Teaching Mode of "Integration of Theory and Practice" of NC Machining Technology and Programming in Application-Oriented Universities

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Abstract. This paper analyzes the current teaching situation, problems, causes and solutions of the course of NC machining process and programming in the application-oriented undergraduate colleges; constructs the teaching mode of NC machining process and programming with the integration of theory and practice, and analyzes the teaching mode in depth; takes the teaching project of rectangular groove plate of comprehensive parts as an example to carry out the teaching design, and specifically explains "theory and practice one" The application of physical teaching mode. Summarize and reflect on the inadequacies of the research, as well as the thinking of future research.

Keywords: Applied Undergraduate College, numerical control processing technology and programming, integration of theory and practice, teaching mode

1. Introduction
The development of social economy depends on the prosperity of manufacturing industry, and machinery manufacturing technology represents the advanced level of manufacturing productivity. The goal of mechanical and electronic engineering major in application-oriented undergraduate colleges is to cultivate students' ability to analyze and solve engineering problems independently, and to cultivate students' composite talents with engineering quality, engineering practice ability, management ability and innovation ability. However, there are still disadvantages in its teaching mode, such as the lack of professional teachers' team; the teaching mode is still dominated by theoretical courses, and the practice teaching ring. The practical teaching equipment cannot meet the needs of teaching. In view of these problems, this paper investigates the current teaching situation of "NC machining process and programming" in mechanical and electronic specialty of application-oriented undergraduate colleges, explores the reform of teaching mode, and constructs the "integration of theory and practice" teaching mode. In addition, the teaching project of "rectangular groove plate processing" in the course of "numerical control processing technology and programming" is designed.[1]

2. Construct the teaching mode of "integration of theory and practice" of numerical control processing technology and programming for mechanical and electrical specialty
in Application-oriented Undergraduate Colleges

2.1 "Integration of theory and practice" teaching content

The teaching design of "integration of theory and practice" includes teaching objectives, teaching focuses and difficulties, teaching object analysis, teaching methods, teaching environment and resources, teaching content, teaching implementation steps and teaching evaluation.[2]

In view of the teaching project of "rectangular groove plate processing", the teaching objectives are divided into knowledge objectives and skill objectives according to the requirements of the teaching mode of "integration of theory and practice". The teaching focuses and difficulties of this teaching project are concentrated on skill objectives, so the training of students' skill objectives should be more emphasized in the teaching. After analyzing the teaching objects, we should choose proper teaching methods, teaching environment and resources. As this teaching project involves theoretical knowledge and practical skills training, the teaching environment and teaching resources are the teaching place and the software and hardware required for teaching.[3]

"NC machining technology and programming" adopts the teaching form of "integration of theory and practice". The formal classroom teaching will be started after the preview task is arranged before class, and the new class will be introduced first. Because this teaching project involves many contents, the teaching activities of this teaching project are divided into three parts. The first part is to learn the necessary theoretical knowledge, the second part is to learn the practical operation skills, and the third part is to carry out the formal processing operation and summary reflection. The last step of teaching implementation is teaching evaluation, which adopts multiple assessment forms.

2.2 Teaching design of "integration of theory and practice" in the processing of rectangular groove plate

(I) Teaching objectives

A. Knowledge objectives:
(1) Master the characteristics of NC machining.
(2) Understand the reason of high productivity of NC machining.[4]

B. Skill objectives:
(1) Master the programming method of rectangular groove plate.
(2) Master the selection skills of cutting tools.
(3) Master the R chamfer instruction format to simplify the program.

(II) Teaching key points and difficulties

Teaching focus: the application of circular r instruction
Teaching difficulties: selection of cutting parameters.

(III) Analysis of teaching objects

The teaching object is the third-year students majoring in mechanical and electrical engineering in application-oriented undergraduate colleges. After the preliminary study of this course, the students have been able to understand the part drawings, master and apply the common instruction programming, and can select the appropriate cutting tools, fixtures, measuring tools, etc. according to the part drawings, with the ability of safe processing.[5]

(IV) Teaching methods

The teaching methods include teaching method, case teaching method, direct demonstration method, cooperative learning method, simulation teaching method, etc.[6]

(V) Teaching environment and resources

In this teaching, a theory teaching classroom is set in the engineering training center, multimedia teaching equipment, multi-functional desks and chairs, computer simulation processing software, xd-40a CNC milling machine and measuring tools are set in the engineering training workshop. See Table 1 for the detailed list of measuring tools.[7]

| Type | Serial number | Name | Specifications | accuracy | Number |
|------|---------------|------|----------------|----------|--------|

Table 1. List of Tools
(VI) Teaching content

A. Knowledge review

(1) Common G commands: G0 (fast moving), G1 (linear interpolation), G2 / G3 (arc interpolation), G99 (fixed cycle back to R point), g82 (drilling cycle with pause), R (fillet function).

(2) Instruction format:
G0 X ― Y ― Z; G1 x ― y ― r ― f_ (arc radius) or G2 / G3 x ― y ― Z ― R (the offset value of the center of the circle relative to the start of the arc)

Note: the application of G0 command, the selection of G2 / G3 arc command, the selection of positive and negative R values in arc command, and the determination of I and j values.

Application of drilling cycle command. R application of fillet function.[8]

B. New knowledge explanation

The main reason why CNC equipment is widely used and rapidly developed in all walks of life is that CNC equipment has the following characteristics:

(1) high machining accuracy and stable quality;
(2) high productivity;
(3) reduce labor intensity and improve labor conditions;
(4) it is convenient to realize stable processing quality, high productivity, reduce labor intensity and improve labor conditions;
(5) computer integrated manufacturing is conducive to production management.

