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Research on "curriculum-certificate integration" teaching case of multi-axis programming and processing technology based on 1+x certificate system

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Abstract: This paper studies "curriculum-certificate integration" teaching case of multi-axis programming and processing technology in vocational CNC technology specialty based on 1+X certificate system. It can provide some reference for the reform of "curriculum-certificate integration" under the 1+X certificate system in higher vocational colleges.
Key words: 1+X certificate system; multi-axis programming and processing technology; curriculum-certificate integration; teaching case

1 Introduction

The implementation of the 1+X certificate system in the major of CNC technology is an important path to promote the high-quality training of compound technical skills in the new era [1]. It is of great significance to promote the modernization of education. The implementation of the 1+X certificate decomposes and reconstructs the assessment content of the vocational skill level certificate, and integrates it into professional teaching courses [2]. The implementation of 1+X certificate system can better promote the sustainable development and improvement of students [3].

Multi-axis programming and processing technology is the core course of CNC technology specialty. The optimization of the course case and the relevant requirements of the 1+X multi-axis CNC machining vocational skill level certificate can effectively promote the implementation of "curriculum-certificate integration" in the course teaching process. Fig. 1 is the three-dimensional model of bearing pedestal of "curriculum-certificate integration" teaching case.

Fig.1. Three-dimensional model of the bearing pedestal

2 Parts drawings analysis

The material of the bearing pedestal is 2A12 aluminum alloy, with no heat treatment requirements and good cutting performance. The features of the bearing pedestal are mainly composed of planes, bosses, holes, threads, etc. The outlines of the bosses are composed of straight lines and arcs, and the relationship between the geometric elements is clear. The dimensional tolerance grade of the $\phi 78^{0}_{-0.03}$ mm and $\phi 76^{0}_{-0.03}$ mm contour is IT7, and the surface roughness value is Ra3.2 μm. The dimensional tolerance grade of the $\phi 42^{+0.007}_{-0.018}$ mm inner hole is also IT7, and the surface roughness value is Ra1.6 μm. The dimensional tolerance grade of the $\phi 54^{-0.01}_{-0.056}$ mm outer circle and the $\phi 37^{+0.039}_{0}$ mm inner hole is IT8, and the surface roughness value is Ra3.2 μm. The bottom surface (reverse side) of the bearing pedestal has the requirement of perpendicularity (0.02mm) for the $\phi 42^{+0.007}_{-0.018}$ mm hole axis (datum A), which is an important dimensional geometric tolerance.

3 Process schemes formulation

The analysis of the part drawing of the bearing pedestal shows that the center line of the $\phi 42^{+0.007}_{-0.018}$ mm inner hole is the design basis. The surface roughness value of the inner hole and the reverse plane of the bearing pedestal is Ra1.6 μm. The machining process of the bearing pedestal is formulated according to the principle of datum first, rough first and then finish, primary first and then secondary and surface first and then hole.

The machining process card of the bearing pedestal is shown in Table 1.

Table 1. Machining process card of the bearing pedestal

Part name	Bearing pedestal	Machining process card	Types of blanks	Square stock	Total 1 page
			Material	2A12 Aluminum alloy	Page 1
Process No.	Process name	Process content		Equipment	Process equipment
1	Material preparation	Material preparation 80mm×80mm×25mm, made of 2A12 Aluminum alloy.			
2	CNC milling	Rough and finish mill the reverse plane, the shape of 78mm×76mm×12mm, the $\phi 42^{+0.007}_{-0.018}$ mm and $\phi 37^{+0.039}_{0}$ mm inner holes of the bearing pedestal. Drill and ream 2×φ8H7 holes (chamfering can be done before reaming) to meet the requirements of the drawing. Drill and tap 2×M8 threaded holes (chamfer the threaded bottom holes before tapping) to meet the requirements of the drawing. Chamfer the $\phi 42^{+0.007}_{-0.018}$ mm and $\phi 37^{+0.039}_{0}$ mm inner holes.		VMC850	Machine vise

