On the Application of Impeller in Multi Axis CNC Machine Tools

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Abstract. Multi axis CNC machine tool has good linkage processing effect. Through the application of integral impeller in CNC machine tools, to improve the adaptability of CNC machine tools to complex surface processing parts, to improve the accuracy of multi axis CNC machine tools. The first part of this paper introduces the integral impeller and its machining characteristics; the second part introduces the basic NC machining process of integral impeller; the third part discusses the application of impeller in multi axis CNC machine tools from the creation of guide track, the simulation of integral impeller, software processing and generation. The purpose is to provide some reference for the processing and production of integral impeller.

Keywords: Integral Impeller, Multi Axis CNC Machine Tool, Application

Introduction
Impeller is a rotating body with blades used to transmit energy to liquid. It is an important part of water pump, engine and other machinery, and has been widely used in military industry, energy and other fields. According to the structure of water pump and engine, the structure of the pump is different. The common impeller forms are closed, front half open, rear half open, open and so on. Different types of impeller processing and production methods are different. The traditional impeller production integrity is poor, and the surface process accuracy is relatively low. With the development and application of multi axis numerical control technology, the production and processing technology of the integral impeller is gradually mature. The improvement of the properties of the whole impeller products has expanded its application scope in various fields to a certain extent, and made its application recognition degree very high. As a typical representative of five axis NC machine tool, the whole impeller is of great significance to the optimization of impeller processing process [1].

1. Integral Impeller and Machining Characteristics
Integral impeller refers to the use of multi axis CNC machine tool for any two axis or three cycle linkage processing. In this way, the machining quality of impeller can be improved by using ball cutter. The core of integral impeller machining is blade [2]. Different from the traditional impeller machining, the five axis machining of integral impeller changes the form of point contact to line contact. The line contact ensures the effective cutting efficiency of the impeller blade edge in the surrounding
processing, and can better control the deformation. Although the five axis NC machining of integral impeller has good effect, the machining process has high requirements for equipment and fixture, and the programming is relatively complex [3].

The root of the blade, the side of the runner and the arc between them are curved surfaces, and the area of the curved surface area is large. According to the surface formed in the root area of the blade, the surface can be divided into two types: conical surface and inclined plane. There is a certain angle between the blade and the runner, forming a transition surface. In the whole blade machining, the accuracy of tool path is very high in the surface machining. The accuracy and efficiency of curved surface cutting directly affect the machining efficiency and quality of the whole blade [4-6].

The integral impeller is processed and produced by multi axis numerical control, which has the characteristics of fast processing speed, high precision of parts, low comprehensive cost, good reliability and high digital production management. As a typical representative of machining five axis CNC machine tool, the integral impeller adopts ball end milling cutter. The arc part of ball end milling cutter has the best geometric cutting tool, which can not only effectively improve the efficiency of blade ischemia processing, but also greatly reduce the scrap rate of parts with high precision. For joint production, a NC machine tool can effectively reduce the utilization rate of CNC machine tools and a series of cost costs such as special tools and special clamps by completing multiple processing procedures. Compared with the traditional numerical control foundation, the efficiency of the five axis linkage production and processing blades is more than ten to dozens times higher than that of the past. The digital configuration of the five axis CNC machine tool equipment and system is very high. Because the whole process adopts digital management and automatic production, the precision and efficiency of parts processing are effectively improved. The most important is that it effectively solves the problem of machining error caused by the manual machining of curved surface parts, and improves the standardization of the whole impeller machining [7].

The integral splitter impeller has the characteristics of complex shape and structure, thin blade, small space distance between adjacent blades, inverted blade surface, longer main blade than flow blade, and all blades are evenly and symmetrically distributed along the axial direction.

Impeller belongs to thin-walled complex parts, according to different materials, its processing method is also different, because the blade surface processing is difficult, the processing process is easy to deform, the requirements of CNC machine tools and processing tools are higher. The selection of cutting tools plays a key role in the machining quality of integral splitter impeller. Reasonable selection of cutting tool types and materials can not only improve the machining accuracy and efficiency of integral splitter impeller, but also prolong the service life of cutting tools. In this paper, according to the shape characteristics, materials, processing difficulties and cost of the integral splitter impeller blank, a comprehensive consideration is given.

2. Processing Technology of Integral Impeller with CNC Machine Tool

2.1 Process Flow
The whole impeller is processed by multi axis CNC machine tool. The process flow is modeling → generating tool path → clamping parts → alignment → home workpiece coordinate system → generating code according to origin coordinate → workpiece processing. When finishing the blade, it should be processed in different areas. Sub regional processing should follow the principle of from shallow to deep, from top to bottom, from basin to hub. The whole machining process should be from curved surface to root cleaning and then to curved surface. When cutting the bottom surface, it should help to solve the problem of overcutting caused by excessive bottom allowance. The steps of machining are rough machining, semi finish machining and finish machining.
2.2 Application of Key Technology in Integral Impeller Machining

2.2.1. Tool selection. In the multi axis NC machine tool processing of integral impeller, the selection of cutting tools should meet the technological requirements of processing materials, as well as the relevant technological requirements of rough machining, semi finishing and finishing. The reference factors include tool hardness, wear resistance, high temperature resistance and economy. For some difficult coating materials, such as titanium alloy and nickel base superalloy, tools coated with TiAlN and Al2O3 should be selected. There are ball end milling cutter, end milling cutter, ring milling cutter, cone milling cutter, drum milling cutter and so on. Among them, ball end milling cutter and end milling cutter are most widely used.

