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Teaching Reform and Practice in 'Modern AC Speed Control' Based on Multi-Simulation Method

Haozhe Liu*

University of Shanghai for Science and Technology, Yangpu District, Shanghai, 200082, China
liuhaozhe@usst.edu.cn
**Corresponding author*

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Abstract: This paper investigates the teaching reform and practical exploration in the "Modern AC Speed control" curriculum based on multi-simulation method. By summarizing the existing problems in the curriculum, a new teaching targets of the curriculum is proposed. The proposed teaching targets have three main aspects of knowledges, abilities and values, which is aiming at improve the students' performances in specialized knowledge, practical skills, creative thinking and scientific sprit. Based on the new teaching targets, improvement measures including optimization of teaching targets, rebuilding the teaching framework are proposed. To improve the practical skills of the students, a multi-simulation method is introduced in the curriculum. In the multi-simulation teaching method, students can have better understanding of the theory knowledge and practice.

1. Introduction

With the development of Chinese higher education reforms aiming at cultivating high-quality comprehensive students for future social requirements, the course reforms to improve to students' critical skills and have been widely implemented [1],[2]. This phenomenon is particularly obvious in the field of electric engineering [3]. On one hand, curriculum reform aiming at student-oriented education system is one of the important parts to upgrade the education level of one university. The course design, teaching skills, interaction between teachers and students, choices of the teaching contents and estimation system in a curriculum need to be optimized for the sake of fostering the high-quality students with important skills. On the other hand, with the rapid development of the electrical industry, the corporations have the increasing requirements of the competitive and efficient students majored in electrical engineering in universities. That means that the post graduates must have some professional skills and abilities rather than only simple knowledges on the book to face the challenges in their future career. Consequently, the reform of the courses is dispensable to the improvement of the students in specialization.

'Modern AC Speed Control', as a fundamental course of electrical specialty for the post graduates, is essential to the post graduates that do research in power electronics and electric machines. However, 'Modern AC Speed Control' is not easy to learn due to the abstract concepts, complex equations and difficult principles. It requires students to have not only sturdy knowledge

system in engineering like circuit principle, machine theory and automatic control but also mathematics and physics. Before studying this course, students have studied the main courses such as electrical engineering, electric power drag, automatic control principles, power electronics, DC speed control, from which it can be seen that this curriculum is aiming at improve the comprehensive ability and establishing and wide range of knowledge system for the post graduates. Meanwhile, many students think this curriculum is very hard to learn. Most of the time in class, they are often half-understand or even confused. Some students may loss the interests in learning this curriculum or even some students think learning this course is wasting of time. Therefore, the teaching effectiveness of the course may not good. Having teaching reform to find a effective method to solve this problem is significant to the students' development.

Outcome Based Education (OBE) [4], as a modern educational philosophy, is increasingly becoming an important introduction for teaching reforms. OBE focuses on the ability improvement of the students, effective application and skills. And the educational process should be student-oriented. To satisfy this meet, curriculum design must not only have the good balance between theory and practice but also concentrate on how to stimulate the learning interest of the students for the sake of cultivate their practical and creative abilities to achieve the teaching goals [5]. In this paper, a teaching reform and practice in "Modern AC Speed control" curriculum based on multi-simulation method is investigated. The reform includes the new teaching targets, new teaching mode and introduction of simulation so as to not only help students master in the specialized knowledges but also have important abilities for their future career.

2. Existing problems in teaching process

2.1. Difficulty in getting start

To start learn 'Modern AC Speed Control', the students must have the fundamental knowledges about circuit principle, automatic control, machine theory and energy conversion. These are fundamental courses in electric engineering faculty but are not easy to learn well. The students with poor learning foundation are hard to getting start so that it is easy for them to lose the learning interests. Consequently, the low attendance rate and scatterbrained minds in class results in undesirable teaching effect.

