



The Reform of Elastic-plastic Mechanics Teaching for Petroleum Engineering Related Majors

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ABSTRACT

“Elastic-plastic Mechanics” is an important course for undergraduates and postgraduates of general engineering majors. However, the theoretical derivation of equations is complex, and the connection with engineering practice is inadequate. Therefore, teaching becomes difficult and boring for a number of students. Firstly, this paper introduces the importance of Elastic-plastic Mechanics for petroleum engineering related majors. Based on the recent teaching experience, the teaching reform of Elastic-plastic Mechanics course is carried out focusing on teaching method and learning content, and a discussion teaching mode based on students’ independent discussion and engineering cases is formed. Remarkable results have been achieved in improving students’ learning efficiency and classroom teaching effect. Furthermore, students’ comprehensive ability of independent innovation and practice is enhanced.

1. Introduction

Elastic-plastic Mechanics, as an important compulsory course for petroleum engineering related majors, mainly refers to the stress, strain, displacement and distribution law of deformable solid under the influence of external load or environmental temperature change^[1]. For petroleum engineering related majors, the basic theoretical knowledge of Elastic-plastic Mechanics plays an important role in oil and gas exploitation, transportation and storage. Learning the course of Elastic-plastic Mechanics well can not only provide theoretical support for students’ during undergraduate and postgraduate study, but also provide engineering theoretical guidance for future engineer career. However, the traditional course

teaching for Elastic-plastic Mechanics is boring due to lots of equations derivation.

In the past course teaching, Elastic-plastic Mechanics is usually divided into three independent teaching parts: elastic mechanics, plastic mechanics and fracture mechanics^[2]. The teaching content involves a wide range of knowledge, strong theory, complex formula, which is difficult to understand. And students are likely to lack interest and motivation. Moreover, due to the limitation of the course hours, students can only passively accept the theoretical knowledge that is difficult to understand, and gradually formed a bad atmosphere of learning in order to cope with the examination, which seriously deviated from the original intention of teaching the course of Elastic-plastic Mechanics, resulting in a serious decline in the

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quality of teaching. Therefore, it becomes imperative to improve students' learning interest and motivation, modify the learning atmosphere, and improve the teaching quality for the Elastic-plastic Mechanics Teaching Team.

In order to change the learning style of students, improve their learning initiative and the effect of classroom teaching, our teaching team carries out the research and practice of teaching strategies through independent discussion in class. It advocates relying on engineering cases, guiding students to adopt the learning method of independent discussion and cooperation, so as to let students think about the significance of engineering cases and understand the complexity of Elastic-plastic Mechanics more deeply. It can promote students' all-round development, consolidate students' mastery of classroom knowledge and improve students' ability to solve practical engineering problems.

2. Importance of Elastic-plastic Mechanics

Elastic-plastic Mechanics is of great significance in petroleum engineering related majors. In the process of oil and gas exploitation, gathering and transportation, as well as storage and transportation, the safety and stability of the process and transportation equipment involved are very important under the load, while the Elastic-plastic Mechanics is mainly a course focusing the mechanical response of the elastic and plastic deformation of solids during the loading process^[3]. Therefore, petroleum majors can use the theoretical knowledge of Elastic-plastic Mechanics to design and check the safety of petroleum process and transportation equipment.

Taking Oil and Gas Storage and Transportation Engineering as an example, the Elastic-plastic Mechanics knowledge should be used to solve the problem, such as the design and stability check of the wall thickness of pipeline and storage tank, prediction of residual strength and failure stress of corroded onshore and subsea pipeline, safety assessment of pipeline damage caused by strong external force in geological disaster area, fatigue damage and stress buckling analysis of submarine pipeline and its riser in complex marine environment. Therefore, Elastic-plastic Mechanics is an important basic theoretical discipline in petroleum engineering related majors. Only by learning this course well can we better learn other professional courses and solve practical engineering problems more effectively.

3. Experience of Teaching Reform and Practice

Combining with the teaching experience of Elastic-plastic

Mechanics in the past five years, the Elastic-plastic Mechanics Teaching Team of China University of Petroleum (Beijing) changed the teaching methods and teaching contents of the course by carrying out the discussion teaching mainly based on students' independent discussion and the practical teaching reform combined with engineering cases, so as to let the students actively participate in the classroom learning.

3.1 Seminar Teaching Centered on Students' Independent Discussion

The traditional teaching method is mainly focused on the teachers' lecture in class. Due to the abstract and theoretical nature of Elastic-plastic Mechanics, it is difficult to attract students' attention. Students are prone to be lacking motivation with high pressure and low learning efficiency, which has a negative effect on teaching. Seminar teaching emphasizes the leading role of students in classroom teaching, which makes students change from forced receivers to active participants. It advocates cultivating students' self-learning ability, innovation ability and application ability, and improves students' summary and expression ability, which is an inevitable trend of modern university education^[4-6].

