

# Discussion on Case Teaching Method of Mechanical Majors in Petroleum Colleges Under New Situation

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**Abstract:** At present, new knowledge in the field of mechanical engineering and petroleum equipment is emerging, which puts forward requirements for increasing teaching knowledge points. Engineering education professional certification also requires controlling the theoretical class hours on the premise of student-centered. In order to explore the teaching strategies of mechanical specialty in petroleum industry colleges and universities under this new situation, the new knowledge in the field of mechanical engineering and the frontier development trend in the field of petroleum machinery and equipment are combed, as well as the requirements of the current machinery industry for personnel training are analyzed. The case teaching method of integrating new mechanical engineering knowledge into petroleum machinery professional courses is proposed, which can teach students more knowledge points without increasing the class hours, and train students' ability to apply multi-disciplinary knowledge to solve complex engineering problems according to professional certification requirements comprehensively. Combined with two courses of the oil and gas field downhole equipment and oil and gas field hydraulic machinery, the teaching case of pipe string with special thread and plunger pump is designed by using the method in this paper, and the practice in the teaching has received a good effect. The study recognizes that the integration of mechanical engineering new knowledge into the course of petroleum machinery specialty and the use of case teaching method can effectively solve the contradiction between the increase of knowledge points and the control of school hours under the new situation, which is conducive to the cultivation of mechanical engineering talents to meet the requirements of industry development. This method can be used as a reference for the training of mechanical professionals in other industrial colleges and universities.

**Keywords:** Mechanical Engineering, Oilfield Equipment, Professional Certification, Teaching Method

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## 1. Introduction

In recent years, with the continuous development of science and technology, much new knowledge and new technologies have emerged in the mechanical design and manufacturing technology and oil equipment technology of the oil industry, which put forward requirements for colleges and universities to cultivate talents in the oil industry. In view of the mechanical disciplines in petroleum universities, not only new knowledge and new technology in mechanical manufacturing technology should be taught, but also the knowledge of mechanical equipment with petroleum characteristics should be taught, leading to the requirement of increasing credit hours. On the one hand, the emergence of new knowledge and

advanced technology makes it necessary for training institutions to increase the teaching content; on the other hand, according to the student-centered concept of engineering education certification, credit hours should be appropriately controlled. As a result, new knowledge and new technical content in the forefront of the petroleum industry need to be taught, but the discipline time is tight. In addition, the previous reference books have different emphases, difficulties and cognitive degrees of students, which result in students' inability to systematically connect the knowledge they have learned [1, 2]. For example, students are in a fuzzy state about the relationship between basic specialized courses, ordinary specialized courses and characteristic specialized courses. This leads to a serious separation between theoretical

knowledge and practical operation, and also makes students only limited to basic theoretical knowledge and stay at the theoretical level. For a long time, students may lose interest and form the phenomenon of “obtaining credits with no efforts” [3]. However, the teaching content of the academy is in a state of lag, or the teaching content between multiple disciplines is not closely connected, which makes it more difficult for students to accept.

After investigation, it is found that many scholars have studied and analyzed the reform of related mechanical professional courses. They have proposed grading optimization in teaching content and focus on discussion-based teaching in teaching methods, so as to stimulate students' interest in this course [4, 5]. Or the reform and exploration of graduation design under engineering education certification are analyzed [6]. At the same time, the research on the implementation of ideological and political teaching reform in mechanical specialty courses is also carried out to improve students' professional quality, political consciousness and patriotism [7]. At present, the articles on teaching reform only study and analyze the changes in the previous teaching content. It is ignored that with the development of science and technology, much new knowledge and new oil industry and machinery industry are ignored. How to skillfully integrate the new knowledge and new technologies of mechanical engineering into the characteristic courses of petroleum machinery specialty under the concept of student-centered education certification of engineering specialty.

For the emergence of many problems and contradictions, this article will study the exploration in the oil industry the teaching of mechanical specialty, how to solve the case, without any increase in discipline school of mechanical engineering advanced technology and the oil industry forefront of the new knowledge, new technology to teach students, in order to achieve higher education to adapt to the development of the society, aimed at industry demand of talents training target.

## **2. New Knowledge and Technology in Mechanical Engineering and Petroleum Equipment Field**

### **2.1. New Knowledge and Technology of Mechanical Engineering Discipline**

Mechanical engineering is based on natural science and technical science, combined with the actual production of technical experience, so as to study the solution of product development, design, manufacturing and application of the discipline. The traditional mechanical manufacturing technology is based on “static, experience, passive and manual” as the basic characteristics [8]. With the proposal of the “Made in China 2025” strategic document, the development of science and technology, the emergence of new technologies, new materials and new technologies, as well as the progress of

manufacturing technology and the development of the manufacturing industry, the discipline of mechanical engineering is also constantly expanding its own new territory and improving its knowledge content. It is more and more widely and closely related to basic disciplines such as mathematics, physics, mechanics and computer science [9, 10]. For this reason, the discipline of mechanical engineering is inseparable from modern design and manufacturing methods, which makes the discipline of mechanical engineering emerge much new knowledge and new technologies in design, manufacturing and automation.

