

Research on CNC Turning Technology Based on Project-Task Teaching Model

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Abstract: Made in China 2025 puts forward the development strategy of transforming from a major manufacturing country to a powerful manufacturing country. How to cultivate outstanding "great country craftsmen" has become the focus of vocational colleges. In response to the needs of the times, the curriculum of numerical control machining has also undergone corresponding reforms. This paper discusses the application of the project-task based teaching mode in the course of NC Turning Technology. By analyzing the characteristics and challenges of the current NC turning course, a student-centered project-task teaching scheme is designed, which takes the combination lock as the carrier of NC turning processing. The research covers project selection and design, teaching contents and procedures, teaching resources and other aspects. Practice has proved that the project-task based teaching mode improves students' learning interest, participation and NC turning skills, and also enhances their ability to analyze and solve problems.

Keywords: project-task based teaching mode; NC Turning Technology; student-centered; combination lock

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Introduction

NC Turning Technology is a compulsory professional course integrating post requirements, skill competitions and vocational certificates for CNC Technology majors. Combined with the current development of numerical control machining and in accordance with students' cognitive rules, guided by the project-task teaching mode, this course integrates the ideological and political element—the ancient combination lock into all teaching links. It enables students to understand the ancient combination lock and the wisdom of ancient locksmiths, promotes the traditional Chinese culture, and stimulates students' patriotism and interest in professional learning. The structure of the combination lock is shown in Figure 1.

Through learning NC Turning Technology, students can develop professional ethics and master knowledge including mechanical drawing and interpretation, tolerance fit and technical measurement, basic calculation, common materials and metal heat treatment, basic machining technology, basic fitter operation, basic electrical knowledge, hydraulic and pneumatic technology, safe and civilized production, environmental protection, quality management as well as relevant laws and regulations ^[1]. Students can obtain relevant certificates of CNC Turner, laying a solid foundation for their future career development as field engineers and technicians.

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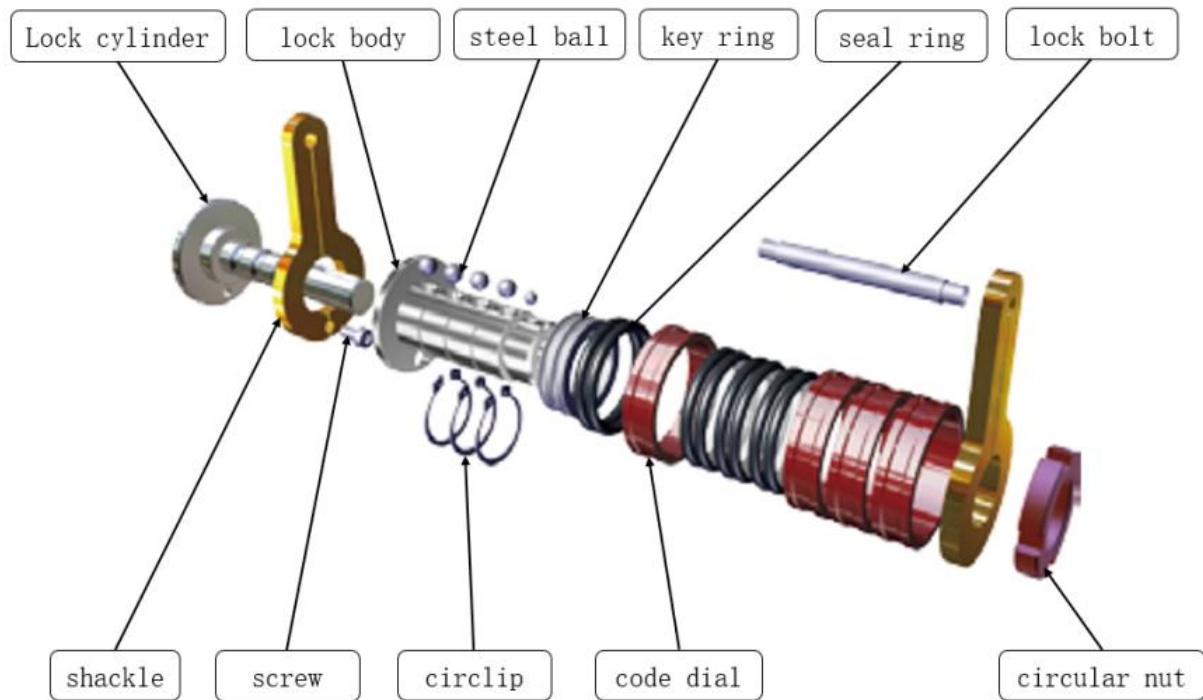