2.2. Abstract concepts

'Modern AC Speed Control' course is related to electric machines. Electric machines is a nonlinear and high-order system with complex equations and coupled multi-physical fields. From electrical field, electric machine has the physical quantities of voltage, current and power. In terms of magnetic field, it also has the he physical quantities of flux, flux density and electromagnetic torque. All these physical quantities interact so the mathematical model of the electric machine is complicated. When teaching, these physical quantities is either visible or sensitive so that the students have difficulty in understand the operation principle of the electric machine, let alone some technologies such as rotating coordinate transformation, equivalent magnetomotive force, which needs good spatial perception ability and imagination to understand. Although the teachers try their best to explain the abstract knowledge by using of methods like analogy approach and demonstrate the derivation of formulas in details, the students feel confused with the cumbersome mathematic or physical equations.

2.3. Outdated teaching contents

The traditional teaching methods of 'Modern AC Speed Control' course always pay much attention to the basic knowledge, simple concepts and traditional technologies for the AC speed control. However, with the rapid development of the power electronics and control theory, some technologies of speed control are outdated and eliminated. For example, the induction machines speed control strategies based on hardware is not only complex and bulk but also inefficient. These strategies are hardly employed in the industrial applications. By contrast, some new methodologies like model predictive control, adaptive control, sliding mode control and sensorless control are the interesting topics. These popular topics can attract the students, motivating them to learn.

3. Curriculum reform

3.1. Optimization of the teaching targets

To solve the problems above, this paper presents a new teaching system for the course of 'Modern AC Speed Control', which contains the three aspects of knowledge education, ability education and value education, as shown in Fig. 1.

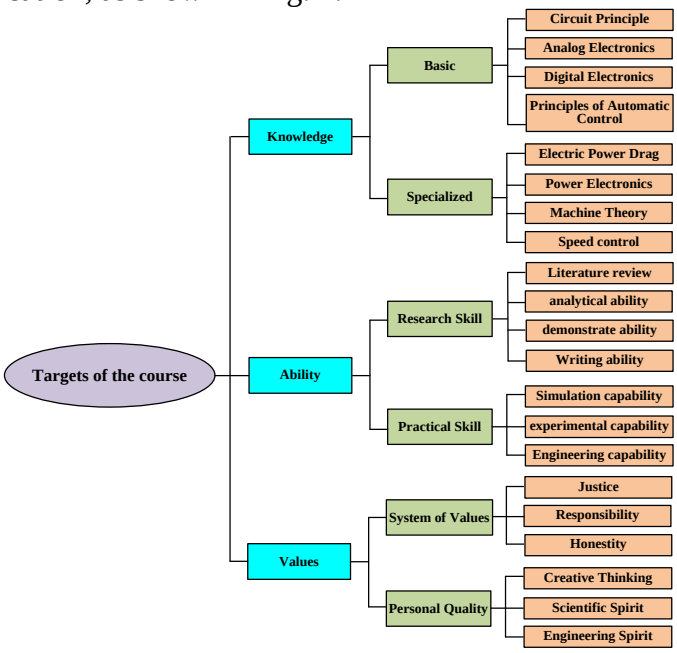

Figure 1: Teaching targets of the course

Knowledge education is categorized into two parts. One is the basic knowledge education which includes the basic courses such as circuit principle, analog electronics, digital electronics, principles of automatic control and so on. The other is called specialized knowledge education, which contains the specialized courses such as electric power drag, power electronics, machine theory and speed control. The basic knowledge is essential to the specialized one while the specialized knowledge is the further exploration of basic knowledge, which means it is more difficult to study and harder to understand for the students.

Ability education is related two aspects. One is research skill and the other is practical skill. Since the educational object is the post graduates major in electric engineering, the students must have the research skills and practical skills for the work or further study in future. The research skill education focuses on the skills of literature review, analytical ability, demonstrate ability and

writing ability. The practical skill education concentrates on the simulation capability, experimental capability and engineering capability.

Value education composes two parts. One part is system of values and the other part is personal quality. The main target of the value education is to establish the positive attitude and correct sense of the values for the students, such as justice, responsibility and honesty. Moreover, the personal quality improvements are also important to the students. The creative thinking, scientific spirit and engineering spirit make the students more competitive for their career.

