



Research on the Teaching of “Fundamentals of Control Engineering” Integrated with MATLAB

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Abstract. Based on the course of Fundamentals of Control Engineering, this paper discusses a progressive teaching method integrating MATLAB simulation. The method evolves the basic teaching materials into professional cases and enriches the teaching cases. Through theoretical explanation, independent design, MATLAB simulation, feedback and innovation, integration of ideological and political education in several aspects of progressive, the learning content is multi-dimensional. Integrate ideological and political education in professional knowledge, so that students can set up correct ideas, value orientation and behavior mode while mastering professional knowledge.

Keywords: Control Engineering · Progressive Teaching Method · MATLAB Simulation · Ideological and Political · Learning Effect

1 Introduction

“Fundamentals of Control Engineering” is the core basic course of mechanical major, which plays a pivotal role in professional education. The course is highly theoretical, the system needs to use the differential equation, the transfer function, the pulse response, etc., involving higher mathematics, theoretical mechanics, linear algebra, complex variable function and other mathematical knowledge [1]. Although control theory has great practical value in mechanical manufacturing and other aspects, it is difficult for professors to combine this theory with practical engineering. In addition, learners need to have rigorous theoretical thinking, unremitting innovation ability, inquiry problem thinking and efficient application ability, so it is not easy to deal with.

At present, the results of the teaching mode reform of the basic control engineering are relatively diversified. For example, Xue Xiaoming [6] analyzed the characteristics of the course, such as strong theory, abstract concepts, insufficient difficulty of learning in the experimental link and so on, and put forward corresponding countermeasures. Pang Xiaoxu et al. [3] discussed the project teaching as the main line, the case teaching as the auxiliary, introduced the frontier of control technology and scientific research technical problems, explored the teaching method of teaching mode, improved teaching quality, cultivated students ‘innovation ability and improved students’ comprehensive

quality. Li Xiaohu et al. [2] put forward multiple teaching methods of quote and practical engineering between theoretical knowledge and engineering practice. Finally, the teaching evaluation system was formed to improve students' 'comprehensive ability and develop students' systematic analysis and design ability in practical mechanical engineering. According to the teaching content of the course, Wang Xianlei et al. [5] selected appropriate knowledge points, made good use of the main classroom channels, attached equal importance to knowledge transmission and valued guidance, explored the ideological and political education function of the course, and cultivated professional and technical personnel who met the needs of the times. Wang Lijun et al. [4] introduced MATLAB to solve the problems of mechanical control engineering in which the drawing quantity is huge and the calculation is complicated. The application of MATLAB is described in mechanical control engineering basis teaching using concrete examples of time analysis and frequency analysis in a contrasting way. Using MATLAB in mechanical control engineering teaching not only improved teaching efficiency, but also trained students' ability to analyze and solve problems. The above research results have achieved good teaching results, and have played a very good demonstration role in the innovative teaching methods.

This paper discusses a progressive teaching method integrating the ideological and political elements by understanding the professional statistics and the knowledge points involved and the evolution history of the advance course, as well as investigating the after-class feedback and assessment of previous students. Typical cases with certain depth, difficulty and certain comprehensive nature are selected, and handouts suitable for the training of mechanical applied talents are compiled. In order to make the case explanation more intuitive and practical, we began to teach the course to applied undergraduates from the aspects of theoretical explanation, independent design, hands-on simulation, feedback innovation, and ideological and political education.

2 Implementation of Teaching Method

2.1 Design Concept

Considering that the teaching object of this course is mainly mechanical manufacturing and automation, and the future work must be inseparable from the electrical parameters and mechanical parameters such as motor, gear, this paper chooses the position servo system as a typical case to introduce the progressive process of the teaching method of this paper.