Figure 1 Structure diagram of the combination lock

Many higher vocational colleges in China have offered CNC machining courses for CNC technology majors. Zheng Jinhui^[2] from Jilin Institute of Chemical Technology investigated the NC turning course from the perspective of craftsmanship spirit, and concluded that project-based teaching is more effective for students to master CNC turning skills. Li Liping^[3] pointed out that the project-oriented teaching mode can significantly improve the practical operation ability and comprehensive quality of secondary vocational students, and cultivate their teamwork and problem-solving abilities. Luo Yueying^[4] et al. proposed that skill competitions should be used to guide and lead the construction of professional courses, which is an important way to improve classroom teaching effectiveness. How to effectively improve the teaching of CNC machining skills in higher vocational education has become a key focus.

1. Basic Course Information

NC Turning Technology is an integrated theoretical and practical course. Centering on students, the course focuses on the combination of theory and practice, aiming mainly to cultivate students' NC turning operational skills. In teaching, students are divided into groups of 5 to 6 members. During class, students are required to complete the task process assessment form and quality inspection form, and submit them to the teacher after task completion. This enables teachers to grasp students' learning mastery and adjust teaching plans and content in a timely manner.

The course content is divided into a basic module and an advanced module^[5]. The basic module includes four projects: (1) Manufacturing the lock cylinder of the combination lock; (2) Manufacturing the lock body of the combination lock; (3) Producing password rings and key rings; (4) Assembly of the combination lock. The advanced module consists of two projects: (1) Machining rotary parts with formula curve contours; (2) Designing and manufacturing independent customized parts.

In the teaching process, ideological and political elements are integrated into the course, such as the spirit of great country craftsmen, the establishment of 6S management concept, and the cultivation of rigorous and earnest work style and professional literacy. The course system is shown in Figure 2.

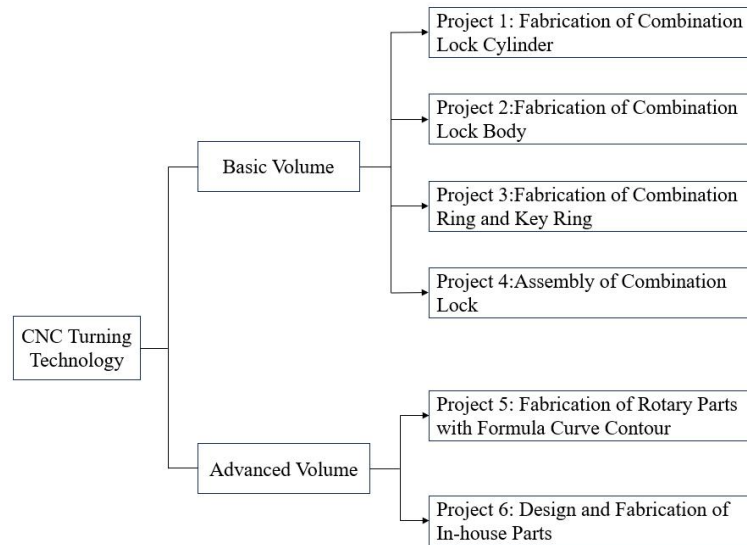


Figure 2 Course Modules

2. Research on Project-Task Based Teaching Mode

The project-task based teaching mode closely integrates theoretical knowledge and practical application in mechanical engineering majors. In the process of completing projects, students are required not only to master relevant theoretical knowledge, but also to apply such knowledge into practical operation, so as to effectively improve their practical operational skills.

2.1 Project Selection and Design

The course of NC Turning Technology takes the ancient combination lock as the teaching carrier to teach professional knowledge step by step. In terms of curriculum design, each task is divided into four parts following three major procedures: process preparation, workpiece machining, precision inspection and error analysis:

(1) Task description: Clarify the knowledge objectives and skill objectives of the task.

(2) Task implementation: Introduce the required equipment and tools, drawing analysis, process analysis, programming and part machining.

(3) Knowledge connection: Explain the relevant professional knowledge required for task completion, including numerical control instructions, metal cutting principles, mechanical manufacturing technology and other related contents.

To achieve the expected teaching effect, the machining of mechanical parts is arranged from simple to complex and from easy to difficult, enabling students to systematically master the relevant knowledge of NC turning technology and programming.

