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Research on Case Teaching Reform of Comprehensive Ability Cultivation in Electromechanical Major Based on the Background of Dual High Construction

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Abstract: The construction of high-level vocational schools and majors with Chinese characteristics is a major strategic measure in the field of vocational education in China, with profound and multidimensional significance. Its construction focuses on advanced manufacturing, modern service industries, strategic emerging industries, and other fields, and aims to cultivate high-quality technical and skilled talents who can adapt to industrial changes such as the digital economy, intelligent manufacturing, and green economy through optimizing the layout of majors. Cultivating students' ability to comprehensively apply and solve practical engineering problems is one of the key training objectives for engineering students in universities. Building a diversified teaching team, leading students to complete engineering problems with practical needs, fully utilizing the strengths of teaching team members, taking problem-solving as the main line, and focusing on student ability cultivation, are all important steps towards achieving this goal.

Keywords: Double High Construction, Mechanical design, Engineering capabilities, Pedagogical reform, Teaching Models

1. Background

The plan to build high-level vocational schools and majors with Chinese characteristics is a major strategic measure in the field of vocational education in China, with profound and multidimensional significance[1].

In traditional concepts, vocational education is often regarded as a "second-best choice". However, the "Double High" construction project, which aims to build a number of high-level vocational schools and professional groups, clarifies the equally important status of vocational education and general education, and promotes it as an independent type of education.

The construction of "double high" focuses on advanced manufacturing, modern service industry, strategic emerging industries and other fields. By optimizing the professional layout, it aims to cultivate high-quality technical and skilled talents who can adapt to industrial changes such as digital economy, intelligent manufacturing, and green economy.

2. Problems in the Teaching of Traditional Electromechanical Basic Courses

Traditional electromechanical courses have significant deficiencies in teaching content, methods, and evaluation systems, especially the lack of comprehensiveness. The courses are organized into independent modules such as mechanical design, electrical engineering and electronics, and electromechanics, with no organic connection between the modules. For example, students can master the basic theories of mechanical design, electrical engineering and electronics, and electromechanics through learning, but they cannot comprehensively apply the knowledge of several courses. At the same time, traditional classrooms focus on formula derivation and standard specification explanation, with students passively receiving knowledge and lacking opportunities to verify theories through experiments, simulations, or project practices, ultimately leading to the lack of comprehensive application ability of students. Therefore, it is urgent to develop a comprehensive application ability training program.

3. Diversified teacher team building

Building an efficient, collaborative and innovative team of teachers is the key to improving the quality of mechanical design course teaching and promoting the development of the discipline[2].

Guided by the construction of teaching-oriented teams, we integrate resources from academic leaders, core teachers, young teachers, and enterprise mentors. Academic leaders are responsible for the overall planning, resource integration, and external cooperation of the comprehensive ability training program for mechanical and electrical majors. Core teachers undertake research on program design and are the backbone of the team. Young teachers grow rapidly through the "old-leading-new" mechanism and are responsible for experimental guidance, course assistance, and other tasks. Enterprise mentors provide real project cases and technical guidance.

Table 1-1 Structure of the Teacher Team

	Teacher1	Teacher2	Teacher3	Teacher4	Teacher5
Task	Academic leader	Key teacher	Key teacher	Young teachers	Corporate mentor
Academic qualification	Ph.D.	Postgraduate	Ph.D.	Ph.D.	Undergraduate
Teaching years	21	21	7	3	15
Professional title	Associate Professor	Associate Professor	Senior Engineer	Lecturer	Senior Engineer
Specialized expertise	Mechanical Design	Mechatronics	Mechatronics	Mechatronics	Electrical Automation

4. Case selection for comprehensive ability cultivation in electromechanical engineering

After comprehensive consideration, motor design integrates knowledge from multiple disciplines such as mechanics, electromagnetics, control, and materials, and can serve as a core carrier for comprehensive ability training programs.[3] Through project practice, students' engineering thinking, innovation ability, and team collaboration ability can be strengthened. The following systematically elaborates how to build a comprehensive ability training program based on motor design from five dimensions: training objectives, curriculum design, practical links, evaluation system, and supporting conditions.