Position servo system is usually a closed-loop control system, which mainly includes detection device, signal conversion circuit, amplification device, compensation device, actuator, power supply device and controlled object. The detection device is used to detect the input signal and system output; The amplifying device amplifies the power of the control signal; The executive part mainly realizes electromechanical conversion and converts the electrical signal into mechanical displacement; The signal conversion circuit and compensation devices make the signals of various components match effectively [7].

Explaining the theoretical knowledge and concept of this part from the perspective of establishing dynamic structure diagram can make students realize the steps of establishing dynamic structure from the overall perspective, but the formula in the potentiometer

bridge, DC motor and reducer-gear system eliminates some students' thirst for knowledge. At the same time, if we only focus on the derivation of each module in the system and no quantitative parameters, but without a certain overall cognition of the system, some students will lose the motivation to learn. In order to make the case explanation more intuitive, more practical, we started from the theory, design, simulation, innovation, into the ideological and political education layer by layer.

What is important is that ideological and political education will be integrated into classroom teaching in the teaching of teaching content. Adhere to the engineering education certification concept as the guidance of the teaching concept, appropriate guidance in the teaching can let the students have the correct values, guide and motivate the students, and promote the comprehensive and healthy development of students.

2.2 Optimize the Teaching Content

By analyzing and studying the teaching content, we can deeply understand the knowledge structure and content system of the teaching material, adopt step-by-step and gradual deepening in the organization of the teaching content, emphasize the understanding and application of basic concepts, and reduce the too detailed deduction process of some theorems and formulas. Focusing on the methods and theories that are closer to the engineering reality can better reflect the frontier of the discipline. In the process of teaching, while ensuring the integrity of the curriculum system, we pay attention to the integration and renewal of teaching contents and teach students according to their aptitude. We cannot talk about or simply mention the parts that intersect with other learned disciplines or other contents that are regarded as key knowledge in subsequent courses.

In this paper, through the analysis of the position servo system, the transfer function model of the potentiometer bridge, amplifier, DC motor and reducer-gear system is obtained, and then the block diagram model and the transfer function model are sorted out. The dynamic structure diagram is shown in Fig. 1. In this way, students can master the theoretical knowledge of each chapter, and better connect with the practical application of engineering.

In the teaching process according to different content characteristics, combining modern teaching methods and traditional teaching methods, making full use of multimedia demonstration, network teaching and other advanced teaching methods cannot only increase the information of classroom teaching, image expression teaching content, help students correctly understand the course content, but also broaden students' horizons and cultivate students' interest. At the same time, advanced technology is added to the teaching content on the basis of the subject. For example, the discussion of speed sensor technology and intelligent control technology is appropriately added in this case. This combination with the latest technology cannot only improve students' interest in this course, but also enable students to understand the latest development trend of advanced technology and expand their knowledge to meet the needs of new project development.

Through this step, students can understand the basic concepts, basic components, basic requirements and control methods of the control system, can use the mechanism analysis to establish the differential equation mathematical model of the linear system,

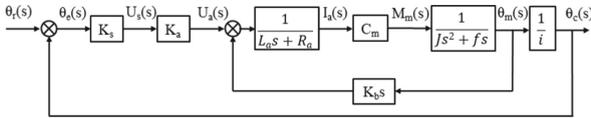


Fig. 1. Dynamic structure diagram.

master the model of using the structure diagram and the signal flow diagram to represent the system, and simplify the transmission function of the system.

2.3 Autonomous Learning

With students’ more and more diversified channels to acquire knowledge, the traditional one-way knowledge flow teaching gradually shows its limitations, and the student-based active learning is imperative. In order to enhance the autonomous learning effect of teaching, the teaching content is arranged in advance. Students can discuss and study in groups after class, and students are encouraged to go to the platform to tell the arranged content in advance. According to the problems exposed in the student’s explanation, the teacher should supplement and correct them. In this way, students can be encouraged to actively think about problems, preview the textbooks in advance, and improve the classroom teaching effect.