The machining time of CNC machine tools can be estimated accurately in advance. The tools and fixtures used can be standardized and modernized. It is easy to realize the standardization of processing information, which is the basis of modern integrated manufacturing.

C. Project description

Rectangular groove plate, as shown in Figure 1, the overall dimension of blank is 60mm × 60mm, material: duralumin.
D. Project analysis

The shape of machined parts is regular, the machining is complex, and the dimensional accuracy is required to be high. $4 \rightarrow r7.5$ fillet can use $r$ fillet function. The center angle of two arcs in $4 \rightarrow r7.5$ arc is greater than 180°, and R should be negative when programming.

E. Project implementation

(1) Determine the processing technology

Analyze the part drawing

Due to the regular shape of the parts, the machine vice is usually used to clamp the two sides of the blank, and the parallel sizing block with high precision is placed between the lower surface of the workpiece and the flat pliers, so as to ensure that all the surfaces to be processed in the positioning clamping are fully exposed for the convenience of processing. Finally, the plastic hammer is used to knock the workpiece to make the sizing block. The workpiece cannot be clamped after moving.[9]

Selection of cutting parameters

See Table 2 for the selection of cutting parameters.

Table 2. Selection of Cutting Parameters

| Serial number | Processing content                        | Spindle speed (n/r/min) | Feed rate $v_f$ (mm/min) | Tool radius compensation |
|---------------|------------------------------------------|-------------------------|--------------------------|--------------------------|
| 1             | Rough machined upper surface             | 1200                    | 80 ~ 100                 | no                       |
| 2             | Finishing upper surface                  | 1600                    | 100 ~ 120                | no                       |
| 3             | Rough machining inner cavity             | 1000 ~ 1200             | 80 ~ 120                 | 5.5                      |
| 4             | Finishing inner cavity                   | 1600 ~ 1800             | 100 ~ 150                | Calculation              |
| 5             | Rough machining Φ20mm round cavity       | 1000 ~ 1200             | 80 ~ 120                 | 5.5                      |
| 6             | Finish machining Φ20mm round cavity      | 1600 ~ 1800             | 100 ~ 150                | Calculation              |
| 7             | Rough machining two arcs R10 and R8      | 1000 ~ 1200             | 80 ~ 120                 | 5.5                      |
| 8             | Finish machining two arcs R10 and R8      | 1400 ~ 1600             | 100 ~ 150                | Calculation              |
| 9             | Machining $4 \rightarrow \Phi 8$ countersunk head hole | 1400 ~ 1600             | 80 ~ 120                 | no                       |
(2) Set workpiece coordinate system
The origin of the workpiece coordinate system is set at the center of the upper surface of
the workpiece, and the zero deviation values of X, y and Z axes are input into the workpiece
coordinate system g54.

(3) Prepare NC machining program
Note: the tool compensation value can be changed to remove the allowance and finish
machining.[10]
See Table 3 for processing operation steps.

| Serial number | Operation steps |
|---------------|-----------------|
| 1             | Turn on the power, turn on the emergency stop button and reset the system |
| 2             | Return to reference point |
| 3             | Use dial indicator to calibrate flat pliers |
| 4             | Installation of workpiece and tool setting |
| 5             | Enter part origin parameters G54~G59 |
| 6             | Enter tool compensation parameters (main menu - tool compensation F4 - tool compensation table F4) |
| 7             | Input and edit machining program |
| 8             | Program validation |
| 9             | Automatic machining (rough machining, one side of machining allowance is about 0.5mm) |
| 10            | Automatic machining (finish machining, control the machining accuracy of parts by reducing the tool compensation value) measure the parts, and remove the machined parts after they are qualified |
| 11            | Cleaning machine tool |
| 12            | Move the worktable to the middle position of the machine tool, press the emergency stop button, and disconnect the power supply of the machine tool |

(VII) Teaching evaluation
The teaching project adopts multiple assessment forms, with a total score of 100. School
teachers are responsible for the evaluation and scoring of the programming part, accounting
for 35%; enterprise masters are responsible for the evaluation and scoring of the operation
link, accounting for 35%; students are responsible for the evaluation and scoring of the
processing size of rectangular groove plates, accounting for 30%. The assessment results of
this teaching project are included in the final assessment part of the teaching evaluation
process of the course "CNC milling of mechanical parts".

3. Concluding remarks
This paper studies the teaching mode reform of "integration of theory and practice" in
"numerical control processing technology and programming" in application-oriented
undergraduate colleges. First, it studies the current situation of teaching mode in
Application-oriented Undergraduate Colleges from three aspects of teaching process, teaching
conditions and teaching evaluation. In view of students' insufficient cognition of future work,
students' dissatisfaction with teachers' teaching, students' poor learning effect and teaching
evaluation, it fails to play a role According to the analysis results, such as the real function,
the practical teaching equipment cannot meet the needs of teaching and so on, this paper puts
forward some improvement measures, such as changing the traditional teaching mode to the
"integration of theory and practice", establishing the integrated teaching place in the engineering training center, and building the teaching staff of the course of "numerical control processing technology and programming". According to the principles of ability standard, situational learning and student-centered, this paper expounds in detail the theoretical basis, teaching objectives, teaching conditions, teaching process and teaching evaluation of the "integration of theory and practice" teaching mode in the construction of application-oriented undergraduate colleges.

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