Study on Virtual Simulation Experiment of Energy and Power Engineering Control System

Weixing Xu\textsuperscript{1,a}, Mingyue Fan\textsuperscript{2,b} and Dong Liu\textsuperscript{1,c}

\textsuperscript{1}School of Energy and Power Engineering, Jiangsu University, Zhenjiang 212013, China;
\textsuperscript{2}School of Management, Jiangsu University, Zhenjiang 212013, China.

\textsuperscript{a}wilsonxujs@163.com, \textsuperscript{b}fanmy520@163.com, \textsuperscript{c}jiangsu11@126.com

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Abstract. In order to help students understand and master the basic theory of energy and power engineering, some virtual simulation experiments of energy and power engineering control system were developed by using MATLAB/SIMULINK tools. The experiments include the basic experiments and comprehensive experiments of energy and power engineering control, also innovative experiments were added. Students can not only carry out various experiments independently related to the courses using the platform, but also mathematical model of actual energy and power engineering control system can be established and simulated through combing with the knowledge of control theory. The virtual simulation experiments of energy and power engineering control system solve the traditional experiment teaching model restricted by factors such as time, place, in content and form design, and strive to reflect the law of teaching requirement. Through the simulation experiments, the experiment purposes, the experimental principles, the experimental data processes, the experiment summaries and experiment practice, we can fully and systematically train students to comprehensively use the methods of energy and power engineering control system and to solve practical problems.

1. Introduction

In higher education, it is encouraged to cultivate students’ practical ability, and the practice is guaranteed by practice. The experiment is the first step in combining the knowledge of the course with the reality. How to improve the experimental efficiency of university is an important question in the reform of education. Energy and power engineering control on the thermal energy and power engineering major is an important professional basic course, in order to ensure the safety and economic operation of the energy and power engineering equipment (engine, turbine, pump, boiler, air conditioning, etc.), the operator needs to have a solid theoretical foundation and excellent operation skills [1]. However, the traditional control system experiments have four outstanding problems: (1) laboratory funds and facilities are limited, the experimental equipment is few, and cannot be updated in time, which is not conducive to the understanding and mastery of theoretical knowledge; (2) the experimental contents are more monotonous, and the new control algorithms on experimental equipment cannot be developed, and it's expensive to maintain. (3) It is difficult to implement advanced and open laboratory management due to the restriction of time and place. (4) Most of the experiments can only be seen, which is detrimental to the practice of the students. The virtual simulation experiments can solve this problem very well. The experimenters using a computer, through the campus network or the internet to connect to the virtual laboratory, can simulate experiment, watch the simulation process, and get the simulation results, and submit the experiment report, etc. It is beneficial to help the students improve their ability of theoretical knowledge and the ability to analyze and solve problems, to develop their creative ability and comprehensive quality, to solve the problem of control by using the energy and power engineering control theory and method [2, 3]. Using MATLAB/SIMULINK to develop the energy and power control engineering teaching experiments, it is very practical to provide students with an all-weather virtual simulation platform.
2. Virtual Simulation Experiment

The virtual simulation experiments refer to using the multimedia, simulation and virtual reality to make model experiments on computers, and to study an already existing system or a system in design. The virtual simulation experiments are built on a virtual experimental environment, such as based on MATLAB/Simulink software, and it is most important to get the interactivity of experimental operation and the simulation of experimental results. The virtual simulation experiments can be done in all or part of the traditional experiments. The students can complete various experimental projects in the virtual laboratory environment and obtain the experimental results in the real experimental environment. With the development of simulation technology, virtual reality technology and multimedia technology, online virtual teaching has become a supplement to classroom teaching [4, 5]. On the one hand, the virtual simulation experiments changed the stereotypical teaching concept. Students do the experiments not only record a few data, but can DIY (do) that they want to do, in the form of independent choice required, experiment content of interest, stimulate students' interest in learning and innovation ability. On the other hand, students will be able to conduct their own experiments independently of time, location, laboratory equipment, and experimental funds. By using virtual experiment technology, students can master the ability of software to process and analyze experimental data, accumulate knowledge and experience for future work.

3. Characteristics of Virtual Simulation Experiment of Energy and Power Engineering Control System

3.1 Multiple goals and multiple levels

Considering the student to the energy and power engineering control theory knowledge, energy and power engineering platform provided by the virtual simulation experiment should meet the requirements of all levels of students. The life of the experimental platform can be long and attractive, only when the experimental platform meets the needs of different levels of students. For the difference of the understanding and mastery of teaching content, the multi zone of the experiments will help students effectively play their own subjective initiative, and understand the theoretical knowledge with the aid of the experiments [6].