Students are required to adjust the transfer function by changing the parameters and breaking the feedback link on the basis of the basic block diagram, and to analyze the “stable, accurate and fast” of the system with the time domain, frequency domain and root track method. Analysis the difference in the performance of the system when removing internal feedback and the influence of the system on the stability, speed and accuracy of the system. Through the analysis, it can be seen that by increasing the feedback, the better the speed and steady-state performance of the system can be adjusted, while adjusting the accuracy and speed of the amplification coefficient can produce contradictions, so as to guide the students to further solve the problems.

After this step, students learn to analyze the stability, dynamic performance and steady state performance of linear systems by time domain analysis, frequency domain analysis and root trajectory analysis, and have a basic understanding of the engineering application background, research goals and problem solving methods of the control system.

2.4 MATLAB Simulation

Applying Matlab and its simulink simulation software to the teaching of Control Engineering Foundation can change the traditional single classroom teaching mode, simplify the formula derivation and concept narration, enhance the intuitiveness and vividness of teaching, and help students to deepen their understanding of what they have learned. Simulink can be modeled with continuous sampling time, discrete sampling time or two mixed sampling times. In order to create a dynamic system model, simulink provides a graphical user interface (GUI) for building a model block diagram. This creation process can be completed by clicking and dragging the mouse. It provides a direct and clear way,

users can see the simulation results of the system immediately. In addition, the Matlab simulation experiment platform also has many characteristics of experimental teaching cannot have. For instance, without interference by external complex factors, personal injury can be avoided, experimental cost can be greatly saved, the unknown results of complex control system can be demonstrated and the system parameters can be changed. The system is demonstrated with the parameters or trend, as shown in Fig. 2.

MATLAB simulation is combined with control engineering to analyze the dynamic and steady-state performance of the system, and to analyze and interpret the simulation results. Taking the modified ratio link Gain1 as an example, the parameter was modified to 0.2/5/20/40. The response of the simulated second-order system to the unit step signal. Thus, as long as the input signal of the system and the parameters of each module are changed, the response of any system to different inputs can be dynamically observed in real time. The changes of the system output as the parameters change are visually shown by MATLAB simulation, as shown in Fig. 3, 4, 5 and 6.

In the system, the adjustment time, overshoot, attenuation process and root trajectory can be clearly observed and the dynamic changes can be seen. Thus students can get a sense of achievement to stimulate the enthusiasm for discussion, realize the unification of theory and analysis methods, and effectively cultivate their ability to solve engineering application control problems.

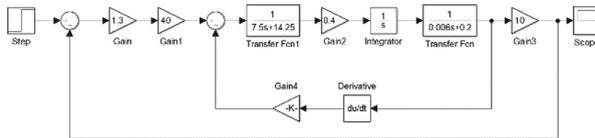


Fig. 2. Control system model.

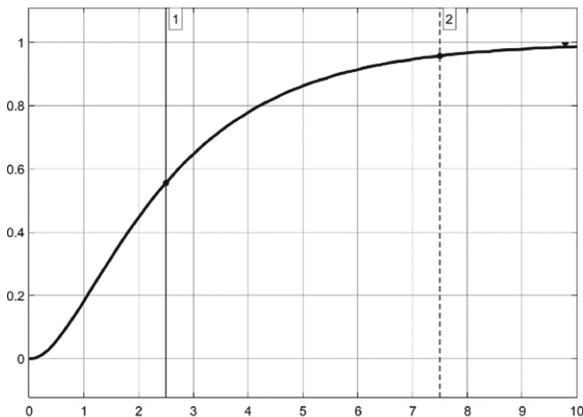


Fig. 3. Simulation diagram 1.

