Research and Application of Automatic Programming and Machining of Impeller Modeling Based on Reverse Engineering

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Abstract: With the deepening of people's understanding of reverse design, the related software and hardware are gradually popularized and perfected. Its convenience and speed become more prominent day by day, and the fields involved are more and more extensive. The integral impeller, as a key part of power machinery, is widely used in the aviation and aerospace field, and the engine is the key to the whole drone. Therefore, the performance of the impeller directly affects the mechanical efficiency of the whole drone, and it plays a greatly significant role in the national defense industry. In designing and re-designing, it is very difficult to establish complex free form surface models. In manufacturing, multi-axis machining technology is also required to achieve it. This thesis mainly studies the application of reverse engineering to realize the measurement, redesign and machining of the integral diagonal impeller in the automatic programming of impeller modeling. Research and demonstration on the acquisition and processing of impeller point cloud data, model reconstruction, redesign, multi-axis machining technology and orthogonal experiments to optimize cutting parameters

Introduction

With the rapid development of economic globalization, in order to develop in the fierce competition, all countries and enterprises are accelerating the speed of research and development in their own fields for the development of their respective economies. The application of reverse engineering in many countries has obtained good economic benefits. France's largest car manufacturer company has applied reverse engineering technology to its seats, reducing time to one fifth of the origin. Using Reverse engineering technology to inversely find that the product model is a relatively fast and efficient method. On this basis, innovation and redesign are made to research and develop your own technology. It is a technological innovation method commonly adopted by various countries. The technical capability in the aviation and aerospace field reflects the national defense strength and technological development level of a country, so the reverse engineering is of great significance to the development of all countries. Integral diagonal impeller is widely used in compressor parts like micro gas turbines. The design and manufacturing technology of impeller blade directly affects the compressor's operating performance and reliability, and it plays a key role in the compressor set. This thesis mainly studies the application of Reverse engineering technology to realize the impeller measurement and redesign in a micro gas turbine. This article adopts Reverse engineering technology in the integral impeller model for reverse reconstruction, and then conducts a finite analysis of the reconstructed overall impeller model structure, further redesigns the model structure optimization. Multi-axis machining technology is performed for automatic programming and simulation machining verification of the integral impeller, and finally trial cutting is performed on the machine tool [1-3].

1. Reverse Modeling of Integral Impeller

Reverse engineering is also called Reverse design or inverse engineering. The English name is Reverse Engineering. It is a collection of analysis methods and application technologies that transform existing product models (physical models) into engineering design models and

conceptual models, and then dissect, deepen and recreate them. The application of reverse engineering can effectively reduce the design cycle to improve product economics and and quickly dominate the market. The process of reverse engineering is also an effective method to absorb and digest foreign advanced technology and develop innovative products. Its main process is to collect data from the original physical model, and then convert it into a product digital model. One of its functions is to provide sufficient information for improving product development design and machining quality analysis.

Reconstruction of the integral impeller's inverse model mainly includes four aspects: the collection of point cloud data, preprocessing data, reconstruction of surface model, and evaluation of impeller surface quality. The quality of the model reconstruction will directly affect the running performance of the gas engine. In this chapter Konica Minolta VIVID9i three-dimensional scanner is used for data collection, then the reverse software Image ware is used for the reconstruction and evaluation of the surface model, and finally UG software is used for the model redesign. Generally, coordinate measuring equipment is divided into two categories: non-destructive measuring equipment and destructive measuring equipment. Destructive measurement mainly refers to: milling of the sample layer by layer, the minimum thickness of each layer can reach 0.01mm, then obtaining the internal and external contours of each layer section after each layer is scanned, and superimposing the data obtained by each layer to form the three-dimensional model, which has the advantages of high sampling accuracy, unrestricted by contours, and both internal and external contour data can be collected. The disadvantage is that the real sample is destroyed at once. Non-destructive measurement mainly refers to: maintaining the prototype of the sample, and dividing it into contact and non-contact according to whether contact with the object surface in measurement process. Efficiently and accurately digitizing the surface of parts is the primary link and key to achieving Reverse engineering technology [4, 5].

2. Multi-axis CNC Programming

One or two rotation axes are added in multi-axis CNC technology on the basis of three-axis CNC technology in order to realize the arbitrary control of the tool and the workpiece position, and the change of tool axis vector is realized by revolving table or yawing. In three-axis CNC machining, the tool axis is fixed in the workpiece coordinate system and is always parallel to a certain coordinate axis, but in multi-axis machining, the tool axis is always changing. Therefore, multi-axis CNC program is generated after multiple complicated spatial geometric operations and coordinate transformations. As we all know, due to the diversity of multi-axis CNC machine tools, the same machining program cannot be applied to all types of multi-axis machine tools. However, the same machining program can obtain the same machining results on three-axis CNC machine tools with different structure types. The control of tool axis vector is the core part of multi-axis CNC machining technology. In the market, multi-axis CNC programming is still completed by CNC automatic programming CAM system. There are two main programming methods based on CAM system: independent CAM system and CAD / CAM integrated system. The independent CAM CNC programming system focuses on the research and development of processing strategies, and strives to obtain the most concise and most efficient CNC machining programs under the premise of good machining quality. The geometric model of this type of programming system is from other CAD systems through some conversion files such as IGES, step, etc. There may be problems such as dimensional errors after conversion, and it actually doesn't take into account the the data association of tool path generated by geometric model. Thus the intermittent machining program occurs and it causes the problem of the cross section of the machining surface, which reduces the programming efficiency to a certain extent. CAD / CAM integrated CNC programming system is based on its own CAD function to build a geometric model, directly obtain the product solid model from the CAD module without file format conversion, and then use the CAM part to complete the CNC programming. Compared with the program generated by the independent CAM CNC programming system, it is not so concise and efficient. No matter which programming method is adopted, the process is basically similar for multi-axis CNC. As shown in Figure 1 multi-axis CNC

programming flowchart[6-8].

