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Optimization of Classroom Teaching of Analysis and Synthesis of Chemical Process

Shi Chen, Wang Yakun, Liu Guanghui, Kang Yuhong

School of Chemistry and Chemical Engineering, Yulin University, Shaanxi, China

Abstract: In order to solve the problem of incomplete alignment between the teaching content and talent training objectives of the course 'Chemical Process Analysis and Synthesis', this paper introduces case-based teaching and integrates practical engineering cases into the course content in order to innovate the teaching mode and improve the quality and depth of teaching. The core of case-based teaching is to allow students to explore and analyze complex chemical process problems in the classroom through real engineering cases. This method makes the teaching content closer to the practical engineering application, and stimulates the students' learning interest and motivation.

Keywords: Professional Certification of Engineering Education; Analysis and Synthesis of Chemical Process; Classroom Teaching; Case Teaching

1. Introduction

Engineering education accreditation refers to the evaluation and accreditation of engineering education courses by professional engineering education accreditation bodies to ensure that these courses meet specific quality standards and teaching requirements [1]. Different countries and regions have their own standards and procedures for engineering education certification, which are usually managed and implemented by national or regional engineering societies or education departments. In the field of chemical engineering, engineering education certification usually focuses on the design of courses, laboratory facilities, teaching quality, faculty, and evaluation of student learning outcomes [2,3]. Certification ensures that graduates graduate with the necessary engineering competencies, expertise and practical skills to meet the challenges and demands of industrial practice. Chemical process analysis and synthesis is a core course in the field of chemical engineering, which aims to develop students' ability to understand and analyze chemical processes, as well as their practical application ability in the design and optimization of chemical processes. Chemical process analysis and synthesis is a necessary knowledge for chemical engineering and technology majors, and is a professional elective course of this major [4,5]. This course draws on the characteristics and contents of the original system engineering and process engineering textbooks, and optimizes the system as a whole on the basis of system analysis and simulation. Therefore, it is also a new course established on the basis of the original system engineering and process engineering.

In order to avoid the excessive teaching content of mathematical methods in the original chemical system engineering, students can be separated from the complicated mathematical derivation and details, and focus on the essential characteristics of the chemical process system [6]. Therefore, this course downplays some mathematical derivations and further emphasizes the global concept of process engineering itself, emphasizing the use of systems engineering knowledge to effectively analyze large chemical systems, and the use of engineering optimization knowledge to conduct global tuning and evaluation of chemical systems as a whole [7,8].

Through the integration of the original curriculum system and teaching content, this course aims to train students' ability to deal with practical problems by comprehensively applying chemical system engineering, chemical process engineering, chemical reaction engineering and transfer and separation engineering knowledge for typical chemical process systems. Through the study of this course, students will dilute the traditional idea of overemphasizing mathematical models, change to the idea of

system engineering, and highlight the typical practical 'case' analysis. To develop students' basic ability to apply the viewpoint and method of systems engineering to study the simulation, analysis, optimization and synthesis of chemical process systems.

2. Conventional Teaching Methods

2.1 Main Content of the Course

'Chemical Process Analysis and Synthesis' is a new core course for Chemical Engineering and Technology major of School of Chemistry and Chemical Engineering of Yulin University since 2020. The program aims to provide chemical engineering and process students with systematic theoretical and practical training so that they can understand and apply the basic principles and techniques of chemical process analysis and synthesis. At present, the course is mainly taught in class, including theory explanation and exercise class. Through teacher explanation and student discussion, students can master the course content. The teaching reference of this course is mainly the relevant textbooks written by Zhang Weidong and others, which are considered to be the authoritative works in the field. In the course, students will learn methods of chemical process analysis, including the application of material balance and energy balance, and how to design and optimize chemical processes. In addition, the course covers the basic principles of chemical reaction engineering, as well as how to choose the right reactor and separation equipment in real industry. Through the study of 'Chemical Process Analysis and Synthesis', students will not only master theoretical knowledge, but also cultivate the ability to solve complex engineering problems through case analysis and practical operation, and lay a solid foundation for the future practice of chemical engineering.