<table>
<tr><td>3</td><td>CNC milling</td><td colspan="3">Rough and finish mill the front plane, the $\phi 54^{-0.01}_{-0.056}$ mm round-table contour, the upper surface and contour of the three $\phi 12^{0}_{-0.027}$ mm bosses and the upper surface of the $\phi 12^{+0.043}_{0}$ mm contour to meet the requirements of the drawing. Chamfer the $\phi 54^{-0.01}_{-0.056}$ mm round-table and $\phi 37^{+0.039}_{0}$ mm inner hole and other chamfering features.</td><td colspan="2">VMC850</td><td>Machine vise</td></tr>
<tr><td>4</td><td>Clip</td><td colspan="3">Deburring and blunt sharp edges.</td><td colspan="2">Vice bench</td><td>Bench vice</td></tr>
<tr><td>5</td><td>Cleaning</td><td colspan="3">Clean the part with detergent.</td><td colspan="2"></td><td></td></tr>
<tr><td>6</td><td>Inspect</td><td colspan="3">Inspection according to drawing dimensions.</td><td colspan="2"></td><td></td></tr>
<tr><td>Prepared by</td><td></td><td>Date</td><td></td><td>Check</td><td></td><td>Date</td><td></td></tr>
</table>

4 CNC programming

According to the relevant requirements of the machining process of the bearing pedestal, the CNC machining program of the bearing pedestal is compiled. The automatic programming method (using SIEMENS NX software) is used to compile the CNC machining program of the bearing pedestal.

(1) CNC programming of the reverse side features of the bearing pedestal

Firstly, rough mill the reverse plane, the shape of 78mm×76mm×12mm, the $\phi 42^{+0.007}_{-0.018}$ mm and $\phi 37^{+0.039}_{0}$ mm inner holes of the bearing pedestal with the ф10mm end mill. The generated tool paths are shown in Fig. 2.

In order to improve the processing efficiency, finish machining the reverse plane, the shape of 78mm×76mm×12mm, the $\phi 42^{+0.007}_{-0.018}$ mm and $\phi 37^{+0.039}_{0}$ mm inner holes immediately after the rough machining of the reverse side features of the bearing pedestal (omit semi-finishing).

Drill 2×φ8H7 and 2×M8 threaded center holes with the φ3mm center drill. Drill 2×φ8H7 bottom holes with the φ7.8mm drill. Then chamfer two bottom holes with φ6mm chamfering tool. And then ream 2×φ8H7 holes with the φ8H7 reamer to meet the requirements of the drawing. Drill 2×M8 threaded bottom holes with the φ6.8mm drill. Then chamfer two threaded bottom holes with φ6mm chamfering tool. Tap 2×M8 threaded holes with the M8 tap to meet the requirements of the drawing. Finally, chamfer the $\phi 42^{+0.007}_{-0.018}$ mm and $\phi 37^{+0.039}_{0}$ mm inner holes with φ6mm chamfering tool.

After the CNC machining program of the reverse side features of the bearing pedestal is completed, the 3D dynamic simulation is carried out by using the tool path visualization function. The simulation results are shown in Fig. 3. It can be seen that the machining process of the reverse side features of the bearing pedestal is reasonable and the program is correct.

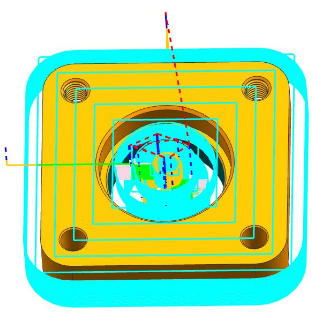

Fig. 2. Rough machined the reverse side features of the bearing pedestal

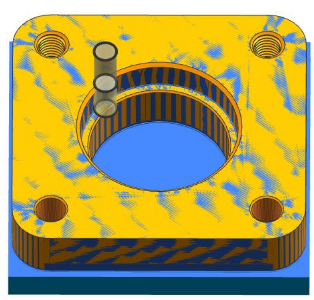

Fig. 3. 3D dynamic simulation results of machining the reverse side features of the bearing pedestal

(2) CNC programming of the front features of the bearing pedestal

Turn it over after machining the features of the reverse side of the bearing pedestal. According to the principle of rough first and then finish, rough mill the front plane, the $\phi 54_{-0.056}^{-0.01}$ mm round-table contour, the upper surface and contour of the three $\phi 12_{-0.027}^{0}$ mm bosses and the upper surface of the $\phi 12_{0}^{+0.043}$ mm contour first. The generated tool paths are shown in Fig. 4.

