Research on Teaching Reform of Smoke Control and Exhaust Course under the Background of New Engineering

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Abstract. A large number of fire cases have proven that smoke is the main cause of casualties in fires, with over 80% of victims dying directly or indirectly due to smoke. Scientific and rational design of smoke control systems is crucial for slowing down the spread of fires and ensuring safe evacuation time. At present, the process of smoke exhaust in fire scenes is still the main way of fire rescue utilization, and industries related to smoke exhaust are also one of the main employment areas for undergraduate students majoring in fire engineering. However, traditional smoke exhaust engineering courses have outdated teaching content, teaching methods, and assessment methods, which cannot meet the demand for cultivating technical talents in energy engineering majors under the background of new engineering construction. This study first starts from the characteristics of smoke control engineering courses and the problems existing in teaching. Using advanced online teaching platforms, advanced teaching aids, mature commercial software, and computer programming language design environments, the teaching content of smoke control engineering courses is upgraded and transformed towards modular computing, intelligent design, and other directions. In the context of new engineering disciplines, students' learning interests are enhanced, and their practical, innovative, and comprehensive computing abilities are exercised.

Keywords: Smoke; Smoke control and exhaust engineering; New Engineering; reform in education.

1. Intriduction

A large number of fire cases have proven that smoke is the main cause of casualties in fires, with over 80% of victims dying directly or indirectly due to smoke. Scientific and rational design of smoke control systems is crucial for slowing down the spread of fires and ensuring safe evacuation time. Therefore, mastering the basic theory of smoke control and exhaust, familiarizing oneself with the main phenomena of smoke control processes, and possessing the ability to calculate and analyze smoke control and exhaust systems are still important aspects of the training process for students majoring in fire engineering.

Since 2017, the Ministry of Education has actively proposed the construction of new engineering disciplines. Under the background of new engineering disciplines, research on teaching reform of smoke prevention and exhaust courses focuses on promoting the transformation and upgrading of existing engineering majors, aiming to respond to changes, shape the future, and cultivate diversified and innovative outstanding engineering tasks for the future. For the transformation and upgrading of traditional majors such as fire engineering, this concept requires students to return to a track centered on practice, design, and integration, integrate cutting-edge technology into traditional engineering, and cultivate fire safety engineers with good comprehensive calculation and analysis abilities. As a fundamental course with strong theoretical and practical significance, the teaching content and effectiveness of smoke control and exhaust are crucial for building students' engineering awareness and system calculation and analysis abilities, and also have an impact on the reform of the professional training system. Therefore, this study will first discuss the teaching content of the smoke control course, summarize the basic problems encountered in the teaching process, and then propose corresponding course reform plans from three aspects: theoretical teaching methods, comprehensive calculation training modules, and multi-level target assessment methods, providing reference for the reform of other courses in the fire engineering major.

2. Characteristics of Smoke Prevention and Exhaust Courses

Through research, it was found that smoke control and exhaust courses, as a fundamental course for undergraduate majors in fire engineering, require both prerequisite courses such as fluid mechanics and heat transfer, as well as prerequisite courses such as fire smoke exhaust technology. They are mostly set in the 5th or 6th semester, with a teaching time of about 32 hours. Taking the university where the author is located as an example, in the 2022 version of the training plan, this course is set in the 5th semester, with a total of 32 class hours. The key requirement is for students to master the basic theories of fire smoke generation and hazards, fire smoke flow and control, and calculation of smoke control system pipelines. They should be able to design smoke control systems for buildings, highway tunnels, and subways, and provide a systematic overview of smoke control equipment and its linkage control, as well as subsequent construction, commissioning, acceptance, and maintenance. In summary, based on the course content and teaching requirements, the smoke control course has the following characteristics.

