Research on nxug10.0 impeller automatic programming and DMU50 five axis machining center

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Abstract. Taking nxug10.0 software as the platform and impeller as an example, this paper analyzes the structural characteristics and processing difficulties of impeller, reasonably formulates the NC processing scheme, and uses nxug10.0 impeller processing module to plan the tool path, generate the tool path file, and simulate the processing to verify the correctness of the tool path. The NC program of impeller is generated by special post processor and uploaded to DMU50 five axis NC machining center to complete the actual processing of impeller. Through the detection of impeller, the results show that the impeller fully meets the design and use requirements.

1. Introduction
Impeller is a complex space curved surface modeling part designed according to the principle of fluid mechanics or aerodynamics, and it is also the core part of many power machinery equipment, which has a wide range of applications in the field of modern machinery [1-2]. With the development of today's CNC technology and the emergence and improvement of five axis machine tools and other advanced CNC processing equipment, high-precision impeller parts can be processed as a whole. In the environment of UG nx10.0, there is a multi-blade NC machining process design module mill_Multi_Blade, the machining process module and its attached sub module can realize the process planning of the overall machining of the impeller, complete the NC machining programming of the impeller parts, and the UG nx10.0 machining environment has the advantages of good operation visualization, strong operation flow guidance, and high programming efficiency [3-4]. Taking the impeller programming as an example, the author introduces the automatic programming process of the impeller in nxug10.0 software. Finally, the impeller program is processed on dmu50 equipment to verify the correctness of the automatic programming program.

2. Impeller machining process planning
2.1. Overall planning of impeller processing technology
According to the impeller structure and processing requirements shown in Figure 1, the geometric structure of impeller parts mainly includes: mainstream blade, hub, fillet of connection, etc. the overall process planning is carried out according to the geometric structure characteristics and NC processing technology: (1) turning blank matrix by CNC lathe, as shown in Figure 2; (2) Rough machining of impeller runner, milling and removing materials between main runner blades; (3) The finishing of blade; (4) Finishing of hub; (5) Finish the fillet of the root.
2.2. Cutter selection
The choice of tool plays a key role in the quality of impeller machining. Reasonable selection of tool type and material can not only improve the machining accuracy and efficiency of impeller, but also prolong the service life of the tool. According to the shape characteristics, materials, processing difficulties and cost of impeller blank, the tool structure size and material are selected. The tool used in this paper φ6 ball headCutter, φ4 ball headCutter, φ2 ball headCutter.

2.3. Determination of impeller processing procedure
In this paper, DMG50 machine tool is used for processing, and the impeller model is measured and analyzed, φ 6, φ 4, φ 2 ball headCutter and other 3 tools, fixture for three jaw chuck clamping, impeller material for aluminum alloy. Considering the above factors and the structural characteristics of impeller, the appropriate NC machining process is formulated. The NC machining process is shown in Table 1.

| Serial number | Processing procedure | Processing content | Tool number | Allowance (mm) | Spindle speed n/ r.min-1 | Cutting speed vc / (m.min-1) |
|---------------|----------------------|--------------------|-------------|----------------|--------------------------|----------------------------|
| 1             | Rough machining      | Impeller passage   | T01         | 0.3            | 10000                    | 800                        |
| 2             | Finish machining     | blade              | T02         | 0              | 15000                    | 1200                       |
| 3             | Finish machining     | Hub                | T02         | 0              | 15000                    | 1200                       |
| 4             | Finish machining     | Root fillet        | T03         | 0              | 15000                    | 1200                       |

3. The programming and Simulation of impeller

3.1. Create a machining geometry group
The machining coordinate system is created and executed according to the description of positioning datum and clamping scheme. The processing coordinate system, design coordinate system and inspection coordinate system are consistent. Create a safety plane, set the top surface of the impeller as the reference, offset 80mm as the safety plane. In the geometry view state, create the part geometry (workpiece), select the impeller as the part geometry, and select the roughcast pretreated by the lathe as the roughcast geometry. Create impeller geometry (multi) under the workpiece group _BLADE_. Choose hub, package, blade and blade root fillet, and the impeller processing method is shown in Table 2 [5].
### Table 2. Impeller processing method and meaning list.

| Serial number | Processing method | Meaning |
|---------------|-------------------|---------|
| 1             | Runner roughing: a multi axis milling process that uses the cutting layer between the hub and the shroud to remove material between the vanes and splitter vanes. Used for rough machining between blade and splitter blade. |
| 2             | Hub finishing: multi axis process for finishing blades. Used for machining blades on turbine parts, etc. |
| 3             | Blade finishing: multi axis process of finishing blades and splitter blades in multiple cutting layers. Used for finishing blades and splitter blades on turbine components. |
| 4             | Fillet finishing: multi axis process for finishing the fillet of Multi Tool Path blade and splitter blade. It is used for finishing the blades and splitter blades that have been rough machined with larger tools. |

#### 3.2. Cutter definition

According to the measurement and analysis of impeller model, the structure and tooling of the selected machine tool DMU50, and the measured data of its tool tip, toolholder, chuck and other parts, the tool is completely defined, and the defined diameter is φ. The ball end milling cutter of 6 is T01 cutter with taper of 5°, the length is 75mm, the blade length is 50mm, and the defined diameter is φ. The ball end milling cutter of 4 is T02 cutter with taper of 3°, the length is 75mm, the blade length is 40mm, and the defined diameter is φ. The ball end milling cutter of 2 is T03, and the taper is 3°, the length is 65mm and the blade length is 40mm.