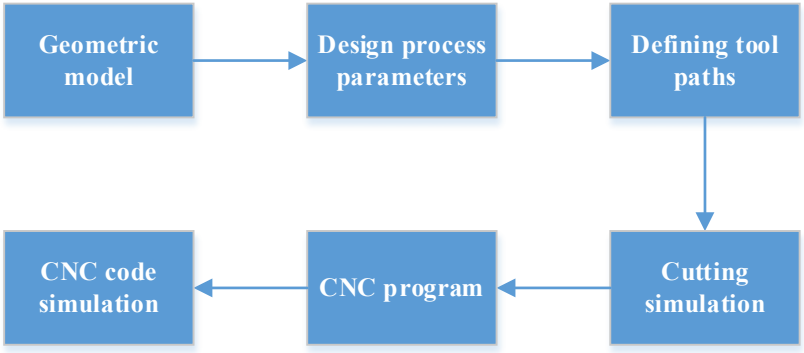

Figure 1. Multi-axis CNC programming flowchart

3. Digital Measurement and Processing of the Parts

Because it is very difficult to establish a mathematical model of a complex free form surface, reverse engineering technology should be applied. A coordinate measuring machine is used to precisely measure the complex free form surface of the part in order to convert the physical model of the part into measured data points, and then to build a CAD model of the part based on the data points. In this paper, the continuous contour scanning method is adopted to realize the automatic measurement of the blade profile. Data processing is a key part in reverse engineering, and its results will directly affect the quality of later surface reconstruction. The purpose of data processing is to obtain the basic characteristic information of the measured data, including the scanning direction, step distance, total number of scanning points, total number of scanning lines, three-dimensional space extremes, etc. These information are helpful for following surface reconstruction. Thus completing the solid modeling of integral diagonal impeller part, as shown in Figure 2.

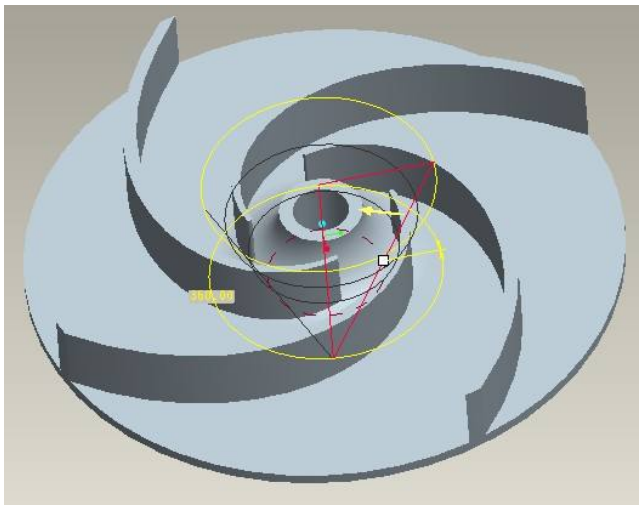

Figure 2. Impeller Part Solid Modeling

Data processing usually includes the following content: data format conversion and compensation, noise point elimination, data multi-view registration, data point refinement, data point encryption, data point ordering, and data point segmentation. For the elimination of noise points in "point cloud" data, it not only should delete the error points, but also prevent the effective points from being lost too much. For noise points outside the boundary, it is difficult to delete them little by little due to the large number, which will take a very long time. If a polygon is defined for elimination, the "point cloud" inside the 3D boundary will be deleted easily. In order to avoid this happens, multiple polygons can be defined to delete in multiple times, but this method also costs much time. After several experiments, a method to quickly delete noise points outside the 3D boundary curve is found, which is called 3D boundary method. This method takes the 3D boundary

of the part measured by a coordinate measuring machine as a reference. As long as a polygon is defined to surround the "point cloud" data to be deleted and the corresponding operation is performed, the "point cloud" inside the polygon can be eliminated. Follow the principle of reverse modeling of point -line-area-body to reconstruct the integral impeller model [9-12].

Conclusion

Integral impeller, as the core part engine of compressor type, is widely used in aviation, aerospace, and ground propulsion systems, and its design and manufacturing technology represents the country's level in advanced manufacturing industry. This paper mainly studies the reverse design and multi-axis machining technology of the integral impeller. The purpose is to use the reverse technology to quickly realize the reconstruction of the integral impeller and complete the machining on the multi-axis machine tool. The optimization of impeller is mainly to consider the influence of the thickness at the blade root and the size of the fillet, so the static strength analysis of impeller shows the stress of the model of each blade thickness and fillet combination, which provides some good references for design variables of impeller optimization.

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