5. Case design for comprehensive ability cultivation in electromechanical engineering

5.1 Training objectives

Build a three-dimensional capability system including technology, innovation, and literacy. In terms of technical capabilities[4], it is required to master skills such as motor electromagnetic design, structural design, and control strategies, and be familiar with motor manufacturing processes. In terms of innovation capabilities, it is required to be able to propose motor optimization solutions based on specific scenarios, use simulation tools for virtual testing, and quickly verify the feasibility of designs. In terms of literacy, it is required to cultivate cost awareness, enhance interdisciplinary communication skills, and improve project management abilities.

5.2 Course Design

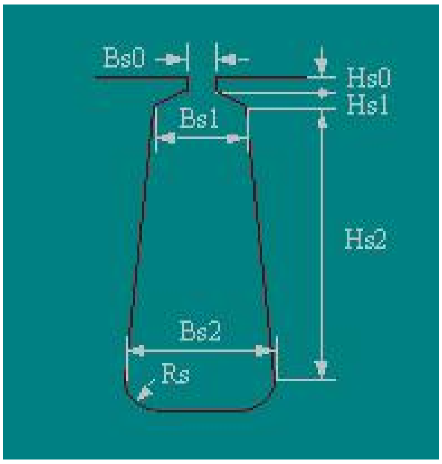
Comprehensive ability training is carried out on the basis of students' mastery of basic electromagnetic theory, mechanical design, materials and processes. Through analyzing the process of inverted planetary roller screw, students gradually acquire the ability to retrieve and identify literature, apply professional knowledge of particle kinematics, gear transmission, and screw transmission, and gain a preliminary understanding of the role and application of the professional knowledge they have learned[5].

Based on the resources that the enterprise can provide, select a 2-DOF multi-purpose gimbal motor design based on harmonic reducer as the practical program for the course.

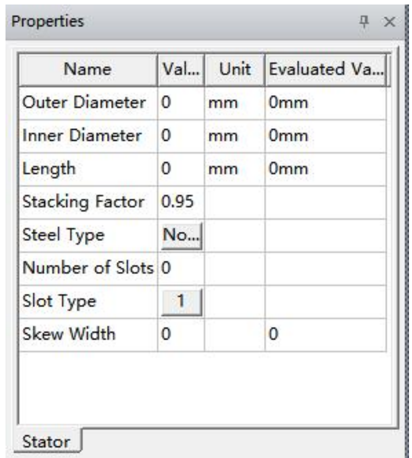
5.3 Design phase

Build a virtual, experimental, project-based progressive practice system for comprehensive ability training. The gimbal motor requires low vibration and light weight while meeting specific torque requirements.

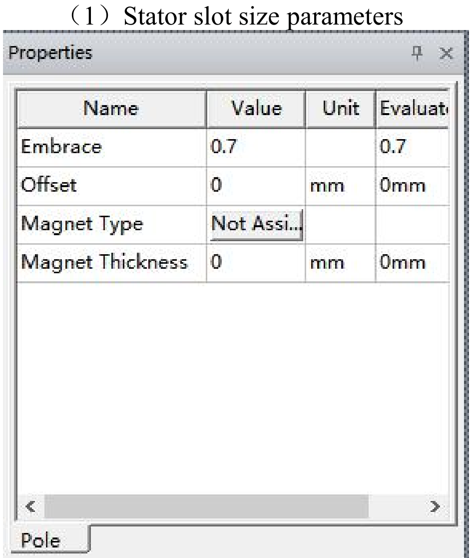
Firstly, the composition of the motor is relatively simple, with the main structure including the housing, stator, rotor, and encoder. The dimensional parameters of the stator and rotor have a significant impact on the performance of the motor. Maxwell software is used for electromagnetic design. The stator slot design interface is shown in Figure 4-1, the electromagnetic simulation model is shown in Figure 4-2, and the power curve obtained through analysis is shown in Figure 4-3. The cogging torque is shown in Figure 4-4, and it can be observed that the cogging torque meets the requirements for low vibration applications[6].



