

Dynamic simulation of five-axis machining using virtual machine in NX system

Dynamiczna symulacja obróbki pięcioosiowej z wykorzystaniem wirtualnej maszyny w systemie NX

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The work presents methodology of preparing and configuration of virtual machine as well as conducting a simulation based on generated NC code in terms of collision.

KEYWORDS: 5 axis milling, virtual machine

Along with development of the industry, the requirements of production technology, including machining, are increasing. Increasingly integrated elements of complex shapes, including full material, such as blade discs, rotors or air frames, are being developed. This involves the use of advanced multi-axis machining centers [2, 4].

Manufacturing of this type of parts is characterized by complex process kinematics. Very often it requires simultaneous five-axis machining. Also, the space, in which the tool is positioned, is very limited due to the complexity of the object structure [2].

In such a process, the risk of collision is much higher. Many times, it turns out that the simulation of the tool path and the handle on the basis of the intermediate code is insufficient, because collisions can occur among other elements of the machine [3].

The alternative is a dynamic simulation of machining using a virtual machine. The ability to take into account the whole geometry of the machine and to analyze the finished NC code allows for a significant reduction in the risk of collisions [1, 5].

The paper presents methodology for the preparation and configuration of a virtual machine and a simulation - based on previously generated NC code - in terms of collision. The DMU 100 monoBLOCK five-axis machining center was used. Machine model was made in NX 10 system using MACHINE BUILDER [1, 5].

Preparation of the machine model

The first step was to model the individual components of the virtual machine (Fig. 1). All elements were prepared in the NX system on the basis of technical documentation. Two machine tool configurations were created. The first model was a rotary table (Fig. 2a), while the second one was the model with a divider (Fig. 2b).

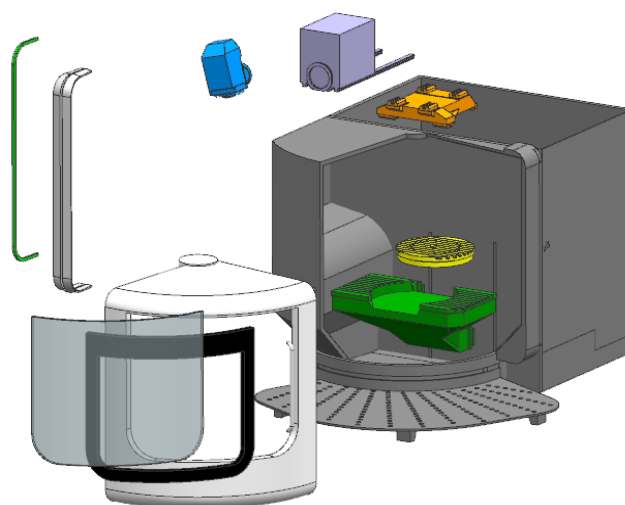


Fig. 1. Modeled components of the DMU 100 monoBLOCK machining center

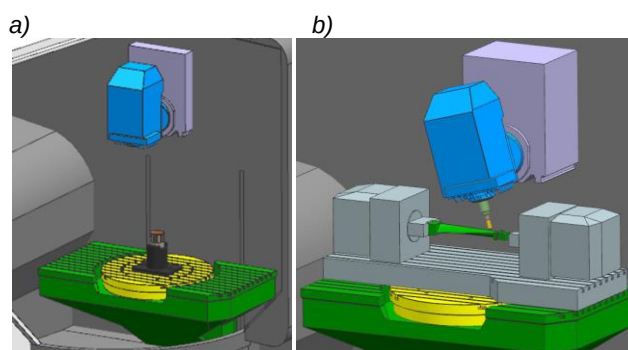


Fig. 2. Tested machine configurations: a) with rotary table, b) with divider

In the next stage, the assemblies of both machine configurations in the ASSEMBLY and MACHINE BUILDER modules of the NX system, were made. In each case, the assembly model was assigned with full kinematic configuration of the machine tool. This consisted in defining specific relations between different elements of the machine model and declaring the directions and limits of axis motion: X, Y, Z, B, C (Fig. 3 and 4).

Fig. 5 shows a kinematics tree for example with a rotary table in NX system. It can be seen that in this structure there is a hierarchy of the type: the parent - the slave. This is evidenced by the fact that when defining

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kinematics, each child part moves together with the parent. It can be seen that the parent element in the first branch is the slider moving along the X axis, and the child elements are: the fixed headstock in the Y axis and the spindle rotating about the B axis. The second branch of the tree is the table, in which the movement along Y axis is the parent and the child - rotation around axis C .