2.1. The course content is highly comprehensive

Smoke control and exhaust is a discipline that mainly studies the design of smoke control and exhaust systems in buildings to achieve safe evacuation of building personnel, with strong comprehensiveness. Taking the smoke spread pattern after a fire in an atrium building as an example, the atrium is surrounded by building structures, which limits air circulation to a certain extent. Smoke may accumulate in the atrium. If the atrium building is a multi-story structure, the smoke may also be affected by the height difference between each floor in the short term, causing smoke to rise or fall. To establish a smoke propagation model for atrium building fires, it is necessary to simultaneously establish momentum conservation models, energy conservation models, mass conservation models, and chemical reaction kinetics models for smoke, and perform coupled solutions. This requires high proficiency in students' professional knowledge and comprehensive computational practical application abilities.

2.2. The knowledge reserve of the course subjects is not strong

The enrollment of fire engineering majors is divided into two channels: young students and team students. Young students are admitted in advance through the college entrance examination, while team students are admitted through the fire rescue team examination. The ratio of young students to team students is about 1:1.5, and the overall quality of students is relatively high. They have completed courses such as chemistry, physics, and fluid mechanics in the early stage and have a basic knowledge reserve.

Smoke Control Engineering "is a course that teaches how to achieve safe evacuation of building personnel through the design of smoke control systems inside buildings. The main content includes chapters on the flow of fire smoke, specifications for smoke control systems, operation and control of smoke control systems, and smoke control technologies for special buildings. It covers multi scenario knowledge such as high-rise building smoke control technology, atrium building smoke control technology, tunnel smoke control technology, and subway smoke control technology. Smoke control and exhaust engineering is a course in the spring semester of the third year of college, which presents a dilemma of limited class hours, extensive content, strong theoretical foundation, and difficult practical application. Due to the difficulty in establishing and reproducing building fire scenarios, students generally report a lack of accessibility and low acceptance of knowledge about the spread of smoke inside buildings during teaching, and are unable to provide positive feedback to practical applications after learning. Considering that most students graduate from firefighting and rescue work, a lack of deep understanding of knowledge can easily lead to confusion in actual fire disposal, resulting in more casualties. Therefore, it is urgent to increase the accessibility and understanding of knowledge points in smoke control and exhaust engineering.

3. Problems in the Teaching Process of Smoke Prevention and Exhaust Courses

3.1. Weak basic theory

The generation and harm of fire smoke, the flow and control of fire smoke, the specification of smoke prevention systems, the specification of smoke exhaust systems, the operation and control of smoke prevention and exhaust systems, the debugging, acceptance and maintenance management of smoke prevention and exhaust systems, and the smoke prevention and exhaust technology of typical buildings are difficult to quantitatively present through existing teaching methods. For example, the basic laws of smoke flow, pressurized air supply and exhaust volume, and smoke control design for high-rise buildings, tunnels, and underground structures. Therefore, in the actual teaching process, students may have a vague understanding of basic smoke exhaust phenomena and processes, resulting in insufficient analysis of subsequent smoke exhaust mechanisms and mastery of basic smoke exhaust theories.

3.2. The comprehensive calculation ability of smoke control and exhaust process is weak

In actual smoke control and exhaust engineering, it includes not only the mass flow of fire heat release rate, axisymmetric smoke plume, balcony overflow plume, and window plume, but also the calculation methods of average temperature of smoke layer and smoke exhaust volume. To solve the problem of smoke control and exhaust engineering, it is necessary to comprehensively consider the theories in different courses, and the calculation and analysis amount is large. In traditional classroom lectures, assignments, or exams, only a specific situation can be analyzed, making it difficult to conduct comprehensive analysis from a complete unit or system perspective. This limits students' practical and innovative application of basic theories of smoke control, especially the ability to comprehensively analyze and calculate smoke control processes from a system perspective.