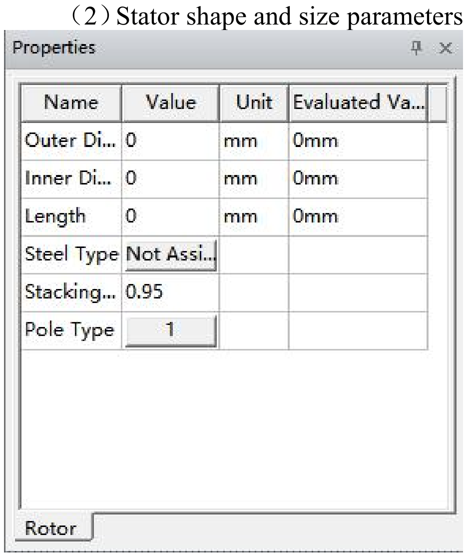
（1）Stator slot size parameters



（2）Stator shape and size parameters



（3）Magnetic pole size parameters



（4）Rotor Dimensional Parameters

Figure 4-1 Electromagnetic design

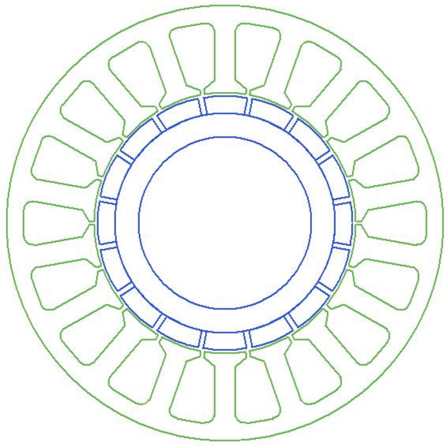


Figure 4-2 Electromagnetic simulation model

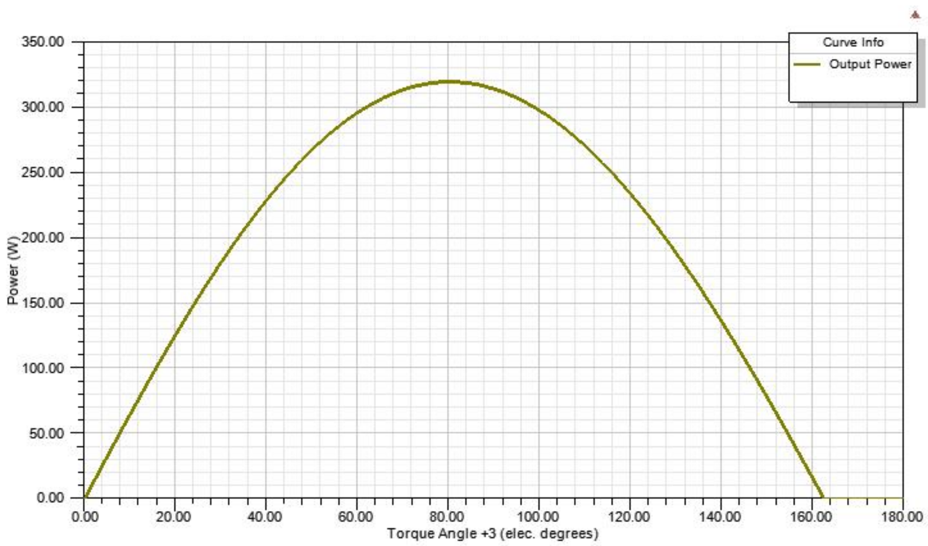


Figure 4-3 Power curve

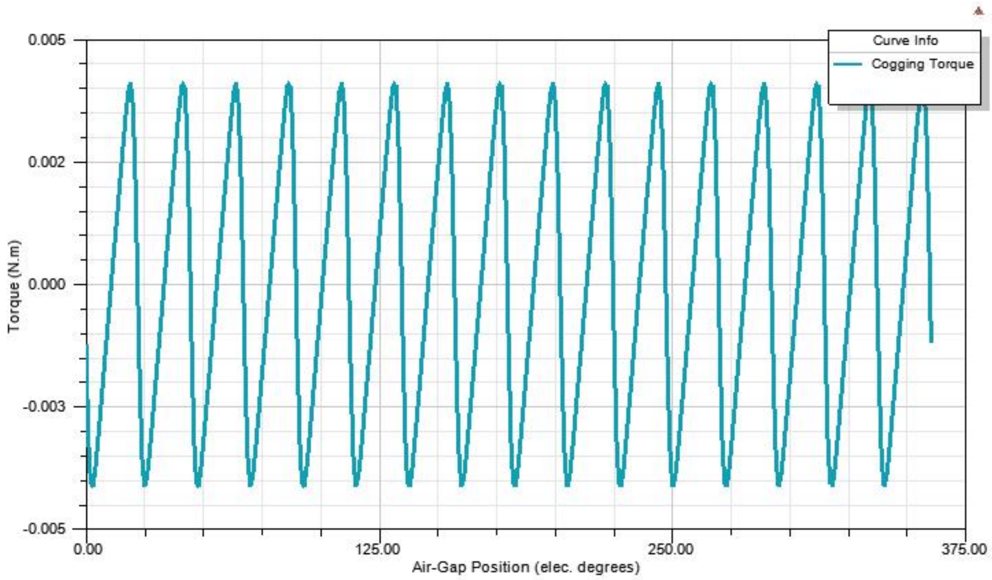
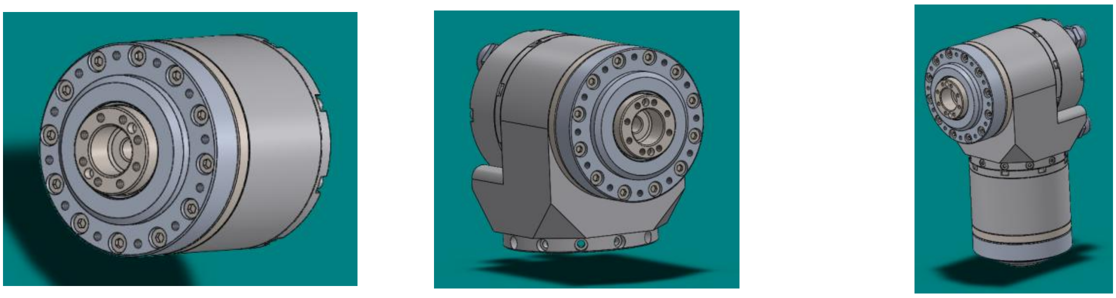


Figure 4-4 Cogging torque curve

Secondly, based on the stator and rotor dimensions obtained from electromagnetic design, Solidworks software was used for mechanical mechanism design. The 3D model of the gimbal motor is shown in Figure 4-5.



