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Engineering-Driven Situational Teaching Study on Electric Control of Mechanical Equipments

Mingxin Yuan[1,2], Yi Shen[1,2], Jinke Gao[1], Qi Wang[1,2]
[1](*Suzhou Institute of Technology, Jiangsu University of Science and Technology, Zhangjiagang, China*)
[2](*School of Mechatronics and Automotive Engineering, Jiangsu University of Science and Technology, Zhangjiagang, China*)

Abstract: *In order to further improve teaching effect of the course regarding electric control of mechanical equipments, and strengthen electrical design and PLC control capability about machinery equipments of students, a situational teaching method under guidance of engineering is presented. The method includes case-based classroom teaching, field-based course teaching and project-based comprehensive practice. Aiming at the course knowledge of each chapter, some engineering cases are combined into classroom teaching. Based on some actual engineering objects, the students can understand electrical systems well through on-site tasks such as use, dismantling, assembly, connection and commissioning. Based on some training devices, the practical ability of students can be improved using project tasks. The teaching results show that, for the students who have no any engineering background, the situational teaching helps them understand, grasp and apply knowledge well.*
Keywords: *Situational teaching, electrical control, programmable logic controller, project task*

I. Introduction

The course regarding *Electric Control of Mechanical Equipments* is an specialized course which integrates traditional relay control technology and PLC technology, and is a required course of mechanical engineering students. The course requires students to have certain engineering background and strong practical ability. However, most students lack of perceptual knowledge to practical engineering and have no practical experience. It is difficult for them to connect course knowledge points with practical engineering. During the study, most students can not grasp and apply the course knowledge points well, such as the functions of common low-voltage apparatus, design methods of speed control circuit and PLC control technologies. In order to improve teaching effect, many frontline teachers carry out some teaching reform. Wu [1] proposed a teaching mode of task-driven project for the course to improve students' capacity of understanding and applying knowledge. Starting from training objective of electrical control and PLC technology course, Ren *et al.* [2] analyzed the importance of the course reform to construction on cultivating students' engineering practical ability and creative ability. Furthermore, he introduced some concrete methods of the course reform. Xu *et al.* [3] analyzed the characteristics of project teaching methodology and put forward the project teaching reform for *Electromechanical Transmission and PLC* according to local actual production and conditions of students learning curriculum. From teaching facilities, teaching content, teaching material selection and curriculum evaluation conclusion of teaching staff construction, Ma *et al.* [4] put forward some suggestions and methods for teaching reform of PLC course by studying the present situation of the vocational education at home and abroad. In order to improve experimental teaching results, Miao *et al.*[5] designed some experimental systems including three levels. The computer communication is used to deepen the experimental contents. The actual and virtual combined systems are applied to make the systems more visual and flexible. The pre-discussion is made to improve the experimental efficiency. The practical teaching results show that the practical and innovative ability of students are improved greatly by the proposed experimental teaching reform.

Considering that the course regarding *Electric Control of Mechanical Equipments* is characterized by strong engineering application background, some project cases have been applied to daily teaching in different degrees by teachers of domestic and foreign universities, and they effectively help students to achieve a combination of theoretical knowledge and practical engineering. However, the current teaching reform remains shortages. In terms of theoretical teaching, though the addition of engineering cases can improve the students' understanding of course knowledge, the teaching contents more emphasis on the teaching of system design. Thus, during the course teaching, we need to carry out engineering-driven situational teaching through the integration of actual projects and course knowledge. In terms of the PLC simulation platform based on MCGS configuration software, some current virtual platform more just plays the role of demonstration. In order to improve the students' skills of system design and programming, the developed virtual platform should have the functions of secondary development and programming to the students.

In view of this, in order to improve the teaching effect of *Electric Control of Mechanical Equipments*, the case-based classroom teaching, field-based course teaching and project-based comprehensive practice are introduced in this paper.