2.2 Conventional Teaching Methods and Their Problems

The current curriculum teaching method is more traditional, mainly relying on teachers to teach according to the content of the textbook. While this mode of teaching helps to ensure the orderly and systematic transfer of knowledge, there are several significant problems. First of all, classroom teaching entirely narrated by teachers may lead to a lack of motivation and interest in active learning. Especially in the complex chemical process system optimization content, such as simply introducing linear programming and nonlinear programming solutions, may make the class seem boring, difficult to attract students' attention and active participation. Secondly, over-reliance on textbook content, and lack of extracurricular learning and practical exploration guidance, may make students lose the in-depth understanding of the course content and the cultivation of application ability. While textbook knowledge is important, relying on textbook teaching alone may not inspire students' interest and enthusiasm for engineering practice, which is essential for their future success in the workplace. To sum up, it is necessary to re-evaluate and adjust the teaching methods of the curriculum, and introduce more interactive and practical teaching activities and projects to cultivate students' problem-solving ability and innovative thinking. In this way, students can better meet their learning needs, enhance their professional ability and practical application ability, and lay a solid foundation for future career development.

3. Exploration of New Teaching Methods

In order to effectively shorten the gap between classroom teaching and practical engineering production, and to promote the cultivation of students' engineering practice ability in the course of 'Chemical Process Analysis and synthesis', concrete engineering cases are introduced. These cases not only help students understand the theoretical knowledge in the course, but also develop their ability to solve practical engineering problems. Two main methods of process system steady-state simulation, sequential module method and equation-oriented approach, were introduced, and the fermentation liquid separation case was selected as the specific application. The background to this selection is that fermentation solution treatment is a common and critical process in the chemical industry, involving multiple separation techniques and operating units. First, start with the operation of a single evaporation unit, which is a common thermal separation operation in fermentation fluid treatment. In this step, students learn how to apply basic evaporation principles and equipment selection in a system.

Next, the concept and realization method of multi-stage flash process are introduced. Multistage flash evaporation is a common technique to improve the separation efficiency. The separation of components is achieved by step vacuum evaporation. In this stage, students learn how to design and optimize a multistage distillation system, taking into account various operating conditions and equipment selection. Finally, the focus is turned to the overall design and optimization of process units. This includes the integrated application of previously learned steady-state simulation methods, taking into account economic, energy efficiency, and operational feasibility factors in the actual project for comprehensive evaluation and optimization. Through this teaching method, students not only learn theoretical knowledge, but also practice the ability to analyze, solve problems and make engineering decisions in real cases. This in-depth teaching method helps students to better understand the course content, but also provides them with practical experience and solution ideas when they face complex chemical engineering problems in the future. For example, when teaching heat transfer network synthesis, a practical case of old plant renovation project is used as an example to teach. First, students are guided to learn how to extract the necessary data and logistics information from this real case. This information includes fluid properties, flow, temperature, etc., which are the basic data necessary for the design of heat transfer networks. Next, students learn how to apply the pinch method to design the most energy-efficient heat exchange network. The pinch method is a commonly used method to maximize the overall energy efficiency by determining the heat load and selecting the appropriate heat exchanger. In this process, students need to consider changes in heat loads and the needs of different processes. Then, the application of cancellation inference method is introduced. This method helps students deduce the heat load at each pinch point, allowing for more accurate selection and placement of heat exchangers. Then, the energy relaxation method is introduced to optimize the structure of the heat transfer network. This approach improves overall energy efficiency by adjusting the position of the heat exchanger, the process path, etc., and ensures that the system meets the heat load demand while reducing energy consumption as much as possible. Finally, a technical and economic analysis is carried out to enable students to consider cost and benefit factors in a comprehensive manner. This step involves not only the evaluation of technical solutions, but also the analysis of return on capital investment, operating costs, and long-term maintenance costs to help students understand how to make economically viable decisions in actual engineering projects. Through this detailed teaching method, students can learn and understand the basic knowledge of problem table method, pinch method and heat exchange network tuning from real cases. This practice-oriented approach not only reinforces their theoretical learning, but also provides practical solutions and experiences for similar engineering challenges in the future.

4. Conclusions

The teaching concept of this course is student-centered and case teaching method is adopted. This method is designed to guide students and teachers to discuss and interact together through specific engineering cases, so as to delve into practical engineering problems. Through this teaching method, we hope to stimulate students' enthusiasm for learning, and cultivate their basic ability to study the simulation, analysis, optimization and synthesis of chemical process systems using the viewpoint and method of systems engineering. In particular, real-life chemical engineering problems are selected and analyzed, such as the recycling of methane in coal mines or the optimization of separation technologies. Through these cases, students will learn how to apply the theoretical knowledge learned in the classroom to solve practical engineering challenges. In the process of discussion, students can not only deepen their understanding of theoretical knowledge, but also develop their ability to analyze and solve problems, as well as teamwork and communication skills. Through this teaching method, the aim is to equip students with a comprehensive understanding of the complexity of chemical process systems and with the ability to apply academic theory to practical engineering practice. This practice-oriented approach not only contributes to students' academic growth, but also lays a solid

foundation for their future career development.

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