The Elastic-plastic Mechanics Teaching Team of China University of Petroleum (Beijing) has reformed the teaching method based on the teaching experience in recent years. The traditional teaching method based on teachers' lectures has been changed to the discussion teaching centered on students' independent discussion. The knowledge points of the main chapters of Elastic-plastic Mechanics are refined, and the complex knowledge system is disassembled and refined to form a series of refined research specialties. Combined with the knowledge of material mechanics and engineering mechanics that students have learned, through teachers' guidance and students' independent thinking, the course learning is completed by putting forward questions, group discussion, comparative hypothesis demonstration, large group report and so on, so as to increase students' sense of participation and experience in class, and mobilize students' enthusiasm for thinking and research. At the same time, teachers go deep into the students' discussion group, actively participate in it, give corresponding guidance, encourage students to start from different angles, bold hypothesis demonstration, dare to question, profound analysis, and strive to fully grasp the theoretical knowledge points in the topic. In the large group report, students go to the podium and randomly select the keynote speaker of the group discussion topic to explain the research results of the topic. In this way, the knowledge structure is integrated and built

up again, so as to complete the whole teaching of Elastic-plastic Mechanics.

In order to encourage students to actively participate in the discussion, the Teaching Team has revised the course assessment method, gradually weakening the proportion of final examination in the course assessment, enhancing the proportion of classroom independent discussion in the assessment, and establishing a reasonable and diversified curriculum assessment system^[7], so as to assess the learning effect of students more comprehensively. Practice has proved that the seminar teaching centered on students' independent discussion can bring students into the classroom atmosphere, cultivate their innovative consciousness and cooperative consciousness. Students have the courage to think, dare to ask questions, excavate and master knowledge independently in the discussion, so as to understand the complex and abstract theoretical content more easily and improve the learning efficiency and teaching effect.

3.2 Seminar Teaching Based on Engineering Examples

In the past, the traditional teaching is lack of connection with the actual engineering cases, which leads to the theoretical knowledge of students cannot be applied to the actual work well, resulting in serious disconnection between teaching and practice. The Elastic-plastic Mechanics that students learn in class is a general theoretical knowledge structure, which cannot be directly applied in practical engineering. Boring and seemingly meaningless learning makes students uninterested and lack learning motivation. In the process of teaching reform and practice, the Elastic-plastic Mechanics Teaching Team of China University of Petroleum (Beijing) has refined a series of projects close to the course content by combining with the national major research projects, the relevant research topics and investigation reports of petroleum enterprises such as Petro-China, Sinopec, CNOOC, etc., as well as the investigation report of students' internship, and the current research topics of students example. According to the contents of different chapters of Elastic-plastic Mechanics, engineering cases are integrated into teaching to guide students to learn theoretical knowledge from practical cases.

3.2.1 Teaching Involving Oil and Gas Pipeline Wall Thickness Design Engineering Case

Plane stress problem and plane strain problem are two very important parts of Elastic-plastic Mechanics^[8]. The analysis of thick-walled cylinder is one of the most important parts in the design of oil and gas pipeline wall

thickness. Only from the theoretical analysis of thick-walled tube, students usually have no practical concept about the elastic-plastic problem of thick-walled cylinder. And it is difficult to understand just only relying on abstract theory. Through the teaching reform, the design and calculation method of oil and gas pipeline wall thickness is introduced into the course explanation of Elastic-plastic Mechanics. The design and failure process of pipeline are combined with the course content, so as to enhance the intuitiveness and practicability of the course content. In order to find more practical engineering cases, relevant technical personnel of CNPC Pipeline Design Institute, Sinopec engineering design and offshore oil engineering design are invited to conduct course discussion and exchange in the course, so as to supplement the practical problems encountered in the engineering into the classroom teaching and guide the students to discuss independently. At the same time, a series of specifications involved in the design of pipe wall thickness are also introduced into the course teaching, so that the classroom teaching can be closer to the actual engineering and students have more specific and more intuitive feelings in the learning process. When students go to work in the future, they can use the in engineering practice.

3.2.2 Teaching Involving Local Buckling Engineering Case for Submarine Pipeline

Submarine pipeline is the lifeline of offshore oil and gas field development. Reasonable design, construction and management of submarine pipeline are very important to ensure its safe operation^[9]. Due to the complex marine environment, the local buckling failure of submarine pipeline under the combined action of internal pressure, external pressure, axial force and bending moment should be considered in the design of submarine pipeline, which requires careful check of local buckling pipeline. In the teaching process of Elastic-plastic Mechanics, the elastic yield criterion and the plastic yield criterion^[10] are combined to check the local buckling of the pipeline, which can well integrate the abstract Elastic-plastic Mechanics calculation method into the specific image of the engineering case. For students, it is convenient for them to grasp the key points of knowledge, compare theoretical calculation with engineering case data, verify the differences and connections between them, so as to enhance students' interest in learning, make students have a better grasp of theoretical knowledge, and broaden their knowledge. For teachers, it greatly reduces the difficulty of teaching, changes the previous dull theoretical classroom situation, and can better grasp the progress and effect of students' learning.

