Research on "Curriculum-Certificate Integration" Teaching Case of CNC Machining Technology and Programming Based on 1+X Certificate System

Zongxiang Weng
Guangdong Lingnan Institute of Technology, Guangzhou 510663, Guangdong, China
DOI: 10.32629/jher.v4i4.1420

Abstract: The 1+X skill level certificate system is a brand-new system design to implement "the Implementation Plan of the National Vocational Education Reform" and actively promote the academic certificate plus several vocational skill level certificate systems. This paper studies "curriculum-certificate integration" teaching case of CNC machining technology and programming of CNC Technology Specialty in higher vocational colleges based on 1+X certificate system. It can effectively promote the implementation of "curriculum-certificate integration" in the course teaching process, and it can also provide some reference for the reform of "curriculum-certificate integration" under the 1+X certificate system in higher vocational colleges.
***Keywords*:** 1+X certificate system, CNC machining technology and programming, curriculum-certificate integration, teaching case

1. Introduction

"The Implementation Plan of the National Vocational Education Reform" (referred to as the "20 Vocational Education Regulations") issued by the State Council clarifies that the pilot of "academic certificate plus several vocational skill level certificates" system (1+X certificate system pilot) will be launched in vocational colleges and applied undergraduate colleges since from 2019[1]. According to the requirements of vocational skill level standards and professional teaching standards, the pilot colleges should integrate the certificate training content into the professional talent training plan organically, optimize the curriculum and teaching content, coordinate the teaching organization and implementation, deepen the reform of teaching methods, and improve the flexibility, adaptability and pertinence of talent training[2]. It is of great significance to launch the pilot work of 1+X certificate system to promote the modernization of education and build a powerful country of human resources[3].

CNC machining technology and programming is the core course of CNC Technology Specialty. The optimization of the course case and the relevant requirements of the 1+X CNC turning and milling vocational skill level certificate can promote the implementation of "curriculum-certificate integration" in the course teaching process effectively. Figure 1 is the three-dimensional model of transmission shaft of the teaching case of "curriculum-certificate integration" (Selected from the sample questions of 1+X CNC turning and milling vocational skill level certificate examination. The sample questions are provided by Wuhan Huazhong Numerical Control Co., Ltd.).

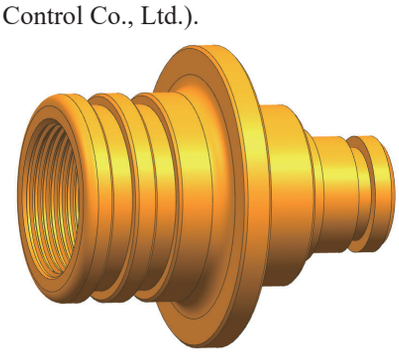

Figure 1. Three-dimensional model of the transmission shaft

The technical requirements of the part drawing of transmission shaft are as follows: (1) Deburring and blunt sharp edges; (2) Undeclared chamfer C0.5; (3) Unmarked tolerance dimensions are in accordance with GB/T 1804-m.

2. Parts Drawings Analysis

The material of the transmission shaft is 2A12 aluminum alloy. No heat treatment requirements, good cutting performance.

The features of the transmission shaft are mainly composed of outer circle, inner hole, internal thread, tool withdrawal groove, etc. The outline of the outer circle is composed of straight lines and arcs, and the relationship between the geometric elements is clear. The dimensional tolerance grade of the left $\phi 36_{-0.034}^{-0.009}$ mm outer circle and the right $\phi 20_{+0.002}^{+0.023}$ mm outer circle is IT7, and the surface roughness value is Ra1.6μm. The dimensional tolerance grade of the $\phi 52_{-0.046}^{0}$ mm outer circle and the $\phi 42_{-0.039}^{0}$ mm outer circle is IT8, and the surface roughness value is Ra3.2μm. In addition, with the right $\phi 20_{+0.002}^{+0.023}$ mm outer circular axis as the datum, the left $\phi 36_{-0.034}^{-0.009}$ mm outer circular axis has the coaxiality requirement (ϕ0.02mm), which is an important dimensional geometric tolerance. The internal thread is M27 fine thread with a pitch of 1.5mm.

3. Process Schemes Formulation

Analysis of the part drawing of the transmission shaft shows that the axis of the $\phi 20_{+0.002}^{+0.023}$ mm outer circle is the design basis. The machining process of the transmission shaft is prepared according to the principle of datum first, rough first and then finish, primary first and then secondary.

The machining process card of the transmission shaft is shown in Table 1.

Table 1. Machining process card of the transmission shaft

Part name	Transmission shaft	Machining process card	Types of blanks	Bar	Total 1 page
			Material	2A12 Aluminum alloy	Page 1

Process No.	Process name	Process content	Equipment	Process equipment
1	Material preparation	Material preparationφ55mm×65mm, made of 2A12 Aluminum alloy.		
2	CNC turning	Turn the right end face of the transmission shaft. Rough and finishturnthe right end $\phi 20_{+0.002}^{+0.023}$ mm,φ23mm, $\phi 42_{-0.039}^{0}$ mm and $\phi 52_{-0.046}^{0}$ mm outer circle. Turn the outer circular groove of 3mm×φ16mm to meet the requirements of the drawing and chamfer.	CAK6140	Three-jaw chuck
3	CNC turning	Rough and finish turn the left end face of the transmission shaft to ensure the total length of 60±0.037mm. Rough and finish turn the left $\phi 36_{-0.034}^{-0.009}$ mm outer circle, R3mm and R2mm fillet and the two outer circular grooves of 4mm×φ32mm. Drill φ20mm bottom hole. Rough and finish turn M27×1.5-7G internal thread bottom hole. Turn 3mm× ϕ29 mm tool withdrawal groove. Turn the M27×1.5-7G internal thread to meet the requirements of the drawing and chamfer.	CAK6140	Three-jaw chuck
4	Clip	Deburring and blunt sharp edges.	Vice bench	Bench vice
5	Cleaning	Clean the part with detergent.		
6	Inspect	Inspection according to drawing dimensions.		

