODUCTION, AUTOMATION TECHNOLOGICAL PROCESS.

1. Introduction

A production site with an automatic production cycle of parts and the complete absence of people is the new reality of modern industry. All enterprises engaged in serial production go to this model of organization of production.

Automated production includes complex mechanical equipment with built-in electronic devices, such a combination creates electromechanical components that operate under the control of microcontrollers and a personal computer. These mechatronic modules have gained wide popularity in all fields, and by combining them whole mechatronic systems are created, for example, automatic production lines.

An automatic line may include CNC machines, robots, conveyors, manipulators, unmanned carts and many other devices. Since all components are interconnected through digital communication and controlled by a computer, they can work without people. This gives the most accurate, high-quality and high-performance result, excluding the human factor, which in turn leads to favorable economic indicators of production costs, and high competitiveness in the market.

Almost all automakers can serve as an example of such automated production; the car body moves along the line from one robot to another, which carry out welding and further assembly of the car without people.

Any production begins with its design, and the more thoroughly it is completed, the more efficient the production itself will be. Since automated production requires maximum debugging of all devices, the design of automated production is a more difficult task and is carried out using various CAD / CAM systems.

2. Design Automated Production

The scheme of automated production for each nomenclature of parts can be completely different, therefore its development is still a more creative process, however, production indicators, such as productivity, efficiency, profitability and others are more tangible and are expressed as specific numbers. The calculation of these numbers is very important and quite amenable to automation.

A lot of things determine the technological process of processing a part or a group of parts, since at the stage of development of the technological process the necessary metalworking equipment, devices, tools and many other equipment and accessories are selected, as well as processing strategies. From how rationally all the details of the technological process are thought out in many respects, they will determine the production indicators.

A lot of factors are involved in the development of the technological process that need to be taken into account; not taking into account the slightest action can lead to inconsistency and

downtime of expensive equipment, and as a result, to obtaining not maximum production indices.

Therefore, it is necessary to design the processing of each element of the part separately as efficiently as possible, accurately calculate all the processing parameters, and also form a sequence of their processing in each operation. This is a rather time-consuming process that requires a lot of knowledge, experience and time, and it is often necessary to optimize the process for various requirements, which takes additional time.

After the development of the technological process for processing the part, it is possible to develop the automated production scheme itself. At this stage, the composition of the equipment, their rational arrangement, the general sequence of moving parts play an important role, since a small inaccuracy in the location of only one element can lead to significant losses of time and other resources. To find the best production indicators, different schemes are compared, while the most accurate calculation gives a virtual simulation of the production process in real time, i.e. virtual modeling of different schemes.

An example of a computer-aided design system with precise detailing and visualization of all production processes is the Siemens Technomatix system (see Fig. 1). Two-dimensional or three-dimensional virtual production is created in the system, object-oriented programming is implemented, with the help of which it is possible to create any non-standard processes, for example, moving a part by a person along a given trajectory at a given speed or assembling a node with hard-to-reach places by a robot. In the database of the system there are many elements of automated production and thus the organization of production with any degree of automation is possible.

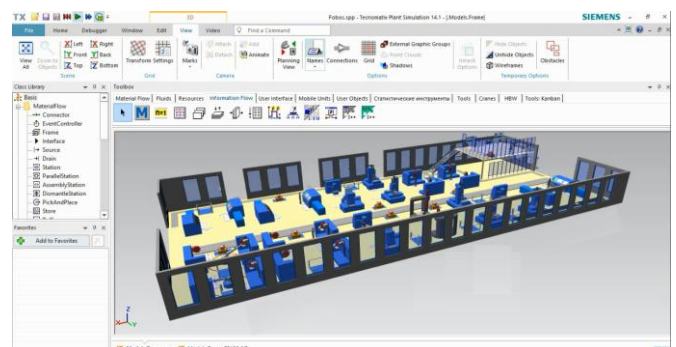


Fig. 1 Automated Production

So, setting the initial data on the technology of processing parts, processing time, you can get the most accurate performance, the designed production, as well as a single section or machine. By changing various elements, for example, moving equipment, replacing a person with a robot, as well as other optimizations, you can see how production indicators change. Thus, it is possible to achieve such a combination or arrangement of all elements of

automation of production, which will bring the maximum possible performance.

3. Automation Technological Process

The main trend in computer-aided design of technological processes for processing parts is the recognition of structural elements of parts, with automatic selection of the processing route and the necessary tools in accordance with a given logic or rules (see Fig. 2).