3.2.3 Teaching Involving Pipeline Safety Assessment in Geological Hazard Area

Fracture mechanics in Elastic-plastic Mechanics is a more complex learning content^[11]. In the teaching process, it is not easy to be accepted by students because of the complex concept and abstract content. Fracture mechanics mainly refers to the crack expansion law of engineering material structure^[12]. When the oil and gas pipeline is in the natural disaster area such as debris flow, landslide, fault, earthquake and so on^[13], the strong natural external force is easy to cause the pipeline crack damage, and the pipeline near the crack will have a large range of buckling. Therefore, it is necessary to analyze the impact of crack induced buckling on the safety of the pipeline and judge whether the pipeline is feasible to continue running. In the teaching mode reform, we focus on refining the engineering cases of pipeline buckling caused by geological disasters in recent years, and integrate the characteristic and targeted cases into the elastic-plastic fracture mechanics. Based on the analysis method and numerical simulation of the pipeline failure buckling in the geological disaster area, this paper explains the fracture mechanics involved in the elastic-plastic state. It can make students more clearly understand the knowledge structure of fracture mechanics, gradually master the calculation method of fracture mechanics, and be familiar with the way of solving practical problems by fracture mechanics from engineering cases, and indirectly let students gradually learn to combine analytical method and numerical simulation method to solve practical engineering problems.

3.2.4 Teaching Involving Tank Wall Thickness Design Engineering Case

The strength and design of storage tank is a compulsory course for Oil and Gas Storage and Transportation Engineering. With the rapid development of the petroleum and petrochemical industry, the construction of storage tank gradually tend to the direction of large-scale construction, which not only meets the demand of oil and gas reserves, but also meets the requirements of storing different kinds of liquid raw materials^[14]. At the same time, considering the influence of wind force and tank settlement on the structural stability of the tank, the influence of wind force and tank settlement on the structural stability of the tank is also discussed. Reasonable and scientific design of tank wall thickness is particularly important. In the classroom teaching of Elastic-plastic Mechanics, the design and check engineering cases of tank wall thickness are integrated into it. Students majoring in petroleum industry have learned the basic knowledge of tank strength and

design and have a certain theoretical basis for the design of wall thickness. After adding it into the knowledge framework of Elastic-plastic Mechanics, the structural stability of tanks with large deformation is analyzed by using Elastic-plastic Mechanics. Checking can not only broaden students' knowledge of tank strength and design, but also make it easier for students to use Elastic-plastic Mechanics to solve the stability problem of large deformation tank. The practice in recent years shows that this teaching method can significantly improve the teaching effect.

3.2.5 Experience of Teaching Reform

Based on the engineering cases, the theory teaching is changed into practice teaching, which makes the Elastic-plastic Mechanics more intuitive and easier for students to understand the theoretical knowledge embodied in the course. In the actual classroom teaching, students of the same major are encouraged to discuss a professional case together. Based on the professional knowledge, the paper discusses how to solve the problems existing in the engineering case by combining the knowledge of Elastic-plastic Mechanics and summarizes the knowledge points of Elastic-plastic Mechanics reflected in the engineering case, and puts forward their own views and opinions. When they encounter the professional knowledge that they don't understand, they can consult the relevant information in time, which indirectly broadens the scope of students' professional knowledge. The teaching practice in recent years has proved that the seminar teaching based on engineering examples can not only effectively mobilize the enthusiasm of students in learning and research, but also cultivate students' independent innovation ability and comprehensive ability to solve practical engineering problems. It can maximize the teaching goal of Elastic-plastic Mechanics and achieve the expected teaching effect.

4. Conclusion

Recently, the Elastic-plastic Mechanics Teaching Team of China University of Petroleum (Beijing) has transformed the traditional teaching mode into discussion teaching mode based on students' independent discussion and practical teaching mode based on engineering cases through the reform and exploration of curriculum mode. It focuses on the cultivation of students' innovative thinking and practical ability, which greatly improves the students' interest in learning. The engine of self-confidence and exploration reduces the pressure of teachers in class. The open seminar teaching practice has completed the transformation from the indoctrination teaching method to the open and independent discussion teaching meth-

od. Furthermore, the transformation from the theoretical teaching to the practical teaching makes the classroom teaching effect of Elastic-plastic Mechanics significantly improved. Students can not only grasp the basic theoretical knowledge intuitively and quickly, but also exercise and improve their practical ability in the face of practical engineering problems, which lay a solid foundation for future work as an engineer.

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