3D SIMULATION MODEL OF A RECONFIGURABLE MULTIFUNCTIONAL MACHINE TOOL WITH COMPLEX FUNCTIONS

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Abstract. The paper presents an active 3D computer model of a reconfigurable multifunctional machine tool, developed in SolidWorks environment.

The suggested machine model provides effective environment for simulation of the work of the Reconfigurable Multifunctional Machine Tool in conditions of frequent changes in the production demand. On the other hand, the model is also used for investigation the functionality and the technological possibilities of machines with reconfigurable structures during the process of complex machining of both rotation and prismatic parts on a single machine (individually or in combination). Moreover, the machine has high concentration of various technological operations, such as: turning, milling, drilling, grinding, etc.

Keywords: 3D model, simulation model, reconfigurable machine tool, multifunctional machine tool

1. Introduction

Traditional machine tools are designed to produce specific work parts while completing specific technological operations. At present, more than 150 different machine tools are developed and put into production, but this technological process is not quite flexible and the necessary technological operations are executed by different machine tools. The machine centres have the highest degree of flexibility, although their functionality is limited for each specific part type. Nevertheless, the question of concentration of more technological operations is being solved.

Moreover, multifunctional technological machines have gained considerable popularity and application in industrial production [3, 4, 7]. Their accuracy rises as their price decreases. This evolution results in their frequent use in production of parts, which are generally assembled by different types of machines. The main advantage is their flexibility and ability to be compatible with different technological operations. At present, however, they are intended for treatment of rotation or prismatic work parts only.

Besides, multifunctional technological machines are characterized by a constant positioning of the spindle – horizontal or vertical, which restricts the technological possibilities of the machine when machining different part types (rotational or prismatic). On the other hand, it is impossible to use the advantages of the machine for placing the part in the same position. In turning-drilling-milling centres, the operations are performed by the respective tools, situated in turrets only, but that restricts the strength characteristics of the cutting modes and from here the productivity of the production process as well.

The short life-cycle of the products and the high technological processing speed change the concept that in some sectors the complex treatment is not in a stable phase of functionality, when the process must be changed. That imposes the necessity of creating new concepts for module design with possibilities for machine reconfigurations from economical reasons and flexibility of the equipment, in order to respond to the market changes and requirements.

Over the last years there has been intensive work on the creation of a new generation of production systems, based on modular design with possibility of reconfiguration of their component structure – reconfigurable machine tools (RMT) [4, 5, 6].

The analysis of the contemporary state of the problem [4, 5, 6, 7, 8, 9, 10] shows that the main directions of development of the RMT are connected with the high requirements from technical, economical and social nature as well.

Reconfigurable machine tools can possess, change or modified specific production parameters, in regards to control, software or machine structure in order to adjust to different production or market requirements. That way, the reconfigarability can be observed in different aspects (machine tool, system, software, control and technological process). This aims at meeting quickly and flexibly the client's requirements, raising the industry efficiency – productivity, quality, minimizing the processing time and production cost.

Worldwide investigations assign the reconfigurable production the highest priority in future investigations in the field of machine-building, and RMT as the basic key challenge to 2020.

The present paper is a practical application of the developed methodology from the author [1] and the logical and further continuation and improvement of the multifunctional machine tools with reconfigurable structure [2].

2. 3D computer model

The component machine modules with indicated motion symbols on the coordinate axis are shown on figure 1 and the developed 3D version of the RMT is shown on figure 2.