2.2 Teaching Content and Procedures

In the course of NC Turning Technology, the theoretical knowledge covers the structure of CNC lathes, commonly used CNC turning cutters, measuring and auxiliary tools, daily maintenance of CNC lathes, conventional NC codes, programming and debugging, as well as practical operation. Theoretical knowledge must be closely combined with practical teaching for students to better understand and master professional skills.

Taking Project 2: Machining the combination lock body as an example, this paper illustrates the specific implementation process of teaching content and procedures in the NC Turning Technology course. The drawing of the combination lock body is shown in Figure 3. Project 2 consists of three tasks: (1) Task 1: Machining the threaded shaft; (2) Machining the thin-walled sleeve with smooth hole; (3) Machining the lock body.

The lock body is a typical shaft-sleeve part, which involves both thread machining and hole machining.

Therefore, the machining of the lock body is decomposed into sequential tasks. Task 1 focuses on the machining of threaded shafts, Task 2 explains the processing of thin-walled sleeves with smooth holes, and the lock body machining is completed in the subsequent teaching. The curriculum content is arranged progressively from easy to difficult, enabling students to steadily master the relevant knowledge and skills of numerical control machining. The engineering drawing of the lock body is shown in Figure 3.

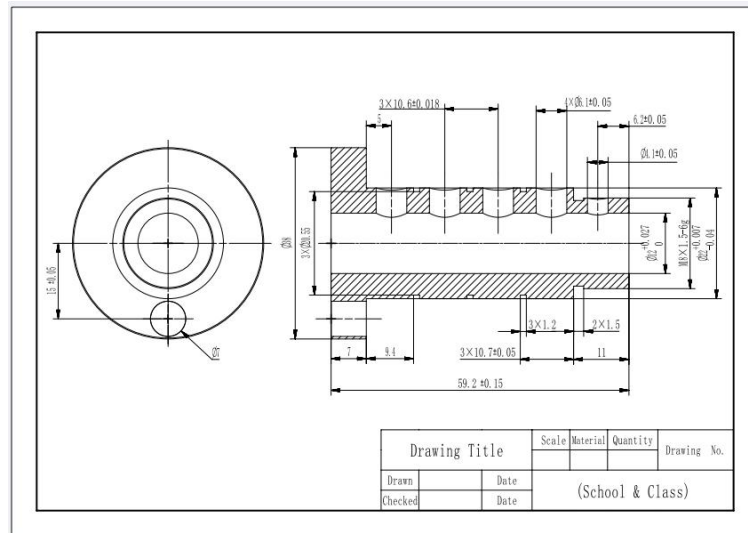


Figure 3 Drawing of Password Lock Body

During the teaching process, the processing of the lock body effectively integrates knowledge objectives, skill objectives and literacy objectives, as shown in Figure 4.

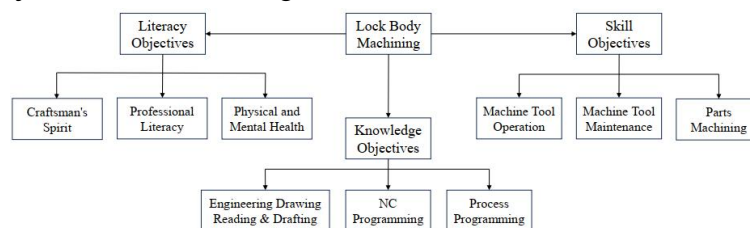


Figure 4 Class Teaching System Framework Drawing

After completing Task 1 and Task 2, students have mastered the machining of metric threads and internal holes. When previewing the lock body machining task, students can apply thread machining instructions and internal hole processing technology, so as to find out their own deficiencies in learning. Students may consult relevant materials or review teaching videos for consolidation, and ask teachers about difficult knowledge points in class.

In the process of part machining, students may encounter safety hazards such as tool collision and chip splashing. In mild cases, machine tools and cutting tools will be damaged; in severe cases, personal safety will be endangered^[6]. NC simulation machining can perfectly avoid such risks.

With the simulation software, students can conduct virtual machining simulation, get familiar with the CNC operation panel and operating procedures, and complete program debugging and optimization. It helps students quickly master programming skills and improve operational proficiency, reduce errors in actual operation, and enhance learning efficiency. Meanwhile, it greatly improves teaching effectiveness and students' practical ability. In addition, a teaching resource library for NC Turning Technology has been established on the Xuetong Platform, enabling students to learn course knowledge anytime and anywhere.