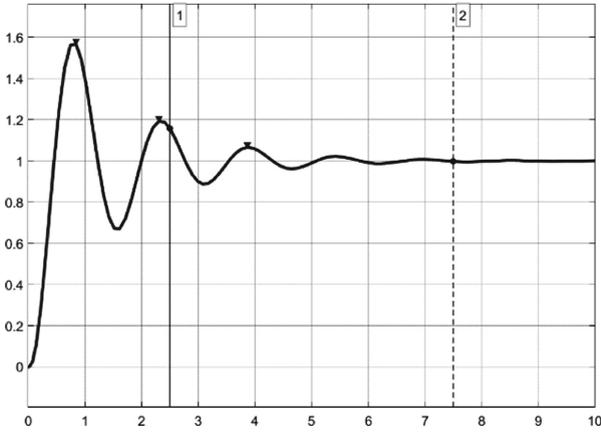


Fig. 4. Simulation diagram 2.

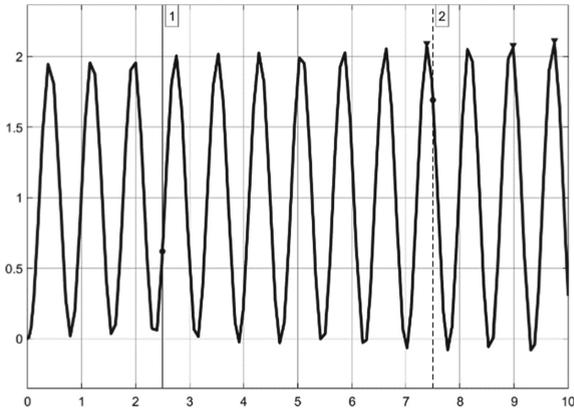


Fig. 5. Simulation diagram 3.

2.5 Autonomous Learning

Students are encouraged to reflect on the problems existing in theoretical learning and simulation, and innovate design. There are contradictions between the system parameters and structure requirements of the various dynamic performance indicators, which causes difficulties in design and debugging or simulation.

For example, the steady-state error of gear speed is closely related to the number of integration links, but the number of integration links directly affects the stability of the system; In order to improve the rapidity of the position servo system, the amplification factor of the amplifier needs to be adjusted, but too large amplification factor may cause system oscillation; There is a contradiction between the rapidity of the motor link system and the ability to suppress noise.

In this case, the position servo system has high requirements for speed, which can choose advance correction, lag-advance correction, etc. Students can increase links for

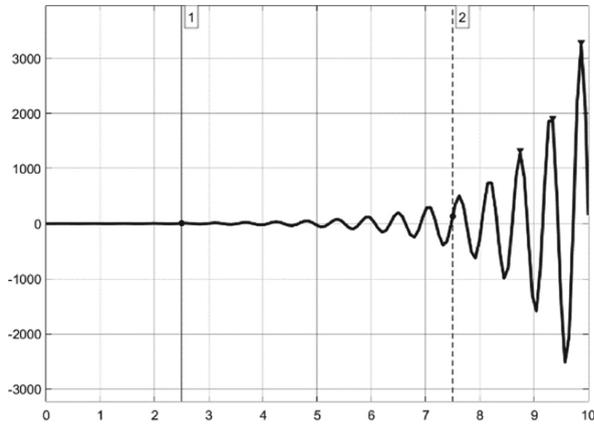


Fig. 6. Simulation diagram 4.

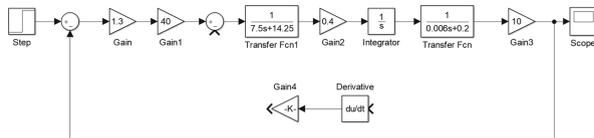


Fig. 7. Experimental failure cases 1.

innovation and improvement. Regardless of the success and failure of innovation, students’ engineering literacy can be exercised through comprehensive design, verification, feedback, innovation and re-verification.

For example, in order to save the cost, the local negative feedback is removed in the design, then the system output is divergent and unstable as shown in Fig. 7 and 8. The rapidity of the system is significantly affected if the proportion link or correction link of the previous channel is removed. as shown in Fig. 9 and 10.