3.2. Rebuilding of the teaching framework

In order to delete the outdated the teaching content and add the popular topics of the modern speed control, the teaching framework of the 'Modern AC Speed Control' is optimized as Fig. 2.

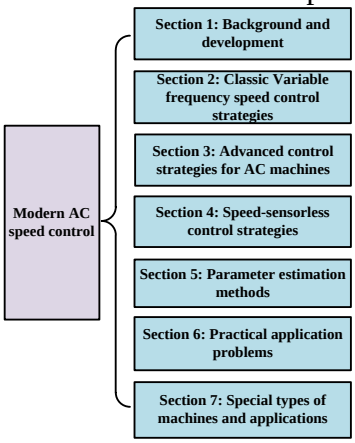

Figure 2: New teaching frame of the course

In Section 2, the outdated control strategies like mechanical-series speed control, rotor-resistance speed control and so on are deleted. And the advanced control strategies like model predictive control, adaptive control are summarized as one new section (Section 3 shown is Figure 2). And the speed-sensorless control strategies, parameter estimation methods parts (Section 4 and 5) also introduce the cutting-edge technologies. To help the students know where can use what they learn, Section 6 is added to introduce the practical applications of the AC speed control technologies and what is the problem to be solved in future. Besides, in some special application fields, some special types of machines are also need to be paid attention. So in Section 7 these issues are discussed.

3.3. Improvement of practical skills based on multi-simulation method

Simulation software can provide a virtual experimental environment, so that students can simulate the real machine-control-system on the computer so as to help themselves have a better understanding of the principles they have learned. Moreover, simulation is good assistance for the students to solve the problems and have further study in what they are interested in. To cultivate the design ability and analysis ability for the students, a multi-simulation method is used in the course.

3.3.1. Design ability for industrial application by finite element simulation

When teaching the basic configuration of the electric machine, teachers can use the finite element simulation software to make the students understand what is the stator, what is the rotor and what is the windings. Figure 3 and Figure 4 are the dimensional layout of the finite element model established in simulation software. Figure 3 shows the 3D structure of the electric machine and Figure 4 shows the section view of the electric machine. By simulation study, students can

understand the dimensional relationship among out diameters, inner diameters, effective length air-gap, the slot area, the winding turn number and wire diameter and so on. Moreover, with good understanding, student can start parameter design of the electric machine by simulation and test the performance, shown as Figure 5, the output of the electric machine is three-phase AC sinusoidal current.

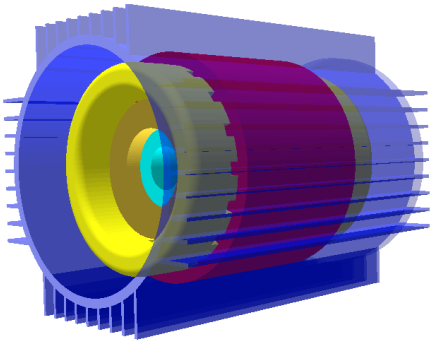

Figure 3: 3D structure of electric machine

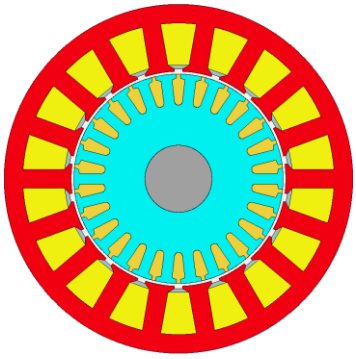

Figure 4: Section view of the electric machine

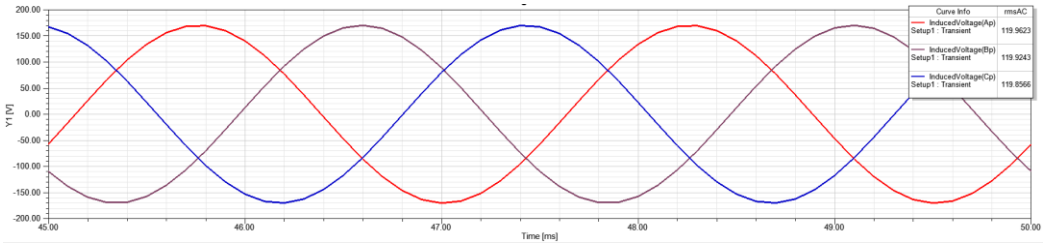

Figure 5: The simulation reuslts of the machine design

In the process of machine design and the compromise of the optimal targets, the students can establish their own cognition about the design procedures of an electric machine for the specific requirements in industry, which is very helpful for those work as a machine designer in future.