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4. CNC Programming

According to the relevant requirements of the machining process of the transmission shaft, the CNC machining program of the transmission shaft is compiled. Manual programming is often used for turning less complex parts, so this method is used to compile the CNC machining program of the transmission shaft.

①CNC Programming of the Right End Features of theTransmission Shaft

Firstly, manually turn the right end face of the transmission shaft to make the surface roughness meet therequirements of the drawing. And then rough and finishturnthe right end $\phi 20_{+0.002}^{+0.023}$ mm,φ23mm, $\phi 42_{-0.039}^{0}$ mm and $\phi 52_{-0.046}^{0}$ mm outer circle. The program (the program compiled for Huazhong CNC lathe system, the same below) is as follows (↵represents line

break,the same below):

%0001↵T0101↵M03 S800↵G00 X100 Z100↵G95 M08↵G00 X60 Z2↵G71 U1 R5 P1 Q2 X0.5 Z0.03 S800 F0.26↵N1 G00 X18 S1000↵G01 Z0 F0.13↵X20.01 Z-1↵Z-14↵X23↵Z-17↵X40↵X41.98 Z-18↵Z-29↵X50↵X51.98 Z-30↵Z-34.5↵N2 X53↵G00 X100↵Z100↵M05↵M30

Then use the cutting tool with a width of 3mm to turn the outer circular groove of 3mm×φ16mm to meet the requirements of the drawing.The program is as follows:

%0002↵T0202↵G00 X120 Z150↵M03 S500↵G95 M08↵G00 X23↵Z-7↵G01 X16 F0.03↵G04 X1↵G00 X39↵X120↵Z150↵M05↵M30

After completing the CNC programming and machining of the above features,the right end chamfering features of the transmission shaftcan be chamfered manually.

②CNC Programming of the Left End Features of theTransmission Shaft

After the right end features of the transmission shaft are processed, turn it around and clamp.Rough and finish turn the left end face of the transmission shaft to ensure the total length of 60±0.037mm.The program is as follows:

%0003↵T0101↵G00 X150 Z150↵M03 S800↵G95 M08↵G00 X62 Z2↵G71 U1 R5 P1 Q2 X0.5 Z0.03 S800 F0.26↵N1 G00 X0 S1000↵G01 Z0 F0.13↵Z-3.74↵N2 X62↵G00 X150↵Z150↵M05↵M30

In the above procedure, the value of Z in N90 Z-3.74 can be adjusted according tothe actual situation in order to ensure that the total length dimension is within the tolerance requirements.

Then rough and finish turn the $\phi 36_{-0.034}^{-0.009}$ mm outer circle, R3mmand R2mm fillet.And then use the cutting tool with a width of 3mm to turn the two outer circular grooves of 4mm×φ32mm to meet the requirements of the drawing.

After completing the CNC programming and machining of the above features, use the φ3mm center drill to drill the center hole on the end face of the transmission shaft under the manual mode. Then use the φ20mm drill to drill to the depth required by the drawing. And then rough and finish turn the M27×1.5-7G internal thread bottom hole with the internal hole boring tool.

After finishing turning the M27×1.5-7G internal thread bottom hole, turn the 3mm×φ29mm tool withdrawal groove with the internal groove turning tool. Then turn the M27×1.5-7G internal thread with the internal thread turning tool to meet the requirements of the drawing.

After completing the CNC programming and machining of the above features, the remaining chamfering features of the transmission shaft can be chamfered manually as required.

5. CNC Machining of Parts

After the parts drawings analysis, process schemes formulation and CNC programming are completed, the blank of the transmission shaft is installed on the three-jaw chuck of the CNC lathe. The transmission shaft is processed by the CNC lathe. When operating CNC machine tools, pay attention to operations such as tool setting and program transmission, and the tool setting results should be verified before further processing. The cutting parameters should be optimized and adjusted in time according to the on-site machining conditions to obtain the best processing parameters, so as to process good quality parts. The actual processed transmission shaft is shown in Figures 2 and 3.

Figure 2. Physical drawing of the machined transmission shaft - external features

Figure 3. Physical drawing of the machined transmission shaft - internal features

6. Conclusion

Under the 1+X certificate system, the vocational skill level certificate for CNC turning and milling processing is a certificate of the level of CNC processing skills for higher vocational students. The 1+X CNC turning and milling vocational skill level certificate test content is integrated into CNC machining technology and programming course teaching, which mobilizes the enthusiasm of students to obtain the vocational skill level certificate, improves students' comprehensive ability of CNC turning and milling processing, and expands the employment and entrepreneurship ability of the students majoring in CNC. The continuous development of "curriculum-certificate integration" is conducive to improving the comprehensive quality of students and the teaching quality of higher vocational education. It can provide effective guarantee for the integration of industry and education and school-enterprise cooperation, and promote the deepening of education and teaching reform in colleges and universities, and help to further improve the quality of talent training.

Acknowledgments

Fund projects: Key project of education and teaching reform and research of Guangdong Lingnan Institute of Technology (JB202006); Excellent open course project (2020JPKC031); School-based textbooks and digital resource project (XBJC202109); Project of educational science planning of Guangdong province (special project of higher education) (2023GXJK1036).

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