2.6 Integrated with Ideological and Political Elements

To comprehensively promote the ideological and political construction of curriculum is a strategic measure to implement the fundamental task of moral education. It is an indispensable part of teaching mode innovation to integrate the ideological education content into the daily teaching process, explore the feelings, ideas and values contained in the cases, integrate the ideological and political education when preaching knowledge and solving doubts, and give play to the dual functions of teachers in both teaching and educating people.

In this case, the following ideological and political elements can be integrated into the overall analysis of the position servo system: The system is an organic whole, each link in the system is in the mutual influence, interaction and mutual restriction, opposed to the one-sided or isolated view of seeing problems. When the system is stable, fast and accurate analysis, students are taught to realize the point of connection, development and

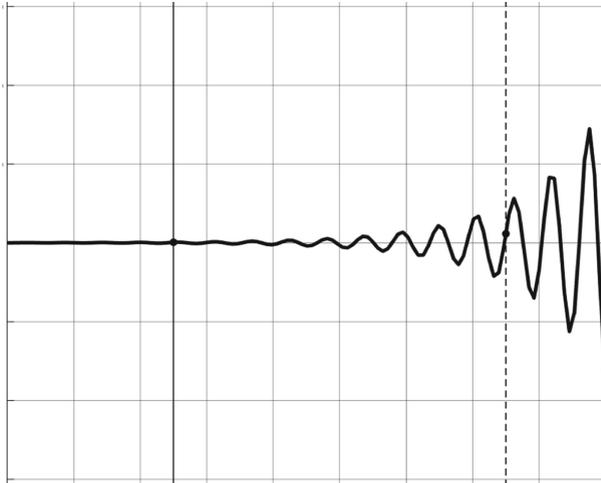


Fig. 8. Experimental failure cases respond 1.

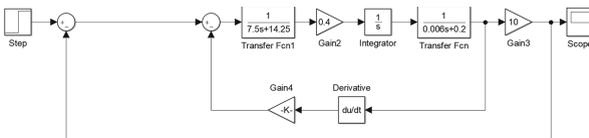


Fig. 9. Experimental failure cases 2.

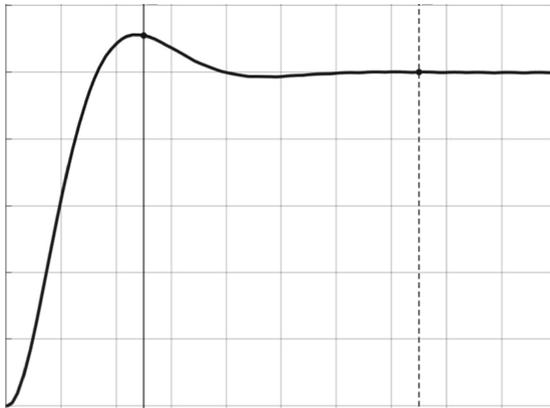


Fig. 10. Experimental failure cases respond 2.

contradictory views of each link of the system. In the simulation innovation link, guide students to combine theory and practice, analyze the problem from the perspective of engineering and “Don’t have thy cloak to make when it begins to rain, provide against possible trouble”. The design of the correction link warns students that “Participation

date erudite gentleman and even their own province”. We should constantly improve and adjust ourselves in order to do better.

3 Conclusions

The progressive teaching method designed in this paper is applied to the recent two sessions of mechanical engineering, manufacturing and automation professional control engineering basic teaching, a total of 4 classes of 213 students. Through the teaching evaluation, student symposium, assessment and other feedback information, students can have a better understanding of this scientific and reasonable progressive teaching method. At the same time, the teaching practice of “Theoretical explanation, Independent design, MATLAB simulation, feedback and innovation, Integration of ideological and political education” has proved that progressive teaching method has achieved certain results: students’ thinking innovation ability and practical ability improved with the optimization of the method; students’ mental outlook and ideological accomplishment has significantly improved; course has greatly improved and score segment distribution to high offset. Students have comprehensively improved their comprehensive quality and the course has achieved the real moral education.

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