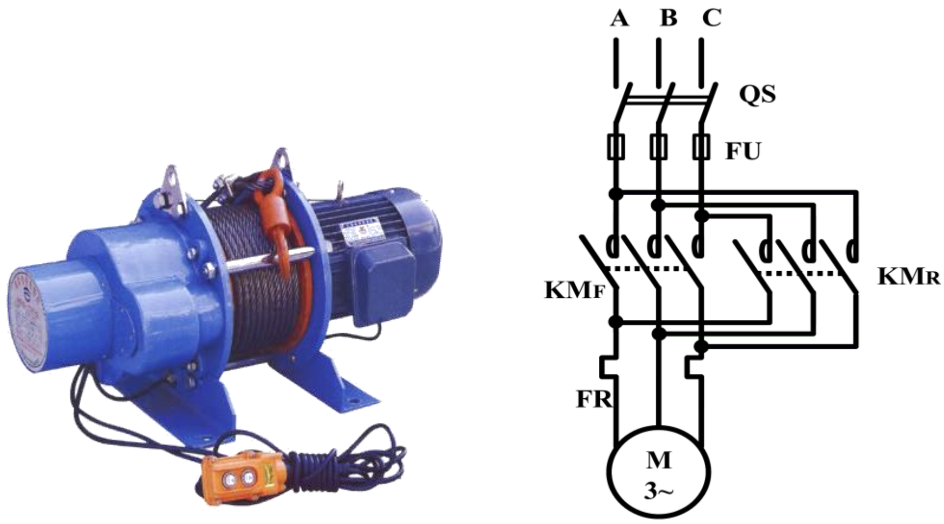
II. Case-Based Classroom Teaching

At present, in the mechanical talent training schedule of our school, the course regarding *Electric Control of Mechanical Equipments* contains 40 class hours. The time for theoretical teaching is 34 class hours and the time for practical teaching is 6 class hour. For an applied specialized course, 40 class hours are not enough. So, teaching contents of the course are firstly streamlined and optimized by our teaching team. Now, the course contents such as common low-voltage electrical appliances, basic electrical control circuits, motor speed control circuits, as well as PLC working principle and instruction system are taken as the main teaching contents. Then, at the arrangement of teaching contents, we carry out the heuristic teaching by connecting engineering background with course knowledge, namely, the classroom knowledge is reflected through engineering objects [6]. Table 1 shows partial heuristic teaching cases which are constructed for the knowledge of each chapter.

Table 1 Partial heuristic teaching cases

Chapter	Engineering objects	Corresponding classroom knowledge
I. Common low-voltage electrical appliances	A case regarding arc burn accident in Anhui province	Contact system, arc-quenching system, low-voltage switchgear, low-voltage circuit breaker, fuse, etc.
	Bridge crane	Universal switch, cam controller, master controller, etc.
	Coal supply conveyor	Time relay, speed relay
II. Basic electrical control circuits	Elevator	Remote control
	Hoist	Voltage-reduced start, positive and negative turn control, series resistance speed control, etc.
	Wire stranding machine	Reverse brake control, Energy consumption braking control
III. Motor speed control circuits	Air conditioner	Speed control methods of three-phase AC motor
	Electric cars	Speed control methods of DC motor
IV. PLC technologies	Control of traffic lights	Common low-voltage electrical appliances, basic electrical control circuits, motor speed control circuits, Basic instructions, sequence instructions and Ladder of PLC, etc.
	Vending machines	
	Control of industrial robot manipulator	

Fig. 1 shows a case for heuristic teaching. In chapter II, in order to better teach the knowledge regarding positive and negative turn control, we introduced a hoist (see Fig.1(a)) during the teaching. As well known, the hoist is widely used in various industrial applications, and it can forward and reverse according to requirements. But how to realize the control function? We can easily lead to the design of control circuit by the engineering case and show the control circuit of positive and negative turn as shown in Fig.1(b). In Fig.1(b), two contacts (namely KMF and KMR) are used. When KMF is closed, the three-phase AC motor starts to move forward. On the contrary, when KMR is closed, the motor starts to reverse.



(a) hoist (b) control circuit of positive and negative turn

Fig.1. A case for heuristic teaching

III. Field-Based Course Teaching

In order to effectively help students to connect the course knowledge with practical engineering and improve students' engineering application ability, our teaching team extracts some knowledge points which are related to course teaching contents from a number of engineering tasks and brings them into field-based course teaching. Fig.2 shows integrated experimental system of RW-SY2-OIMATE numerical control machine.

Through the experimental system, our teaching team makes three teaching tasks, namely, design, installation, commissioning and maintenance regarding typical electrical control system of a three-phase asynchronous motor; design, installation, commissioning and maintenance regarding typical electrical control system of a CNC milling machine; design, installation, commissioning and maintenance regarding PLC control system of a three-phase asynchronous motor. The field-based course teaching is not only necessary complement to classroom teaching, but also is the continuation and development of classroom teaching. First, the field-based course teaching is helpful for students to understand and grasp theoretical knowledge; second, the actual operation trains the practical ability of students and improves the learning interest of students.

Fig.2 Integrated experimental system of a numerical control machine

IV. Project-Based Comprehensive Practices

4.1 Teaching reform of curricular experiments

Experiments are the important and indispensable parts of course teaching. For the course regarding Electric Control of Mechanical Equipments which is characterized by strong practice, the experiments are particularly important. In order to help students to understand the course knowledge points and grasp basic application of important knowledge points, the time of curricular experiments is increased from 4 class hours to 6 class hours. Fig. 3 is an experiment device of THPFSL-1A programmable controller. Based on the experimental device, students can not only complete PLC cognitive training, digital display, three-story elevator control, four conveyor control; but also can complete four-story elevator control, intersection traffic light control, and box assembly line control. The former is mainly replication experiment and is for students to understand and grasp course knowledge points; the latter is mainly comprehensive experiment, and the students are requited to complete the distribution of PLC hardware resources, hardware connections and the writing and debugging of ladder according to given functional requirements. The teaching reform of curricular experiments plays subjective initiative of students and improves the ability of solving practical problems using course knowledge.