2.3 Teaching Resources and Support

To ensure the effective implementation of teaching, teaching resources, software and equipment are crucial. CNC machining simulation software includes Swansoft Simulation Software, Mastercam and CIMCO Edit. The

CNC lathes used in practical courses adopt the FANUC system, and the operation interface of Swansoft Simulation Software is highly consistent with that of physical CNC lathes.

A teaching resource library for NC Turning Technology has been built on the Chaoxing Xuetong Platform. To achieve better teaching effectiveness, the course contents in the resource library are classified in detail and organized in a modular way. The specific contents are shown in Table 1.

Table 1 Teaching Resource Library Content List

No.	Item Name	Content Added to Resource Library
1	Fabrication of Combination Lock Cylinder	Recognition of CNC Machining Environment
2		Extension: Craftsman Spirit
3		Structure of Password Locks
4		Task 1: Machining a Smooth Shaft
5		Task 2: Machining a Simple Stepped Shaft
6		Task 3: Machining a Compound Stepped Shaft
7		Working Environment of the Lock Core
8		Task 4: Machining the Lock Core
9		Extension: Basics of CNC Lathe Programming/CNC Machining Process Design
10	Fabrication of Combination Lock Body	Task 1: Machining a Threaded Shaft
11		Task 2: Machining a Smooth-Bore Thin-Wall Sleeve
12		Working Environment of the Lock Body
13		Task 3: Machining the Lock Body
14	Fabrication of Combination Ring and Key Ring	Working Environment of Password Rings & Key Rings
15		Task 1: Machining an Eccentric Sleeve
16		Task 2: Machining a Flange Plate
17		Task 3: Machining Password Rings & Key Rings
18		Extension: Turning Compound Cycle Commands
19	Assembly of Combination Lock	Task 1: Lock Body Subassembly & Precision Inspection
20		Task 2: Final Assembly of the Password Lock
21		Learning Materials: Programming Examples
22	Fabrication of Rotary Parts with Formula Curve Contour	Task 1: Machining a Lathe Control Handle
23		Task 2: Machining a Bullet Keychain
24		Task 3: Machining a Goblet
25	Design and Fabrication of In-house Parts	Task 1: Design & Fabricate an Independent Component
26		Task 2: Design & Fabricate an Independent Component
27		Jilin Youth Craftsman Yongxiu Yang
28		Summary of CNC Turning Competitions

On the basis of online teaching resources and simulation software learning, students can systematically master the theoretical knowledge of CNC machining. In practical courses, students are able to quickly get started and master the practical skills of NC turning.

The teaching resource library not only contains ideological and political contents such as the stories of great country craftsmen, but also collects the contents of NC turning skill competitions in recent years. It inspires students to continuously improve their NC turning skills and actively participate in relevant skill competitions, so as to transform passive learning into active learning.

2.4 Assessment and Evaluation

The course adopts examination-based assessment. The overall grade consists of three parts: process evaluation, skill assessment and comprehensive test. The assessment not only examines students' professional knowledge and application ability, but also evaluates their daily performance, CNC machining skills and theoretical mastery. The detailed assessment composition is shown in Table 2.

Table 2 Assessment Standard English Translation List

Evaluation Method	Assessment Content		Weight	Total Score
Process Assessment	Daily Performance	Attendance, 6S site management, Attendance, 6S site management, Participation in Classroom Activities, online resource learning status	20%	100%
	Assignments	completion status		
Skill Assessment	1. Safety & civilized production operation specifications of CNC lathe, daily machine maintenance 2. Professional basic knowledge: engineering drawing reading, tolerance fit, engineering materials, product quality awareness 3. Machining of combination lock cylinder, lock body, combination ring and key ring 4. Use of common measuring tools, precision measurement and general assembly of combination lock		40%	
Comprehensive Test	Assessment of theoretical knowledge and basic operational skills		40%	

3.Conclusion

After six rounds of teaching practice involving about 1,800 student participants, it has been verified that the project-task based teaching mode of the NC Turning Technology course can significantly improve students' practical operation ability and comprehensive quality. Under the guidance of teachers, students have cultivated teamwork awareness and problem-solving competence, which greatly improves the teaching effect of the integrated theoretical and practical course. In the follow-up teaching, the project-task teaching mode will be further optimized and improved to cultivate more high-quality technical talents and contribute to the construction of socialism with Chinese characteristics.

Meanwhile, students also pointed out some shortcomings of the project-task teaching mode. For instance, individual students in group learning show low participation and lack initiative in learning. These problems will be gradually revised and perfected in the subsequent teaching reform.

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