Finish machining immediately after the rough machining of the front features of the bearing pedestal. Finish mill the front plane and the upper surface of the three $\phi 12_{-0.027}^{0}$ mm bosses of the bearing pedestal with the φ10mm end mill. And finish mill the upper surface of the $\phi 12_{0}^{+0.043}$ mm contour and the $\phi 54_{-0.056}^{-0.01}$ mm round-table contour by using the same milling cutter. Since the roots of the three $\phi 12_{-0.027}^{0}$ mm bosses have R4 rounded corners, the φ8mm end mill is used to finish mill the contour of the bosses.

Chamfer the $\phi 54_{-0.056}^{-0.01}$ mm round-table and the $\phi 37_{0}^{+0.039}$ mm inner hole with φ6mm chamfering tool. The same method can be used to chamfer 2×φ8H7 holes and 2×M8 threaded holes.

After the CNC machining program of the front features of the bearing pedestal is completed, the 3D dynamic simulation is also carried out by using the tool path visualization function. The simulation results are shown in Fig. 5. It can be seen that the machining process of the front features of the bearing pedestal is reasonable and the program is correct.

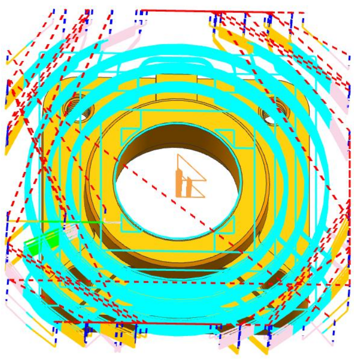

Fig. 4. Rough machined the front features of the bearing pedestal

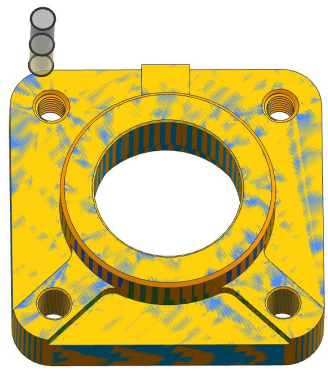

Fig. 5. 3D dynamic simulation results of machining the front features of the bearing pedestal

5 CNC machining of parts

After the parts drawings analysis, process schemes formulation and CNC programming are completed, and the blank of the bearing pedestal is installed on the machine vise of the workbench of the CNC milling machine. The bearing pedestal is processed by the CNC milling machine. The actual processed bearing pedestal is shown in Fig. 6 and 7.

Fig. 6. Physical drawing of the machined bearing pedestal - reverse side

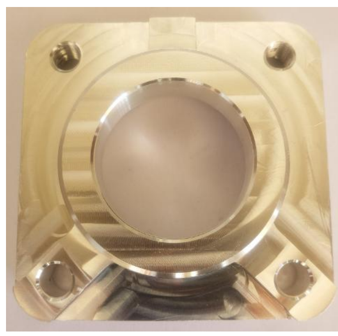

Fig. 7. Physical drawing of the machined bearing pedestal - front side

6 Conclusion

Under the 1+X certificate system, the vocational skill level certificate for multi-axis CNC machining is a certificate of the level of CNC processing skills for higher vocational students. The 1+X multi-axis CNC machining vocational skill level certificate test content is integrated into multi-axis programming and processing technology course teaching, which mobilizes the enthusiasm of students to obtain the vocational skill level certificate, improves students' comprehensive ability of multi-axis CNC machining.

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Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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