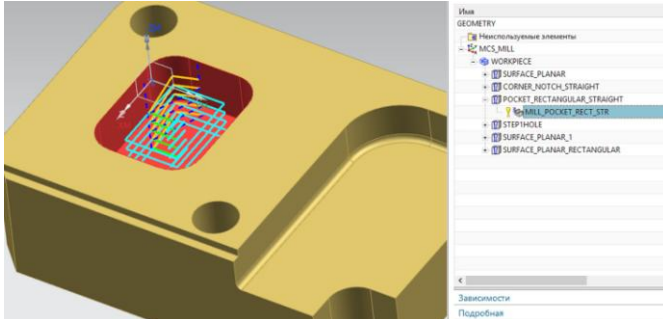


Fig. 2 Recognition of elements in the CAD/CAM-system

Automatic selection of the processing strategy with the selection of tools was implemented in the «CAD TPP CNC» for designing the processing of complex, precise holes, the processing of which requires more than 6 ... 10 transitions. Manually designing the processing of such holes takes a lot of time, this method made it possible to design the processing of complex holes in a matter of seconds using the one-button method, with all the necessary tools in the database [1].

Modern CAD / CAM systems implement similar capabilities for processing typical structural elements, taking into account the accuracy and roughness indices specified in the 3d model, as practice has shown, this significantly reduces the time of technological design. This possibility so far concerns only simple elements, and for non-typical and frequently encountered elements, it is possible to set individual logic.

However, the task of logic is often required for many typical elements, since the same element can be processed with different strategies, transitions and tools, it is necessary to teach systems to choose the most efficient processing method for a particular case, taking into account the characteristics of the machine, the processed material and other data.

To improve the method of recognition of elements, it is necessary to use more complex algorithms and a more developed database. Such improvement must be carried out taking into account modern requirements of production.

Recognition of elements is a big step in the automation of technological processes, but still insufficient, since modern automated production requires a higher degree of automation of design work. This requires not only recognition of the structural elements of the part, but also their grouping in operations, as well as the effective grouping of all transitions for processing grouped elements. Effective recognition in combination with a progressive grouping of operations will give a tremendous synergistic effect, which can significantly reduce the time and complexity of design.

Automating such a grouping of elements and technological transitions is a difficult task, since it is influenced by a huge number of factors. In addition to scientific research, account must be taken of practical tests and many other data. It is necessary to unite and consolidate world experience. Digitization of this experience will provide a developed database, for which it is necessary to create a complex algorithm that can make decisions and self-learn. Thus, it is possible to create automation of the design of technological

processes of a completely new level, the level of artificial intelligence.

The possibility of manual editing of the technology should be implemented very carefully, it should be as simple and quick as possible, for example, by highlighting a particular structural element in a 3D model and moving it to another operation, then the system itself will integrate the processing of the new element into the operation. And also the system should check all human actions for the possibility of this change, and exclude the human factor. Frequent the same manual changes to the technology, the system should fix and offer to adapt to them.

During the design of technological processes for automated production, a solution of many non-standard problems is required. For example, the selection of grippers for moving parts, the calculation of gripping forces, storage of parts, their correct positioning during movement, installation in the device, etc. For each detail, these tasks are solved individually.

Part of these tasks is difficult to automate, therefore it is necessary to create auxiliary modules that help technologists make the right decisions, as well as select or find new ideas for specific production conditions. Similar tasks must be solved in conjunction with a new approach to the automation of technological processes - recognition of structural elements with grouping of operations and transitions.

So the technologist will be able to quickly design a progressive technological process, select all the necessary devices for capturing and moving workpieces, calculate more accurate technological parameters for processing and movements, i.e. to get the exact necessary numbers with which you can create a scheme of automated production.

4. New Module of CAD/CAM-System for Automated Production

4.1. Technological Process

As has already been established in the automation of the design of technological processes in modern CAD / CAM systems, there are many bottlenecks, many tasks are solved manually or in a semi-automated mode, which is a laborious and inefficient design process.

The trend of automatic recognition of structural elements of a part plays an important role, but this is not enough, higher-order automation is necessary, namely, automatic grouping of operations and transitions. Also, many additional modules are needed to solve auxiliary problems of technological design.

In this connection, a new module of the CAD / CAM system is needed, which will link the solutions of these problems into a single whole. And also adapt the module in the CAD / CAM system, replacing existing recognition modules.

An analysis of the problems discussed above leads to the fact that in CAD / CAM systems there are no close links between the part, the processed material, the technology, the control program, the tool and the equipment (see Fig. 3).

Having established these close ties, as well as creating a developed database summarizing world experience, it becomes possible to automate such complex tasks as automatic selection of tools, machining strategies, calculation of cutting modes, grouping of transitions and many others, which will significantly reduce the time and complexity of design.