#### 3.3. Automatic programming and simulation machining of impeller

According to the above impeller processing procedure table, the impeller processing process is divided into: rough machining of impeller runner, blade finishing, hub finishing and blade root fillet finishing.

#### 3.3.1. Rough machining of impeller runner

Insert operation, select "Mill_Multi_Blade" → multi blade rough machining strategy. The program is named channel rough machining, and tool is T01 φ Ball end milling cutter for 6, multi geometry _ BLADE_ Geom, set processing parameters: the driving method is to extend 2 mm along the blade direction, 0mm in radial direction, automatic for cutter axis, reciprocating rise in cutting mode, and forward milling in direction. Cutting depth mode is from cover interpolation to hub, tolerance 0.03mm, blade allowance 0.3mm, hub allowance 0.3mm, check allowance of 0.3mm, and generate rough machining tool path of single channel, Right click tool path → object → transform → rotate around straight line → transform parameters as point and vector → number of unrelated copies is 6, etc., transform the other 6 channel rough machining tool paths, and generate rough machining tool path of impeller runner, as shown in Figure 3, and simulation processing is shown in Figure 4.
3.3.2. Blade finishing. Insert the operation and select "Mill Multi Blade" → "blade finishing" machining strategy. The program name is blade finishing, tool is T02 φ 4 ball end milling cutter with multi geometry_ BLADE_ Geom, set the processing parameters: the driving method is to cut the blade along the blade direction, the cutter axis is the side edge, the tolerance is 0.01 mm, the blade allowance is 0 mm, the hub allowance is 0 mm, the inspection allowance is 0 mm, the single blade finishing tool path is generated, and the remaining six blade finishing tool paths are transformed according to step (1), as shown in Figure 5, and the simulation processing is shown in Figure 6.

3.3.3. Hub finishing. Insert the operation and select "Mill Multi Blade" → "hub finishing" machining strategy. Program name is hub finishing, tool is T02 φ 4 ball end milling cutter with multi geometry_ BLADE_ Geom, set processing parameters: the driving method is to cut the blade along the blade direction, the cutter shaft is the side edge, the tangential extension is 2 mm, the radial extension is 0 mm, the cutting mode is reciprocating rising, the direction is mixed milling, the tolerance is 0.01 mm, the blade allowance is 0 mm, the hub allowance is 0 mm, the inspection allowance is 0 mm, and the tool path of single hub finishing is generated. According to step (1), the remaining six hub finishing tool paths are transformed, as shown in Figure 7, and the simulation machining is shown in Figure 8.
3.3.4. Blade root fillet finishing. Insert the operation and select "Mill_Multi_Blade" → "fillet finishing" machining strategy. The program name is fillet finishing, and the tool is T03 φ 2, the geometry is multi_BLADE_Geom, set processing parameters: the driving method is to cut the blade along the blade direction, the cutter axis is the side edge, the tolerance is 0.01mm, the blade allowance is 0 mm, the hub allowance is 0 mm, the check allowance is 0 mm, the single fillet finishing tool path is generated, and the remaining six fillet finishing tool paths are transformed according to step (1), as shown in Figure 9, and the simulation processing is shown in Figure 10.

4. Actual machining of impeller
After the simulation machining is correct in nxug10.0 software, the NC code of NC machining is generated by postprocessing the cutter path file of impeller simulation, and the NC code is uploaded to dmu50 five axis NC machining center. The bar blank and machining tools are installed, and the tool setting of each tool is completed, and then the actual machining of impeller is carried out. Finally, the dimensional tolerance and roughness of the impeller parts are tested by CMM, and the data fully meet the design and use requirements. The actual machining drawing of the impeller is shown in Figure 11, and the enlarged drawing of the actual machining drawing of the impeller is shown in Figure 12.

5. Conclusions
In this paper, nxug10.0 software is used to program the impeller automatically. The tool and machine tool are selected reasonably. The control mode of the tool axis is determined according to the geometric characteristics of the flow channel and blade. The appropriate tool path driving method is selected to process the flow channel and blade. The tool path generated is simulated to prevent the interference between the tool and the machine tool. The correctness of the program is verified, The optimization of machining parameters is realized. The actual measurement of the impeller shows that the impeller fully meets the design and use requirements.
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