Research on the Programming Technology of Five Axis CNC Machining Impeller Based on Virtual Reality Technology

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Abstract. With the rapid development of computer technology, Virtual Reality Technology (hereinafter referred to as VRT) has been applied to a variety of industries, especially industry. With the development of science and technology, people have higher requirements on the structure, quality and accuracy of products, such as aircraft shell, engine blade, mold, automobile complex surface, etc., which requires the application of Five axis CNC (hereinafter referred to as FA-CNC) machine tools. FA-CNC machine tool is the most recognized CNC machine tool in the market, which can achieve flexible pose conversion. Through the FA-CNC machine tool, we can achieve one-time clamping, which will better complete the processing of parts. Through the FA-CNC machine tool processing, we can ensure the processing accuracy, which can greatly improve the production efficiency. At the same time, CNC machining (hereinafter referred to as FA-CNC) simulation is the last verification program, which can verify the correctness of the program [1]. Through VRT, we can make clear the various conditions in the process of processing, which will facilitate the analysis of the processing program. Based on UG platform, this paper studies the impeller programming process. Through the VRT, this paper carries on the simulation verification to the processing technology, which will better complete the impeller and other complex surface structure equipment processing.

Keywords: VRT, FA-CNC Machine Tool, Impeller Processing, Programming Technology

1. Introduction

With the improvement of market demand, people will continue to improve the demand for complex surface parts, which requires us to continue to increase the processing equipment. Therefore, FA-CNC machine tool will become the most important equipment, which is also an effective means of machining complex surface parts. Through five axis machining technology, we can improve the CNC programming, which is the link of CNC-M. With the maturity of VRT, VRT has been widely used in the field of CNC-M, which can verify the correctness of CNC program [2]. Through the inspection, we can clear the various conditions in the actual processing process, which will facilitate the analysis and processing of
technical personnel. By modifying the machining program, we can eliminate the hidden trouble in the program, which will improve the machining efficiency of impeller and other complex surface structure parts.

2. Process analysis

2.1. Basic structure of FA-CNC machine tools

In this paper, cx110100 machine tool as an example, the structure is shown in Figure 1. The swing range of axis B is from -30° to 180° and the rotation range of axis C is from 0° to 360° when it is used as a turntable. The maximum rotation speed is 500 R/min when converting to spindle, and Siemens 840D is used as CNC system.

![Figure 1. Basic structure of FA-CNC machine tools.](image1)

2.2. Impeller structure diagram

This paper intends to process impeller parts, as shown in Figure 2. Among them, the maximum outer diameter of the impeller is 140 mm, the number of blades is 8, and the outer edge of the impeller is approximately circular. Therefore, we need to clamp the cylindrical turning tool on the b-axis swing head first [3]. Then, with the c-axis turntable as the main shaft, we can process the outer rim of the impeller. The integral impeller is milled by the process of separating rough from fine. Through the three-axis method, we can roughly mill out the outline of the impeller. Precision milling focuses on dimensional accuracy and surface quality, which can be processed by the two shafts of the machine tool, which is called "3 + 2" machining. In the specific processing, we need to use 10 mm cemented carbide ball cutter for milling according to the blade spacing.

![Figure 2. Impeller structure diagram.](image2)
3. Machining programming

3.1. Turning programming

The cylindrical blank is machined into the outer contour of the blade by turning [4]. The programming origin is located at the center of the cylinder top surface [4]. CNC-M program adopts manual programming.

3.2. Milling Programming

In this paper, UG NX is used for milling programming. There is impeller processing module in UGNX. Therefore, we can simplify the impeller programming process, as shown in Figure 3 [5]. In UG NX impeller module, we need to use indirect processing. Then, through the hub and blade machining function of impeller module, this paper can generate five axis tool path for finishing.

![Diagram]

**Figure 3.** Programming process of impeller.

3.3. Virtual simulation

We need to establish a simulation environment, which can simulate the processing of the program. By comparing the machining model with the original design model, we can confirm the correctness of the programming method. The main method of impeller machining is milling. Based on UG cam CNC programming process, we can complete the creation of nodes, which helps to modularize the cumbersome programming process [6]. In the process of CNC programming, we need to create tool node, machining method node, program node and machining geometry node. First, tool node. In this node, we can select tool type and set tool geometry parameters, which will create or modify tools. Each tool node represents a tool used by the operation. The operation sharing under the same tool node is the same tool. And only one tool can be used for one operation. Second, processing method node. Parts processing needs to go through rough machining, semi finishing, finishing several steps. The machining method node can be used to set machining parameters such as machining allowance, internal and external tolerance, cutting step and feed speed. In UG cam, we divide milling into rough milling (C mill rough) and program node. The program node is mainly used to arrange the order of each processing operation in the program [7]. A complex part can be divided into program groups to facilitate tool path output and management. Fourth, machining geometric nodes. Through the operation of this node, we
can determine the machining orientation of the specified part on the machine tool, including MCS, part, blank geometry, boundary and inspection geometry. After creating the node, we can insert a new "operation", which will determine the machining parameters. The processing scheme of impeller is shown in Table 1.

Table 1. Impeller processing scheme.

| NO. | Tool number | Cutting mode                      | Processing range                                |
|-----|-------------|-----------------------------------|-------------------------------------------------|
| P1  | T1          | Cavity milling                    | Rough milling the whole part                     |
| P2  | T2          | Deep machining five axis milling machine | Semi finishing of curved surface and blade |
| P3  | T3          | Z-Level Milling                   | Finish machining of inner hole and side of step |
| P4  |             |                                    | Arc surface finishing                           |
| P5  | T4          | Variable axis surface profile milling | Blade finishing             |
| P6  |             |                                    | Corner cleaning                                 |

3.4. Program simulation

After the CNC program is generated, in order to ensure the correctness of the program and the safety of the machine tool, it is necessary to check and verify the program before it is put on the machine. The capacity of post generated impeller machining program is large. In addition to the beginning and end of the routine program, there are a large number of point coordinates in the middle, which is very difficult to check manually [8]. Therefore, we must use the corresponding simulation program for verification. VERICUT is a commonly used CNC program verification simulation software, which can not generate program code, but can simulate the existing G code program [9]. We can simulate the production process by machine tool simulation, collision check and cutting model size analysis. At the same time, there is a special interface between VERICUT and UG, which can call simulation directly in UG. The simulation flow chart is shown in Figure 4.

![Simulation flow chart](image)
3.5. Tool path verification of machining simulator

In the simulation environment of VERICUT software, we can simulate the cutting process of parts, which can effectively verify the interference and machine collision, as shown in Figure 5.

![Figure 5. Tool path verification of machining simulator.](image)

4. Conclusion

With the increasing complexity of machining parts, people have higher and higher requirements for CNC-M program [10]. Through VRT, we can better simulate the machining process, which will better realize the optimization of CNC program. Through UG, VERICUT and other software, we can improve the utilization rate of FA-CNC machine tools, which will reduce the processing security risks.

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