3.3. The difficulty of supporting some course objectives is relatively high

According to the needs of our school's professional training plan, the smoke prevention and exhaust course has four course objectives: ① Understanding the generation, hazards, and characteristics of fire smoke; Master the basic laws of smoke flow, the control mechanism of fire smoke, the structure and composition of smoke prevention and exhaust systems, and the smoke control technology of typical buildings. (M1)；② Master the Technical Standards for Building Smoke Control and Exhaust Systems, understand the requirements for setting up smoke control and exhaust systems, and calculate the pressurized air supply and exhaust volume (M2); ③ Master the operation and control methods of smoke control systems, as well as the debugging, acceptance, and maintenance management methods of smoke control systems (M3); ④ Understand and master the basic theories of mathematics and other natural sciences, and apply them to the analysis of smoke control engineering problems; Ability to apply knowledge and mathematical modeling methods related to fire engineering to deduce, analyze, and solve problems in smoke control and exhaust engineering (M4); ⑤ Be able to select appropriate theoretical and technical means based on specific smoke control engineering problems and determine design and implementation plans; Ability to inspect, debug, and maintain smoke control and exhaust systems (M5); ⑥. The course objectives M2, M3, and M4 are difficult to achieve and assess solely through traditional methods such as assignments, exams, and classroom lectures. They require the support of new teaching resources and practical teaching content to gradually form a comprehensive and reasonable course assessment system.

4. Exploration of Teaching Reform Plan for Smoke Control Course

The new engineering concept advocates integrating cutting-edge technology into traditional engineering disciplines such as dynamic engineering, and cultivating new energy engineers with good

comprehensive computing and analytical abilities. Therefore, this section proposes a reform plan for the teaching status of smoke prevention and exhaust courses.

Firstly, relying on online teaching resources and advanced teaching aids to achieve blended online and offline teaching, further consolidating the theoretical foundation of smoke prevention and exhaust; Secondly, relying on computer language platforms, multi-level modular training for comprehensive calculation of smoke prevention and exhaust is carried out to strengthen students' practical application and comprehensive calculation abilities in smoke prevention and exhaust courses; Finally, the reform content of this course will be combined with traditional assessment methods, gradually constructing a "three in one" assessment system with theoretical foundation as the main focus, practical application and comprehensive computing ability as auxiliary.

4.1. Relying on online teaching resources and advanced teaching aids to achieve online learning

Offline blended learning divides the smoke prevention and exhaust course content into: in the initial stage, a blended online and offline teaching mode is adopted, and micro course resources are used in the front of the class to enable students to master the basic concepts of knowledge units; Offline teaching sessions, combined with the list of questions submitted by students, focus on explaining difficult problems and emphasizing the flexible application of knowledge units. Mid-level students are organized to conduct practical teaching in the smoke control training room, enabling them to possess the ability to operate, control, debug, inspect, and maintain smoke control systems. Through the introduction of smoke control design principles and case studies for high-rise buildings, tunnels, and underground structures, we guide students to track the latest smoke control technologies and methods, and carry out teaching reforms in three aspects.

Firstly, with the help of online and offline courses, we will teach about the flow of fire smoke, the standardization of smoke control systems, the operation and control of smoke control systems, and special building smoke control technologies. Effectively controlling the flow of fire smoke inside buildings, reducing smoke hazards, and clarifying the flow patterns and control measures of fire smoke inside buildings are crucial for personnel evacuation and firefighting.

Secondly, using mature commercial software such as Fluent, students can construct different building models according to their own pace and interests, such as tunnels, high-rise buildings, subways, etc., based on the diverse characteristics of fire and smoke spread in different buildings. They can actively discover and solve problems, effectively improve students' learning enthusiasm, and cultivate their scientific thinking and independent thinking ability. Meanwhile, exposure to virtual simulation can help students familiarize themselves with software operation processes in advance, improve their professional skills, and lay a solid foundation for them to complete their undergraduate graduation projects.

Finally, with the help of MOOC teaching videos, virtual simulation platforms such as classrooms, etc., practical training is conducted on the overall smoke control system process, special site structures, and control concepts. For example, conducting smoke control design principles and case studies for high-rise, tunnel, and underground buildings, guiding students to track the latest smoke control technologies and methods, can promote students to form the concept of designing and calculating smoke control processes from a systematic perspective.

