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Application Analysis of Virtual Simulation Technology in NC Machining

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Abstract. With the help of the computer simulation technology, the virtual machining simulation system of NC machine tool was built based on the integrated simulation module of the UG NX software. Through setting the NC machine parameter of the virtual machining system, the machining process simulation of the typical parts in virtual environment was completed, which implements the collision and interference checking in the process of NC machining and verifies the correctness of NC programs. Finally, the simulation results prove that the assembly modeling method of virtual simulation system for the NC machining is feasible, and the simulation of machining process can effectively determine the mutual interference problem of the machining system, which lays the foundation for effectively preventing the collision accident.

Introduction

With the rapid development of computer technology and the continuous improvement of the computer graphics, computer simulation technology has been widely used in manufacturing industry. NC machining simulation, as an advanced human-computer interaction technology, with the help of computer graphics, applies visualization technology to produce an artificial virtual environment to simulate the realistic environment of NC machining process system [1]. NC machining simulation technology, by means of computer simulation and modeling software, is to simulate the actual machining environment and its working state, portraying the processing route on the computer screen, and providing some feedback about false information to help the engineering technical personnel to observe the manufacturing process in advance, in order to timely discover the problems and effectively predict the collision phenomenon occurring in the process of NC machining, which will significantly improve the safety usage of NC machine tool and has important practical significance to avoid occurrence of machine accident [2].

At present, for the realization of NC machining simulation system, very few independent machine simulation software has machine simulation function by itself, but its function of modeling is very limited, especially for the assembly model of machine tool and fixture with complex structure, which is usually forced to implement the simplification. Thus this will lose a lot of useful information, can not reflect the actual working environment. However, for the commercial CAD/CAM software, a large number of references mainly introduce how the software was combined with other existing modeling software or with the help of VC++ and OPENGL technology to build the NC machining simulation system. The disadvantage of this method lies in the lack of corresponding technical foundation and need to write a lot of codes of machine tool machining simulation.

This paper aims at the existing NC machine tool of the experimental center as the research object to construct a NC machining simulation system and focuses on discussing the construction process of the complete process system model of NC machining in detail, and successfully realizes the dynamic entity machining simulation of NC machine, and truly reflects the actual machining process. Through the simulation of the machining process, the correctness of the NC program were evaluated accurately, and NC program can be quickly modified according to the simulation results, in order to

avoid repeated process of trial cutting on the actual machine, save material consumption and production cost, which provides a powerful tool for the reliability verification of NC machining program and prediction of machining process.

Application of NC Machining Simulation

At present, the simulation model of NC machining process commonly includes two modes, namely tool path simulation and dynamic entity simulation.

Tool path simulation stores the key point coordinate during the process of machining in a certain data structure, and then read out the coordinates of these points to real-time display the machining process through wire frame mode, in order to check whether the calculation of tool location is correct, whether there is overcut phenomenon occurring during the machining process, whether the selected tool and the tool path is reasonable, whether the interference and collision occurs between the tool and the constraint surface and so on, however, the results of simulation in this way is not ideal.

Dynamic entity simulation is to display the tool and workpiece, and dynamically simulate the ablation process of the workpiece material according to the tool path, which can directly observe the workpiece cutting and obtain very lifelike simulation effect. But this pattern does not consider the whole processing system for its simulation model ignores the machine tool, handle, fixture and other geometry, resulting in no checking out whether there is interference between machine tools-cutter-workpiece-fixture. Therefore, the simulation results are not ideal. Tool path simulation and dynamic entity simulation process are shown in Fig. 1.

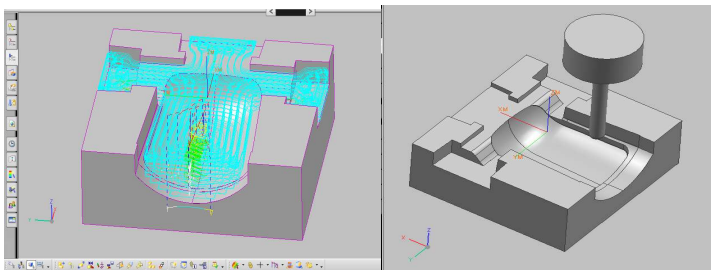

Fig. 1 Tool path simulation and dynamic entity simulation process

In order to obtain the ideal simulation results, it is necessary to establish a more perfect processing system model to accurately reflect all kinds of interference of the actual machining process. The advanced integrated simulation module of UG/CAM can simulate machine movement. Through the establishment of precise motion model consistent with that of NC machine tools in the actual production process, the simulation results will fully accord with the actual situation. Therefore, it can preview all machining operations, including macro instruction, cycle control, processing ready command and tool function instruction and so on. So many practical problems related to NC machine tool can be found in the generation process of tool path. Until the actual parts processing, we have already identified which can be processed on the machine tool. This operational mode not only saves the cost but also improves processing efficiency, not to interrupt processing because of the processing problems, which makes NC programming safer, more efficient and more adaptable.