3.3.2. Analysis ability for engineering problems by system simulation

When teaching flux-oriented control strategy, teachers can make use of the simulation software Matlab Simulink to demonstrate how the flux-oriented control works. Figure 6 shows the control system of the flux-oriented control for induction machine in Matlab Simulink. The system contains the machine module, coordinate transformation module, regulator module, flux orientation module and pulse-width-modulation module. The students can modify the parameters of the regulators to have better performances of the machine or design the new controllers by themselves. From Figure 7, the given speed of the machine is 1500rpm. It can be seen that the practical speed of the machine is controlled around 1500rpm, which means the speed regulator works. At the time instant 2s, a step load is carried out, and the machine speed can also be regulated to about 1500rpm.

The main target to add the simulation learning for the students are to help students make full use of the auxiliary tools to analyse and solve the problems. In their career in future, they may face to more and more complicated engineering problems in different applications. The system simulation is a good assistance for them to effectively analyse and solve the problems.

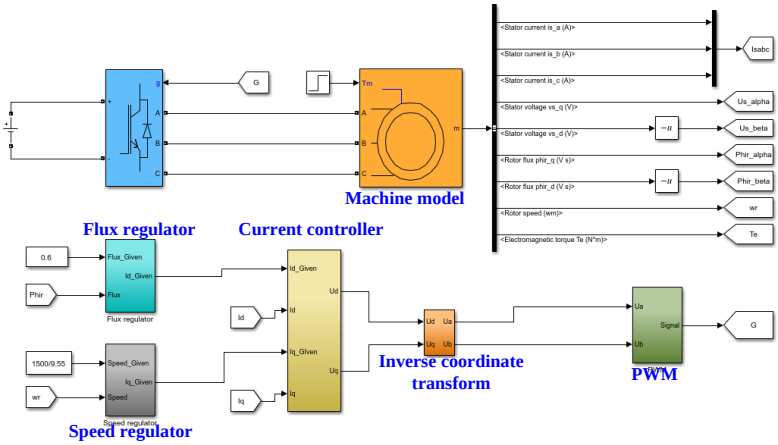

Figure 6: The control system in Matlab Simulink

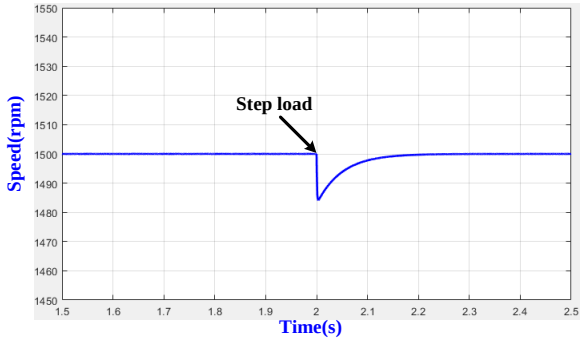

Figure 7: The simulation reuslts

4. Conclusions

This paper investigates the teaching reform and practical exploration in the “Modern AC Speed control” curriculum based on multi-simulation method. Through analysis of the existing problems and the reasons why the teaching effects are undesirable, a new teaching targets and the teaching framework are proposed. The proposed teaching targets have three main aspects of knowledges, abilities and values, and the in new teaching framework, the outdated content is deleted and advanced technologies are added. To improve the practical skills of the students, a multi-simulation method is introduced in the curriculum. In the multi-simulation teaching method, students can have better understanding of the theory knowledge and practice.

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