4.2. Multi level comprehensive calculation training for smoke control and exhaust based on computer language platform

Based on the smoke prevention and exhaust curriculum system, a series of comprehensive calculation training questions with moderate difficulty have been condensed, which can not only integrate theoretical knowledge learned but also directly solve smoke prevention and exhaust engineering problems. It mainly includes four levels: the first level is the calculation of pressure difference in smoke exhaust engineering, which mainly includes using advanced calculation methods and computer languages to calculate the minimum and maximum pressure difference in the smoke

exhaust process, and based on this, designing and training a simple smoke exhaust system; The second level is to calculate the pressurized air supply volume for stairwells, lobbies, refuge floors, refuge corridors, and their lobbies, and analyze the control factors for smoke exhaust areas; The third level is the calculation method for the heat release rate of a fire, the mass flow of axisymmetric smoke plumes, balcony overflow plumes, and window plumes, the average temperature of the smoke layer, and the smoke exhaust volume. It is solved using Fluent commercial software or self-programming methods to achieve a deep understanding of specific fire smoke exhaust systems. By establishing corresponding comprehensive calculation and training modules for smoke prevention and exhaust at the above levels, students can be grouped during the implementation process, and each group can choose 1-2 practical questions for training. This can not only effectively help students master abstract knowledge of smoke prevention and exhaust mechanisms, but also exercise their ability to use basic knowledge of smoke prevention and exhaust to solve practical problems in the combustion process, and overall enhance their practical application and comprehensive calculation and analysis abilities for smoke prevention and exhaust system settings.

4.3. Reform of assessment and evaluation methods for diversified smoke control courses

At present, the assessment mechanism for smoke control courses has problems such as a high proportion of final grades and a lack of assessment basis for regular grades, making it difficult to objectively evaluate students' active learning ability, teamwork problem-solving ability, creativity, and practical application ability. On the basis of retaining the original assessment methods such as final exams, assignments, experiments, and regular tests, adding new teaching aids for demonstration and analysis discussions can effectively mobilize students' classroom participation and more deeply assess their mastery of smoke control theory foundation; At the same time, by introducing a comprehensive computing training module and assessing the innovation of research reports, student reporting expression, and cooperation among students within the group, the assessment of students' practical innovation application ability and comprehensive computing ability can be further improved. Specifically, the course assessment module can be divided into five parts: classroom performance, mainly evaluated through attendance, classroom discussions, and classroom exercises; Experiment, evaluating the accuracy of students' characterization and interpretation of physical phenomena during smoke exhaust process; Evaluate the accuracy of homework completion and mastery of basic principles of smoke exhaust through regular homework; The comprehensive calculation training module evaluates scores based on research reports, group peer evaluation scores, and report scores; The final exam evaluates the completion and accuracy of knowledge points for each course objective. Through this evaluation system, a "three in one" assessment and evaluation system for smoke prevention and exhaust courses can be gradually realized, with theoretical foundations as the main focus, practical innovation and application, and comprehensive computing abilities as auxiliary.

5. Conclusion

Through the reform and practice of smoke prevention and exhaust courses, the teaching content of smoke prevention and exhaust courses can be improved, and the relevance of various knowledge points can be increased; Enriching teaching methods through online and offline modes and introducing advanced teaching aids, enhancing students' interest and focus, and achieving the goal of strengthening the foundation; Through multi-level comprehensive training modules, students' ability to use modern computing tools is enhanced, and their ability to analyze and solve smoke control engineering problems from a systematic perspective is strengthened; Through diverse assessment methods, we aim to strengthen students' subjectivity and enhance their abilities in self-directed learning, innovation, and teamwork. In future teaching, the author will continue to enrich teaching content, explore new teaching methods, and improve diversified assessment systems under the concept of new engineering, focusing on cultivating high-quality and advanced computing ability fire engineering college students.

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