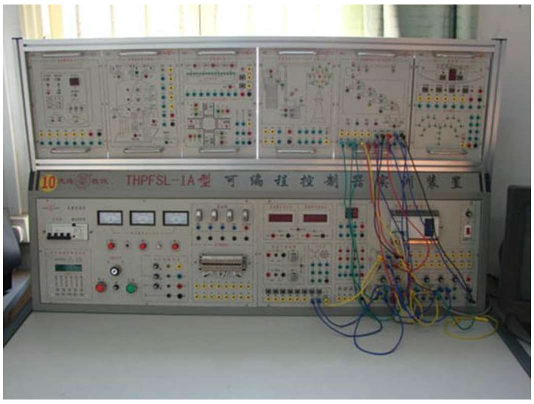


Fig.3 Experimental device of THPFSL-1A programmable controller

4.2 Extracurricular comprehensive training

The curricular experiments facilitate the students to master and use some important course knowledge points. However, the practical engineering ability of students should be improved through strengthen training. In regard to this, some training assessment devices are introduced in our school. Fig. 4 is one of devices. The device consists of PLC module unit, touch screen module unit, inverter module unit, simulation training module and various sensors. Based on the device, the students can classify various artifacts by writing the ladder program. During the training, the involved technologies include a touch screen, inverter and PLC control, and they are very close to the practical engineering. So, all kinds of training tasks based on the training assessment devices can further strength the students' design and control capabilities of electrical system.

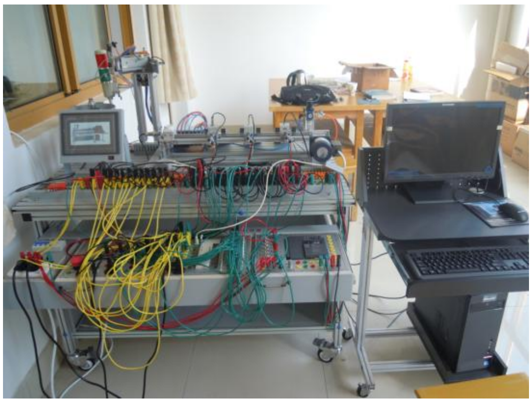


Fig.4 YL-235A light mechatronics trainer

4.3 Training based on virtual experimental platforms

Based on all kinds of experimental and training devices, the actual practical ability of students can be improved well. However, in our country, the education funds in colleges and universities are limited. It is difficult for them to buy a large amount of laboratory equipments. In regard to this, our teaching team developed a series of virtual experiment platforms based on MCGS configuration software [7,8]. Fig. 5 is one of virtual experimental platform, namely virtual platform of pasta stirrer. Based on the platform, the students need to independently choose I / O port resources of PLC controller to design the control circuit and finish the control of pasta stirrer using ladder program. The developed virtual platforms not only save the education funds, but also provide students with a lot of practical hands-on opportunities.

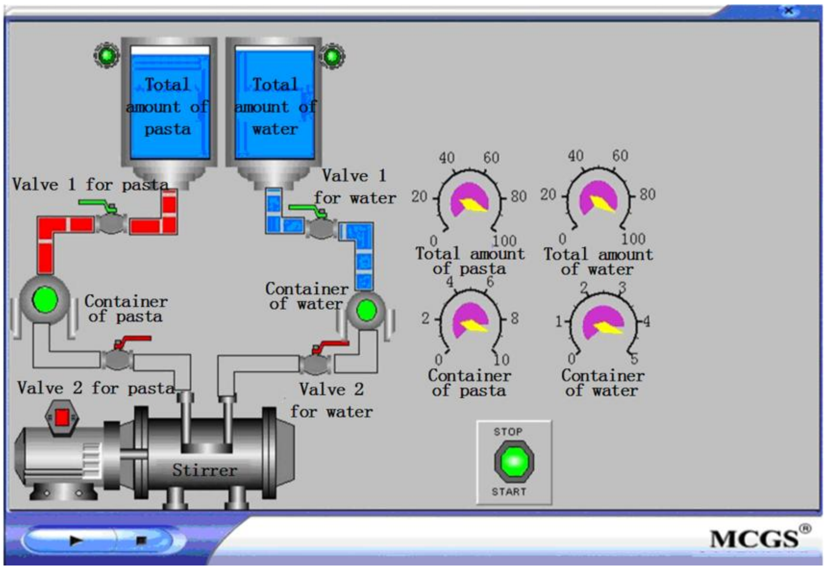


Fig.5 Virtual experimental platform of pasta stirrer

V. Conclusion

The course regarding *Electric Control of Mechanical Equipments* is the required course of mechanical engineering students. Considering that the course is characterized by strong engineering background and practice characteristics, the engineering-driven situational teaching is carried out. Through a number of engineering cases, the students can understand, grasp and use the course knowledge points well in engineering background, and their design capability of electric control systems is improved greatly. Obviously, the situational teaching reform is very important to improve teaching effectiveness of the course regarding *Electric Control of Mechanical Equipments*. In fact, for many specialized courses of engineering majors, the situational teaching reform is also required. So, the teaching reform in this paper has a certain reference for other courses.

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