2.2.2. Rough machining. When the multi axis CNC machine tool is used to roughen the cavity, when the plane contour is used to process the cavity, the UG area is milled with the cavity, and the CAXA area is roughed with the region method. Three axis machining can be used in rough machining, and the unilateral allowance is set to 4mm.

2.2.3. Semi finishing. Semi finish machining uses variable axis sequential milling to process inclined rib cavity several times. For semi finishing variable axis curved surface contour milling, the upper third part has a margin of 0.5mm, the middle third part has a margin of 1mm, the lower third part has a margin of 2mm, and the base has a margin of 1mm. One third of the top part of the blade is machined with a margin of 0.5mm, the lower third part is machined with a margin of 1mm, and the base part is machined with a margin of 0.5mm.

2.2.4. Finishing. The precision machining uses the variable axis sequence milling once to fine process the inclined bar cavity. The allowance of the top part and the upper third part of the finished blade is 0mm, the allowance of the middle third part is 0mm, and the base allowance is 0mm.

3. Application of Impeller in Multi Axis CNC Machine Tool

Automatic programming and simulation analysis are used in multi axis NC machining of integral impeller. The simulation model is generated by MasterCAM software to deal with multi axis machining of integral impeller. MasterCAM software has the functions of automatic part modeling, tool path creation, solid modeling, simulation processing and machining code generation.

3.1 Tool Path Creation

After the modeling of the part is completed, the blank centerless is selected according to the part processing technology, the workpiece coordinate origin is determined, the origin coordinate system is established, and the machining tool is selected according to the process, and the tool path is automatically created by setting the parameters of the tool. There is a menu of machining group information in tool path selection. In the main menu, select tool path, then select multi axis machining, then select multi axis surface five axis, you can set the default options of CNC machine type. According to the processing procedure, the surface parameters, cutting parameters, compensation form and compensation direction can be set, and the tool path of multi axis CNC machine tool can be customized by defining the parameters such as step length and step length.

In the impeller processing, the ball head cutter is usually used for processing. In the case of determining the diameter of the tool used, the tool path is the primary requirement to ensure smooth machining; when planning the tool path, the interference phenomenon between the blades should be considered. The deeper the machining depth is, the more limited the tool space can be. When generating tool path (tool path), the machining path of layered milling should be selected first. There are many ways of track layering, the most common are isoparametric method, wheel hub isometric method and flange isometric method.
3.2 Simulation Machining of Integral Impeller

The solid machining function of MasterCAM software is used to verify the tool path (Figure 1 trajectory verification), and the solid simulation machining of the integral impeller is carried out. Through the simulation processing, we can observe the rationality of the cutter, cutter position, cutter path, advance and retreat of the impeller blank in the actual processing process, so as to more truly understand the whole impeller processing process, so as to correct the problem in time. In the process of solid simulation machining of integral impeller, if over cutting, collision and other problems occur, the model will be automatically expressed in different colors (Figure 2 simulation results), so that users can find the problem and its location in time and clearly, and adjust the machining process of integral impeller.

Due to the different NC code requirements of each machine tool, the planned tool path code can not be recognized by all machine tool control systems. It is necessary to convert these tool center coordinates and tool axis vectors into machine tool motion coordinates, and generate NC machining program with the help of special post-processing.

Mastercam, as a special NC machine tool simulation software, establishes the virtual machine tool body, control system and tool library on the computer. By adding blanks and calling NC program, you can see the same effect as machine tool processing on the PC end, so as to verify the correctness of the planned tool path.

3.3 Software Processing and Generation

After the tool path is created by MasterCAM software, NCI file can be generated. NCI file can’t be used to control NC machine directly. At this time, only the processing NCI file needs to be converted into NC program. The NC program can automatically generate the code used to control the NC machine tool. With the code generated by NC program, the NC foundation can be controlled and the whole impeller can be machined automatically (Figure 3 physical effect).
4. Conclusion
Impeller is a part with complex surface. The structure of integral impeller is very complex, and the process accuracy is very high in the process of processing quality. Using five axis CNC machine tool to process the integral impeller is conducive to optimize the tool path through programming and improve the accuracy of impeller processing. Using the five axis CNC basic simulation processing technology, we can also understand the problems in the whole impeller processing through simulation analysis, and strengthen the processing accuracy by strengthening the control of influencing factors, so as to improve the production efficiency and reduce the cost of comprehensive production.

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