(1)Straight Tube Module (2)T-shaped module (3)2自由度云台模块

Figure 4-5 Gimbal solution

(1) Stator (2) Casing (3) Motor

Figure 4-6 Experimental Work

Thirdly, based on electromagnetic design and 3D modeling, work on part processing, motor assembly, and gimbal assembly. As shown in Figure 4-6.

Fourth, the project progresses by assembling the motor module into a gimbal and applying it to a robotic arm, as shown in Figure 4-7.

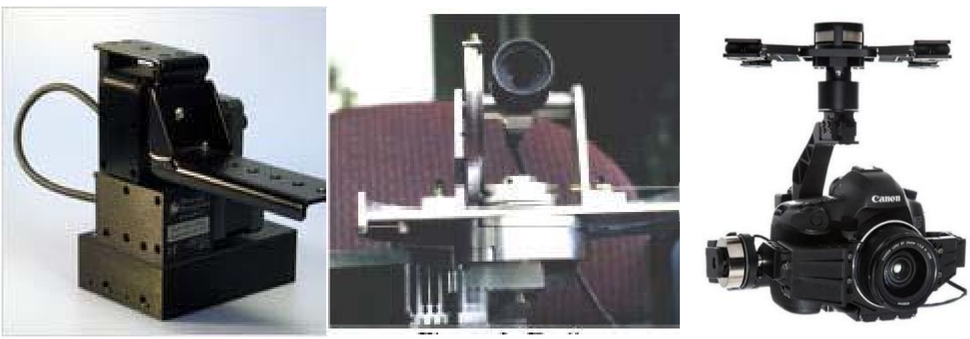
Figure 4-7 Experimental work

6. Case implementation

6.1 Raise a question

First, let's ask the question - designing a 2-degree-of-freedom gimbal. What is a 2-degree-of-freedom gimbal? What are the design requirements for a 2-degree-of-freedom gimbal?