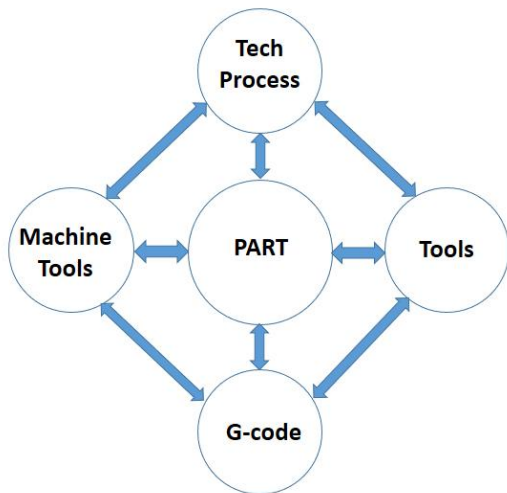


Fig. 3 The relationship of CNC-program with design elements

For example, setting the characteristics of the material to be processed, the rigidity of the part, machine tool, fixture, you can automatically select the strategy for processing the part and the corresponding tools, as well as calculate the cutting conditions, and then group transitions.

In this case, it is necessary to take into account various recognition and grouping filters, for example, recognition of elements located on certain sides of a part or grouping transitions with minimal tool changes or minimal part rotations, etc.

In the algorithm of the new module, it is necessary to take into account the rigidity of the technological system, the capabilities of the machine, otherwise the design result will be far from reality, and accordingly, performance indicators, including economic indicators, will be distorted.

In the «CAD TPP CNC», a relationship was realized between the parameters of each element of a complex hole and the methods of processing it, the processing routes, which in turn are associated with tools, and all this data is contextually related to each other [2].

This way of organizing data is also called a semantic model, i.e. different processing properties are inherited from each other, for example, when processing a hole, the processed material and equipment are already predetermined at the stage of tool selection; therefore, a drill compatible with this data is searched. So after recognizing the hole, the system, knowing about the machine, the material being processed, as well as other data, will independently select the necessary tools, and there is no need to set many additional filters. This also applies to the selection of processing routes and other technical data [3].

However, linking is not enough to group processing transitions for complex holes. To do this, it is necessary to give the system additional logic, for which a special algorithm has been developed that allows, based on the obtained interconnected data, as well as technological knowledge, to compose the necessary sequence of transitions for processing a complex hole of arbitrary shape.

Many complex holes can be present on one part, for the processing of which the same tools are used, in this case the system should group the processing transitions of the entire part in the most optimal way without unnecessary turns and tool changes.

4.2. Technical and economic indicators of automated production in the new CAD / CAM system module

According to the theory of productivity, technical production indicators are mathematically related to economic indicators. By

asking in this mathematical model technical data on technology, processing time, cutting conditions, productivity, composition of automated production, we can find out the cost of production, production costs, payback period, economic efficiency, profitability, etc. Thus, we can quickly draw a conclusion on the economic possibilities of building this production.

On the other hand, this theory works in the opposite direction, i.e. by setting the desired values of the cost of production, economic efficiency, it is possible to obtain technical indicators of automated production, such as the composition of equipment, degree of automation, number of jobs, design dates, etc.

Thus, using this mathematical model and the parameters of the new CAD / CAM system module, you can quickly work out several options for automated production and find the most optimal one for a particular enterprise. For example, for one plant, production will be 100% automated using the most productive equipment, for the second 70% with partial use of human labor, and for the third it will be necessary to develop special multi-spindle equipment, etc.[4]

To study this mathematical model, it is necessary to describe the elements of production: types of automated equipment, auxiliary equipment, drives, transport, warehouse, etc., including establishing links between them, as well as criteria for their effectiveness. In addition, it is necessary to establish links between typical technological processes, routes and elements of automated production [5].

The construction of this mathematical model is a difficult task, because it requires a lot of different studies, in addition, it is necessary to take into account a number of parameters that are difficult to automate, for example, the parameter of production flexibility. Production can be fully automated, but it may be absolutely not adapted to change the manufactured parts. And in the world with a frequent change of products, the task of automating production requires taking into account the requirements of flexibility.

4.3. Digitalization of production

The passing Fourth Industrial Revolution aims to combine industrial and digital technologies, during which the construction of virtual production, digital doubles, robotic production and many other changes.

These opportunities show rapid development and already today demonstrate a positive effect, and will soon become the main criteria for the competitiveness of enterprises.

The introduction of various technical equipment is now tested in a virtual environment and only after that is their production and implementation carried out. Many physical tests are not required, which significantly reduces the cost and speeds up the process of introducing new equipment into production.