In the process of the integration of mechanical engineering discipline and modern design methods, a lot of new knowledge and new technology in the new era has emerged in design. A good product is designed first, and then it is manufactured. Therefore, the development of new products should first apply advanced design technology. In terms of design theory, we should not only adopt the latest technical theory in the field of product-related technology, but also adopt the latest research results of modern design methodology theory. A modern design method is the product of multidisciplinary integration, so it is necessary to learn a variety of relevant new knowledge, such as mathematical planning, computer programming, mathematical modeling, computer software and hardware, engineering graphics and other aspects of new knowledge. And modern design has produced many design technologies and methods in the process of continuous development, such as computer-aided design, simulation and virtual design, optimization design, artificial neural network method, engineering genetic algorithm, parallel engineering, reliability design, finite element method, modular design, similarity design, tribology design, reverse engineering and intelligent engineering. Students of mechanical engineering major should have an understanding of the new knowledge and new technology and make it flexibly applied.

With the development of the economy, the progress of society and the improvement of modern design technology, new knowledge and technology have emerged in the manufacturing of mechanical engineering. The manufacturing industry is the pillar industry of the national economy. It not only creates value, produces material wealth and new knowledge, but also provides advanced means and equipment for the improvement of human quality of life. Nowadays, with the application of various disciplines in mechanical manufacturing, a lot of new knowledge has emerged, such as manufacturing systems and manufacturing informatics, nanomanufacturing and nanomanufacturing science, bionic machinery and bionic manufacturing, manufacturing management and reconfigurable manufacturing systems. Manufacturing technology is a technical service that converts raw materials and other production factors into finished or semi-finished products directly used. With the promotion of technology and the traction of the market, many new manufacturing technologies have emerged, such as advanced forming technology, ultra-high-speed machining technology, ultra-precision machining technology, rapid prototyping

manufacturing technology, agile manufacturing, parallel technology, virtual manufacturing, biological manufacturing and other new technologies.

Manufacturing automation technology is an important symbol of the development of the manufacturing industry. With the progress of technology and the continuous improvement of automation means, many new technologies in automation have emerged, such as machine tool numerical control technology, industrial robots, detection and monitoring technology, and flexible manufacturing technology. The new technologies of mechanical engineering constantly absorb the achievements of microelectronics, computer and automation, and form modern integrated manufacturing technology systems such as computer-aided design (CAD), computer-aided engineering (CAE), computer-aided process planning (CAPP), computer-aided manufacturing (CAM), computer-aided quality testing (CAT). It enables mechanical products to be cleaner, integrated, networked and intelligent from design to processing, and combines theoretical technology with the actual environment to better develop new knowledge and technology of mechanical engineering in the new era.

The mechanical manufacturing of the oil industry needs to use the above technology to simulate and verify the mechanical products, and put forward the reference for the development and design of the product, so as to improve the quality of the product, and to manufacture petroleum machinery and equipment with efficient and safe processing methods, so that the product is more in line with the working environment of the oil industry.

## ***2.2. New Knowledge and Technology in the Petroleum Equipment Field***

In the new era, due to the increasingly harsh environment of oil and gas well drilling, many new types of equipment are also produced in the field of petroleum machinery and equipment. With the vigorous development of scientific knowledge and manufacturing technology, the innovation of key technologies in the oil industry has been promoted accordingly, and the oil equipment has been continuously improved. New drilling equipment such as offshore drilling platform, helicopter lifting rig, quick pry rig, polar low-temperature drilling rig, etc [11]. Oil field special vehicle equipment integration, automation vehicles, such as double engines and double pump cement truck, 7000m logging truck, Linkage well test truck, back tank truck, self recirculation well washing truck, offshore oil 981 deepwater semi-submersible drilling platform, 12000m ultra-deep well drilling rig, 3000 type fracturing truck, geosteering drilling technology, top drive device, PDC bit, large compressor, new multistage fracturing tools, EILog logging system, Huiyan 2000 imaging ground numerical control logging system, carbon fiber reinforced plastic continuous sucker rod and other new equipment.