3.2 Flexibility and simpleness

Flexibility, main show is: During the experiment, students can easily change the structure parameters of the system and observe the effect of different structural parameters on system performance. By comparing the experimental results of different structure parameters, the student can get visual perceptual knowledge. Through the phenomenon, they can find the essence of the problem [7]. At the same time, because that the energy and power engineering control system virtual platform is a software package, the students can copy this software package to their own computer, in this way, students can make simulation experiments at any time, to deepen the understanding of the teaching content through the experiment, further stimulates the interest on the energy and power engineering control system.

4. Overall Design of Virtual Simulation Experiment of Energy and Power Engineering Control System

4.1 Contents

The virtual simulation platform of energy and dynamic engineering control system includes three parts: the basic experiment of energy and power engineering control system, the comprehensive experiment of energy and power engineering control system, and the innovative experiment of energy and power engineering control system. The basic experiment contents includes: the characteristics of the typical parts is introduced and identification, and any system of typical analysis of time domain and frequency domain analysis, etc. [8, 9]. The basic synthetic experiment of mechanical engineering control is the application of frequency domain analysis and time domain analysis, and the performance analysis and correction are performed on the existing system. The actual application to
energy and power engineering as an example, the mathematical model is set up by the students, build simulation model, the application of energy and power engineering control theory to analyze the system performance, and puts forward ways to improve and enhance the actual control system performance, innovative experiment is completed. Help students achieve a leap from reality to theory.

Figure 1. Virtual Simulation Experiment of Energy and Power Engineering Control System.

4.2 Design
The virtual simulation experiment platform of energy and dynamic engineering control system uses MATLAB as the development tool. In MATLAB GUI environment creates any UI (User Interface, UI) Interface can be other UI Interface called, the called UI Interface is equivalent to other functions in the programming. The virtual experiment of energy and power engineering control system uses the method of block programming, the control project of the experiment is divided into different modules, made a relatively independent UI interface, performed by a UI call to other modules of the UI.

5. Implementation
When using MATLAB for virtual platform design, the main way that the user interacts with the computer is through the control provided in the MATLAB GUI. The application of PUSH BUTTON, RADIOBUTTON, CHECK BOX, LIST BOX, and other control events and methods to implement the whole virtual platform functionality.

5.1 Basic Experiment
The basic experiment consists of three experimental subsystems, namely, the typical link recognition, time domain analysis, and frequency domain analysis. The typical link consists of the definition of each typical links, the motion equations, the transfer functions and their corresponding instance analysis.

After the mathematical model of the control system is established, the performance of the control system must be analyzed. The time domain analysis is one of the most important methods on the performance of analytical systems in the control engineering. Time domain analysis is an input signal to the control system, by observing the system output signal changing with time curve for the analysis of steady state performance, stability of the system. In the virtual experimental interface for the time domain analysis (Fig.2), the time domain response of any system (including the typical link) can be done. And the analysis of the same system with variable structure parameters is very intuitive.

Frequency domain analysis is a common method for analyzing the performance of the control system and correcting the performance of actual system performance. By input some particular signals, we can detect the specific signal frequency response characteristics of the system, so that the
analysts have deeper understandings of systems and components and do more efficient analysis. This module mainly studies the frequency properties of linear time-invariant systems (Fig.3).

5.2 Comprehensive Experiment

The inherent part of the general control system does not allow the control system to meet the performance requirements of the user, so it is necessary to correct the original system. The comprehensive experiment is a performance analysis of an existing control system, by the method of frequency domain and time domain analysis. At the same time, we will select the appropriate calibration device to meet the control requirements of the system.

5.3 Innovative Experiment

In order to improve the students' ability to analyze and solve problems, to train the students to combine energy and power engineering control theory with the practical problem of engineering, the interface with the aid of MATLAB/SIMULINK tool, provide students with practical engineering problems of modeling and control simulation platform[10]. Students in this interface, can show all of the knowledge about the energy and power engineering control theory, and can further deepen students' understanding of the course and practical application.

6. Conclusion

The virtual simulation experiments of the energy and power engineering control system can solve the problems of the traditional experiment, such as time and place, etc. It is not only the content and form of design, but also strives to reflect the requirement of the law of teaching. Through the simulation experiments, the experiment purposes, the experimental principles, the experimental data processes, the experiment summaries and experiment practice, we can fully and systematically train students to comprehensively use the methods of energy and power engineering control system and to solve practical problems. According to the progress of the course, the students can do the experiments with the simulation at any time. Before the simulation, students could use the virtual platform to preview and reduce the blindness of the simulated experiment. Meanwhile, they can compare the simulation results to the simulation results, and verify the accuracy of the simulation experiment. The comprehensive and innovative experiments are conducive to the cultivation of students' comprehensive ability and innovative ability. The virtual simulation experiments of the energy and power engineering control system by MATLAB, can reduce the cost of such course experimental teaching, also can stimulate students' interest in learning, and have large practical value. Results show that the virtual simulation experiments have some guiding significance for the reform and improvement of the practice teaching system of the existing energy and power engineering control system and the quality of practice teaching.
7. References