When simulating, several hundred calculations are carried out that determine the scheme and composition of automated production equipment, the manual method of carrying out these calculations takes a lot of time, which is unacceptable in modern conditions.

The new CAD / CAM system module is designed not only to design the most advanced technological processes in the most automated way, but also to build effective automated production of parts on their basis, determine the number of equipment, the number of jobs, and find the optimal technical and economic performance indicators that can be used to virtually real-time test production. If parts are changed, you can also quickly adapt their processing in this production.

Digitalization involves the conversion of all information into a digital form, thus creating databases, visualizing processes, automating calculations, developing high-order algorithms, introducing industrial networks, common industrial sites, digital

services and many other features. All this creates new requirements for the construction of automated systems.

For example, as the initial information, it is not the drawing of the part, but the 3d model, thus new requirements for the construction of the design 3d model appear, in which all the data indicated in the drawing should be reflected. According to this model, it is possible to carry out automatic recognition of elements and solve many other problems in an automated mode.

In this regard, in some cases, the design of drawings and technological processes becomes an unnecessary task, in the presence of a detailed 3d-model, or rather a digital double of the part, the designed technologies and control programs for CNC machines, documentation is no longer necessary, all these data are transmitted to the machine in paperless form. Thus, a number of enterprises today have already refused to issue design and technological documentation. However, for enterprises where complex products are manufactured, technological processes are still required, but if detailed digital data are available, generating it is a possible automation task.

4.4. Design of mechatronic modules

In the construction of automated production, the share of electronics involvement is steadily increasing, there is a transition from mechanics to mechatronics. In fact, mechatronics unites many different areas: mechanics, electrical engineering, microelectronics, information technology, power electronics and many others. As a result of this association, a new technique is created that implements any actions, for example, moving parts between machines. It is impossible to create such a technique on the basis of only one field of science; therefore, mechatronics products are very complex and are implemented by many specialists.

The mechatronic module is an independent product for the implementation of movements, and the mechatronic system is a collection of mechatronic modules that are synergistically connected to each other to perform a specific functional task, for example, an automated part production line.

The design of such mechatronic modules and systems is the team work of many specialists in mechanics, electronics, programming and many others - this creates the requirement of a single space in which all specialists will be interconnected when working on one project.

In the new module, we will consider only the mechanical part of the design process of automated production, but with the possibility of integrating modules for other specialists. Therefore, in the framework of the new module, it is necessary to solve the following problems: a more detailed selection of gripper and other manipulator nodes, and calculations for loading equipment. With a detailed drawing of all the components of the mechatronic modules, it becomes possible to more accurately calculate whether they will cope with the flow or not, based on the designed technological process.

Thus, at the design stage, it is possible to track that one machine or robot cannot cope with the flow, thus a number of solutions are applied to eliminate bottlenecks at the design stage. It is possible to add a robot, and it is possible to move the robot on its guides, or to take other measures.

4.5. Implementation of a new CAD / CAM system module for automated production

Summing up all of the above, for the design of automated production it is necessary: development of an optimal technological process, calculation of technical and economic indicators, digital representation and simulation, design of mechatronic modules, creation of a single space, as well as the solution of many related tasks.

Automation of a very large number of tasks, but all of them must be solved interconnected, supplementing each other with data, with a possible return to the initial data for their correction and new tests. This requires the creation of a large software module for the CAD / CAM system.

However, in the framework of the study on the creation of such a module, it is important to understand the relationship between various design data both within a separate task, for example, the tasks of computer-aided design of technological processes, and between data of different tasks, for example, data on the technological process and determining the composition of the equipment of an automated complex. Between the technological process and the calculation of technical and economic indicators.

The work of such relationships has confirmed its relevance in conjunction with the algorithm for grouping technological transitions for processing complex holes. This makes it possible to implement a higher order algorithm, namely the grouping of structural elements of a part in an operation, as well as the construction of automated complexes for processing these parts [6].

Such algorithms will endow the CAD / CAM system with the property of independent decision-making, which people today still decide.

5. Conclusion

The most important for the construction of automated production is the establishment of an effective technological process with the accurate calculation of all technological parameters: productivity, efficiency, etc. For this, a new module of CAD / CAM systems is needed, which allows solving this problem more automatically.

The establishment of close relationships between the part, tools, machine tool makes it possible to create high-order algorithms to achieve this goal, as well as the design of automated production.

In the context of the rapid development of digital technologies, automation of production, this task becomes one of the most important for the quick launch of new products on the market and ensuring its low and competitive cost.

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