Students are familiar with using the internet and quickly find relevant information through search engines, as shown in Figure 5-1. However, they are unclear about its principles, which arouses their curiosity and creates an expectation to understand its details.[7]



(1) PTU-D47 (2) Active eye system (3) Z15

Figure 5-1 Types of initial data collected by students

6.2 How to initiate research work

At the end of the preliminary data collection stage, the students had established a perceptual understanding of the gimbal. However, they were unsure how to begin their initial analysis, mainly due to two reasons:

First, during the study of professional courses, I have never been exposed to motor design. Although I have learned basic professional knowledge, I don't know how to integrate these knowledge together[8].

Secondly, even experienced engineers need certain basic data support when launching a new project. In real work, most of the work is carried out on the basis of existing work, and inventive work that starts from scratch is more difficult and is not within the scope of this article.

In summary, conducting research requires the support of foundational knowledge and materials. Students have already acquired the basic knowledge, with the focus being on locating the necessary foundational materials. Under the guidance of enterprise mentors, students will visit enterprises to observe the assembly process of motors, initially grasping the structure and design essentials of motors[9].

6.3 Carry out work in depth

The process of conducting in-depth work is the process of understanding literature. Students generally reflect that this process is difficult, mainly due to the difficulty of analyzing mathematical formulas. This part of the work needs to be mainly interpreted by students with solid professional knowledge, and then analyzed to other students. This process can help students with weak professional foundations understand the operating principles of motors. At the same time, in the process of analysis, it can improve the proficiency of the lecturer in understanding the structure of motors. In this process, students with solid professional knowledge may also encounter difficult points, which can be answered by the teacher to help students clarify their thinking[10].

6.4 Work Demonstration at Each Stage

When work of each stage is presented in the description of each stage. Students provide materials, organize materials to build PPTs, and conduct PPT presentations. As each stage progresses, the PPTs built by students gradually evolve from monotony to richness, and students' on-site expression ability evolves from naivety to maturity.

Practice has proved that in the context of "Double High" construction, through the case of comprehensive ability cultivation in electromechanical Major, on the one hand, it expands students' professional vision, effectively enhances students' enthusiasm, and cultivates students' abilities to consult materials, learn independently, analyze and solve problems, as well as engineering practice abilities; on the other hand, it urges teachers to re-learn teaching and professional abilities, and optimizes the establishment of a diversified teaching team[11].

Conclusion

With the support of the "Double High" construction project, a diversified mechanical design basic teaching team consisting of multiple majors, educational backgrounds, professional titles, and experiences has been established. The team integrates teaching and research capabilities, and selects cases that are moderately difficult and have a certain degree of cutting-edge nature to train students' engineering practical abilities. Reasonable selection of course assessment topics, determination of assessment schemes, optimization of teaching methods, and engineering application are all crucial elements in achieving this goal[12].

Through this case study, all students gained valuable experiences: those who retrieved information honed their ability to discern and evaluate literature; those who analyzed formulas deepened their understanding of integrating theory with practice; those who presented PPTs further honed their communication skills. During the project, teamwork and collaboration among students strengthened their team spirit. The presentation of their achievements boosted their sense of accomplishment. Overall, all students reported a comprehensive understanding of the mechanical and electrical knowledge they had learned. Cultivating comprehensive electromechanical abilities is an effective method to enhance students' engineering capabilities.

Fund Project:

1. Research on torque motor of high torque density and adaptive drive technology of collaborative robots (No.22KJA460008)

2. Scientific research start-up fund project of Suzhou Vocational Institute of Industrial Technology (No.2017kyqd030)

3. Research on the structural construction scheme of the teaching team of higher vocational colleges under the background of "Double-high construction" (No. SGYJG2023A)

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