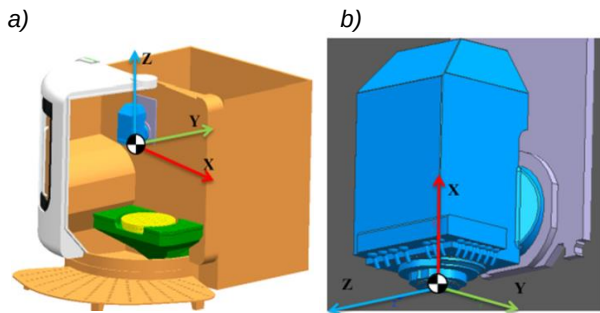


Fig. 3. Definitions: a) machine's base, b) spindles and tool-changers

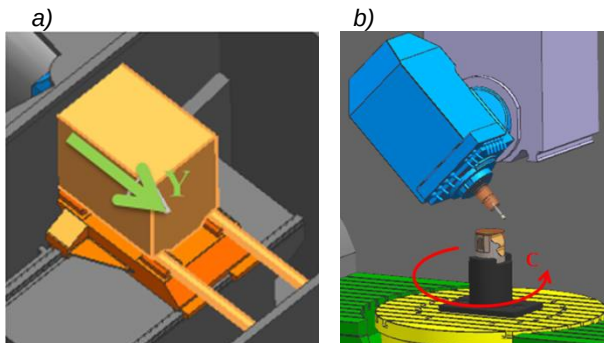


Fig. 4. Definition of axes: a) linear, b) rotary

DMU_100_MONOBLOCK_5AX_BA		
MACHINE_BASE	_MACHINE_BASE	MACHINE_ZERO_JUNCTION*
X_SLIDE		
Y_SLIDE		
B_ROTARY_HEAD		B_AXIS_ROTATION
SPINDLE	_DEVICE	S*
POCKET_01	_STATIC HOLDER	T1
Z_SLIDE		
A_ROTARY_TABLE		A_AXIS_ROTATION
SETUP	_SETUP_ELEMENT	
BLANK	_WORKPIECE_SETUP_EL...	
FIXTURE	_SETUP_ELEMENT	
PART	_PART_SETUP_ELEMENT	
DOOR		DOOR

Fig. 5. Configuration tree of the virtual machine kinematics

Machining simulation

Simulations for both configurations were based on the code generated by the system and the NC code generated by the postprocessor. Two examples have been prepared to check the simulator. Both consisted of the five-axis machining.

The NC code analysis allows to verify the finished program. This is an important advantage, because there is always the risk of additional errors at the post-processing stage.

In the first example (Fig. 6a), too much spindle deviation occurred when working on a rotary table. As a result, the spindle collided with the table during machining. This situation can occur especially during the positioned machining of complex structures. In this case, the movement tracking simulation of the tool itself with the rim was not sufficient to detect the collision.

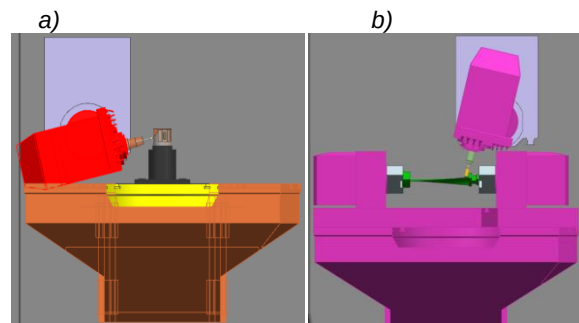


Fig. 6. Spindle collision: a) with rotary table, b) with dividing jaw

During the simulations with dividers (Fig. 6b), changes were made to the tilt angle of the tool. This angle is strictly dependent on the shape of the work surface. During the line operation, the momentary spindle tilt caused a collision with the jaw of the divider. This situation would also not be detected during the simulation of the tool path only.

In addition, a case in which a manual change has been made to the generated NC code, has been investigated. There were also irregularities detected here.

The generated code was used to make a turbine blade (Fig. 7) at the configuration with a divider. The machining was done correctly and there were no differences in the kinematics of the machine relative to the simulation.



Fig. 7. Ready blade

Conclusions

By analyzing the cases discussed in the paper, one can conclude that the virtual machine model works correctly. Both models detected collisions, which, based on the simulation of the work of the tool itself, would not be noticed. It is also important that the simulation is carried out not only using the intermediate code but also applying the NC code. This avoids additional errors due to postprocessor malfunction.

In the case of five-axis machining, the risk of collisions is much higher, therefore the use of virtual machines is highly justified.

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