NC Machining Process Simulation

Virtual Assembly Model of Machine Tool. Geometry modeling of virtual NC machine tool is crucial for the realization of NC machine tool simulation. Firstly, each motion submodule of NC machine tool is precisely divided according to architectural features and movement characteristics of NC machine tool, and then divide the Machine tool bed, spindle module, X-axis feed module, Z-axis feed module, the turret based on the kinematic chains of "work-framework" and "tools-framework"; Secondly, according to the motion transmission relation of the kinematics' chain, the layers and positions of all modules in the model tree are determined in accordance with the principle of the

previous level as sub-assembly of next level in the model tree; Thirdly, on the basis of the bottom-up assembly principle, after each subassembly is firstly established respectively, we start to finish the upper assembly from the bottom assembly and the correlative parts; finally, general assembly model of NC machine will be established through a layer-by-layer assembly [3].

This paper takes NC lathe of the experiment center as the research object, to execute the structure dynamic analysis of machine tool and then obtain the mechanism moving transmission diagram. According to the above modeling method, two kinematics' chains of NC lathe involved are as follows:

(1) The assembly model including the workpiece and fixture (SETUP)-Lathe spindle-Machine base;

(2) Turning tool-Tool carrier-X-axis feed module-Z-axis feed module-Machine base.

According to the above two kinematics' chains, we can draw the assemble model tree of NC lathe and then establish the assembly model of NC lathe as shown in Fig. 2.

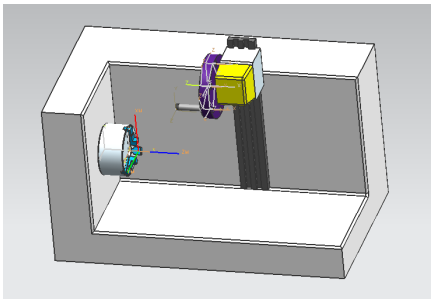

Fig. 2 Assembly model of NC lathe

Establishing the Motion Model of NC Lathe. Motion model of machine tool defines the mutual movement relationship between the moving parts of the assembly model, specifies the direction of movement, travel route and range of motion for all the axes of machine tool, and sets machine zero point, workpiece mounting point, tool mounting point and other related parameters. UG/CAM integrated simulation module can identify spindle, feed shaft, tool carrier and other moving parts through interactive mode. When clicking the icon of machine tool builder, motion components and each moving axle can be inserted into the motion model of machine tool through right-click in the name column, and then set the connection point, with reference to the two kinematics' chains of the above NC lathe, the motion model of NC lathe will be gradually established as shown in Fig. 3.

Machine Tool Navigator - Setup Configurator

Name	Classification	Axis ...	Initia...	NC ...	Junctions
HORIZONTAL_LATHE_2_AXIS					
MACHINE_BASE	_MACHINE_BASE				MACHINE_ZERO*
Z_SLIDE		Z	933....	✔	
X_SLIDE		X	643....	✔	T_ROT*
TOOL_CARRIER	_DEVICE	TURRET	0	✔	
CHUCK	_LATHE_SPINDLE	C	0	✔	WORKPLANE
SETUP	_SETUP_ELEMENT				PART_MOUNT
PART	_PART, _SETUP_E...				
BLANK	_WORKPIECE, _S...				
FIXTURE	_SETUP_ELEMENT				

Fig. 3 Structural drawing of motion model of NC lathe

Machining Process Simulation

After the establishment of a complete machine environment, we can enter the UG/CAM integrated simulation module for processing simulation. Firstly, the typical part model must be input in the UG/CAM module, and then enter the machine tool view through the operation Navigator window, and then double-click the "Generic machine" to select "Change machine", and then the typical parts,

which has already generated tool path, will be imported in simulation model of NC Lathe, as the same time, fixture, workpiece, cutter and blank are also relocated to machine tools, thus the whole machining simulation system of NC lathe is established.

As to the simulation system of NC lathe, we open the machine tool view of the operation navigator, and select the command “tool path / simulation” to enter the "simulation control panel" dialog box, and the integrated simulation and check operation can be carried out in the whole process. In the simulation process of the NC lathe, we can observe simulation process omni-directionally by scaling, translation and rotation operations and discover the processing problems. Aiming at any collision and interference errors arising from some parts and fixture in the process of simulation and the corresponding NC codes, we can adjust and correct them until there is no mistake in them, and then output the useful NC code. NC machining process simulation and NC processing code is displayed as shown in Fig. 4.

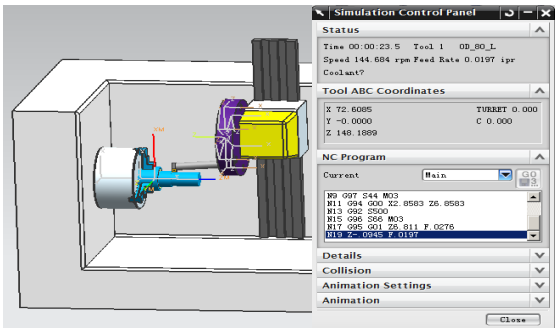

Fig. 4 Machining process simulation and NC processing code

Summary

Combined with UG/CAM simulation module, through the reasonable modeling process of virtual machining simulation system, this paper establishs the exact motion model completely consistent to that of NC lathe in actual production processing, and eventually develop the virtual machining simulation environment of NC lathe. Through dynamic simulation processing for typical parts, the simulation results is fully in line with the actual situation, reflects all kinds of interference problems of the actual machining process in detail, obtains the ideal simulation effects. For this reason, the final research results show that the simulation of machining process can effectively prevent the collision accidents, significantly improve the safety usage of NC machine tools, and has important significance for promoting the development of modern manufacturing industry.

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