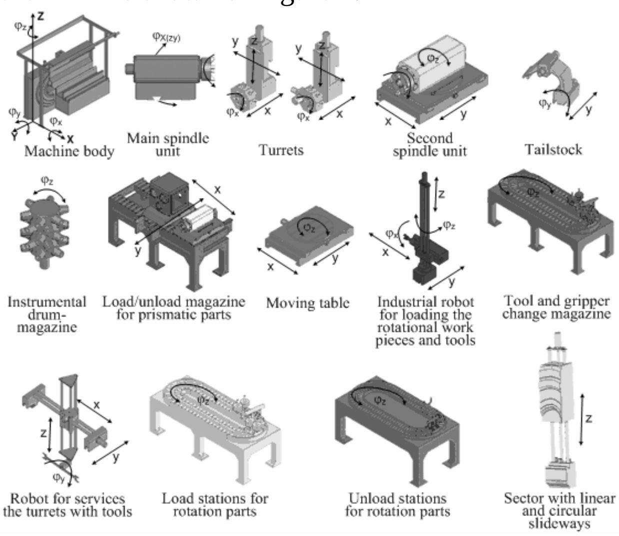

Figure 1. Modules

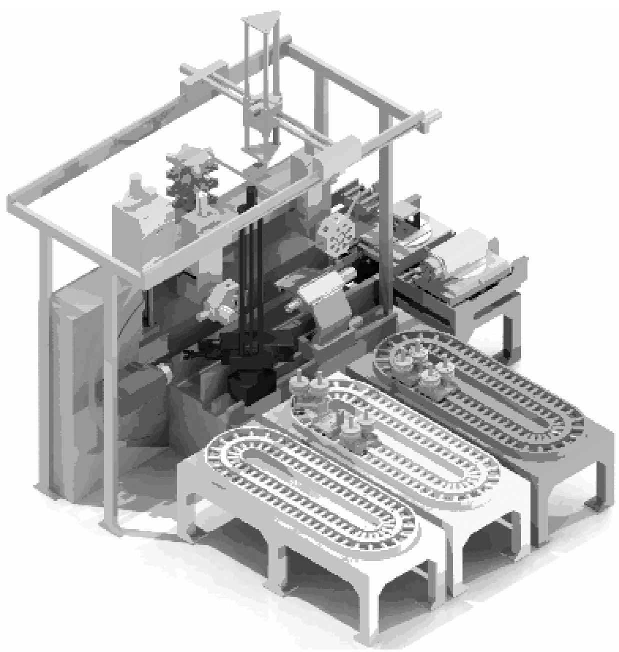

Figure 2. 3D model of the RMT

Assembled in this way, the reconfigurable multifunctional machine tool has the ability to rearrange its structure and to:

- process rotation, prismatic parts and parts with sophisticated configuration;
- perform different technological operations - turning, milling, drilling, grinding, etc.;
- make use of the advantages of the different machine structures – with vertical or horizontal position of the spindle unit;
- automatically change the tools, parts, etc.

Concerning the process of simultaneous machining of more than one part, the machine is able to perform in the following combinations:

- two rotation parts (one work part $L/D > 5$ and one work part $L/D < 5$);
- two rotation parts ($L/D < 5$);
- one rotation part ($L/D > 5$) and one prismatic part;
- one rotation part ($L/D < 5$) and one prismatic part;
- two prismatic parts (or two sophisticated parts, consisting of rotation and prismatic surfaces).

The choice of a correct option of machine reconfiguration depends on the production task and is accomplished by different criteria, including the following technological indicators:

- the work part type;
- the positioning of the machine type according to the position of the main spindle unit – horizontal, vertical or at a random angle;
- the number of simultaneously machined sides of the work part;
- the number of necessary tools and their precise position – in turrets or in the spindle unit chuck;
- the number of simultaneously machined work part.

With the modules defined that way (figure 1) and the technological indicators, we can define 9 different constructive variants for building up multifunctional machine tools, for machining of single or combined variants of working parts:

- three variants for processing of a single work part – rotation $L/D > 5$, rotation $L/D < 5$ and prismatic work part;
- five combination variants, as shown above.

The developed working model of the RMT in SolidWorks environment creates possibilities through using the SolidCAM package in order to simulate a real production process and to investigate different technological and economic parameters in real time, such as:

- coefficient of utilization of the machine;
- economic effectiveness from technological operations concentration;
- standardization and definition of the effective number of parts in bunches (batch capacity);
- the service temp of loading and unloading the machine shops, from point of view of transport, and in condition of fully automated manufacturing etc.

An example for machining one rotation (D < 5) and one prismatic work part is shown in figure 3.

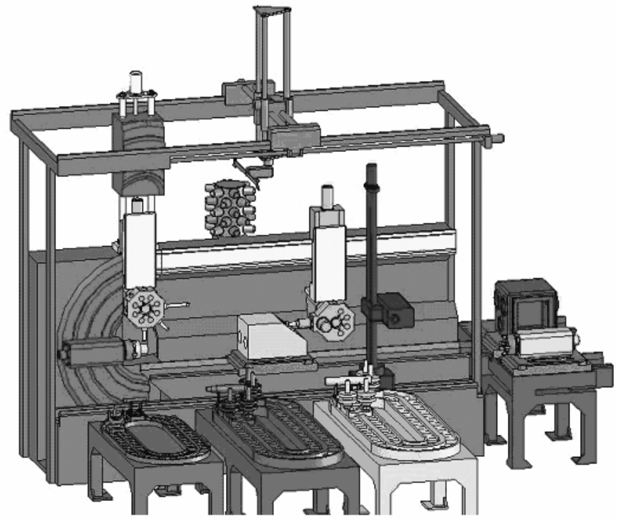

Figure 3. RMT configuration for machining one rotation (L/D<5) and one prismatic work part

3. Concluding remarks

This paper presents a real 3D computer model of a reconfigurable multifunctional machine tool, developed in SolidWorks environment. The visualized model gives a real image of the reconfigurable possibilities of the machine and can be used as simulation of an actual production process by complex machining rotation, consisting of prismatic parts or parts with sophisticated configuration in a single machine (individual or in combination).

The model can also be applied for investigation of different parameters, such as: coefficient of utilization of the machine; economic effectiveness from technological operations concentration (turning, milling, drilling, grinding, etc.); standardization and definition of the effective number of parts in bunches (batch capacity); the service temp of loading and unloading the machine shops, from point of view of transport, and in condition of fully automated manufacturing, etc.

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