New equipment in oil casing string, such as downhole special thread joint, is different from API thread. It mainly applies special sealing structure, high connection strength technology of thread, thread anti-sticking technology, and

joint stress optimization technology. The research and development of special threaded joints are of great significance in the oil industry, which promotes the development of oil and gas secondary exploitation technology in the oil industry in the new era, makes the oil machinery and equipment for oil and gas exploitation more efficient, portable and economical, and prevents the waste of energy.

## **3. Methods and Strategies to Solve Teaching Problems**

How to teach new knowledge and new technology to mechanical majors in petroleum industry colleges? And how to student-centered, optimize the hours? In order to solve these problems, colleges and universities should change the teaching content and teaching methods to meet the requirements of industry and engineering education. This paper proposes to integrate advanced design methods, manufacturing and automation technologies in mechanical professional courses into petroleum characteristic courses in teaching content, and strengthen case-based teaching in professional characteristic courses to optimize the allocation of hours. Put forward on the teaching methods to teaching, case teaching in the teaching process fully, and system integration of extension advanced new knowledge, new technology, the relevant mechanical new products and new equipment design, development, manufacture, application and maintenance process systematization, the interpretation of the formation of case type teaching way, so it can bring the students' interest in this course, and the modern machinery manufacturing process of the oil industry and have a comprehensive understanding of application process.

According to the practical engineering problems in the process of petroleum machinery research in the new era, the classic cases are selected, and the knowledge content of modern design and manufacturing methods is integrated. The combination of theory and practice promotes the ability of students to comprehensively apply mathematical knowledge analysis to solve complex engineering problems. Taking Xi'an Shiyou University as an example, in colleges and universities with petroleum and petrochemical characteristics, there are many petroleum machinery professional courses, and there is a separation between professional basic courses and professional courses. In professional courses, ordinary professional courses and characteristic professional courses are separated. Due to the limitation of learning science, some teaching contents are missing. The traditional teaching content should be innovated, the combination of modern design and advanced manufacturing courses with petroleum machinery should be increased, the traditional or lagging knowledge content should be simplified, the advanced technology related to petroleum machinery should be increased, and the professional basic courses, general professional courses and characteristic professional courses should be deeply integrated. The case teaching method should be adopted in the characteristic professional courses.

## 4. Case Analysis of Characteristic Courses Integrating Frontier Knowledge

### 4.1. Cases of Characteristic Courses in Petroleum Machinery

The important point of case teaching of characteristic course of petroleum machinery is the selection of cases, which determines the quality of teaching content [12]. The special courses of petroleum machinery and equipment in our university include petroleum drilling and production machinery, hydraulic machinery of oil and gas fields, downhole equipment of oil and gas fields, special vehicles of oil fields, oil and gas gathering and transportation and refining equipment, etc. We selected the downhole special screw thread and plunger pump knowledge points in the downhole equipment and hydraulic machinery courses of oil and gas fields as cases for analysis and discussion. In practical engineering applications, there are many frontier new knowledge and new technology in underground special thread and plunger pump. Therefore, advanced design and manufacturing methods of mechanical engineering are integrated into the knowledge points of underground special thread design, and mechanical fault diagnosis technology is integrated into the knowledge points of piston pump vibration.

### 4.2. Teaching Case of Integrating Advanced Design and Manufacturing Methods into Underground Special Thread

Due to the increasingly harsh drilling environment of oil and gas, the depth, pressure and temperature of the bottom hole are also getting higher and higher, and the outer diameter of the wellbore is getting smaller and smaller. In order to meet the needs of oil and gas development under harsh conditions, a special threaded joint oil well pipe is proposed. The main structure of the special thread joint includes the sealing part, torque shoulder part and thread part. The sealing part of the special threaded joint mostly adopts the specially designed metal-to-metal sealing structure. The thread structure adopts the trapezoidal thread with the bearing surface of  $0^\circ$  or the hook thread with the bearing surface of negative angle, and the shoulder is mostly the reverse shoulder with a negative angle. Complex connection form, sealing surface precision, the complexity of special thread design and manufacturing, from design to manufacturing to use different advanced technology, and special thread is currently more advanced petroleum equipment, the integration of the two teachings, in order to achieve the ideal teaching content and teaching methods.

In the process of special thread design and manufacturing, the modern design techniques and methods in the design and manufacturing process are integrated into the teaching of special thread design cases in the underground petroleum characteristic courses. The teaching content after integration is shown in Table 1.

**Table 1.** Design scheme of integration of advanced design and manufacturing technology and teaching knowledge points of petroleum pipe thread.

| Frontier knowledge points of mechanical engineering  |   | The knowledge points of 'petroleum pipe thread' in mechanical professional courses  | The integration method of new knowledge of mechanical engineering and knowledge points of petroleum specialty characteristic course   |
|--|---|---|---|
| Modern design method<br>1. Three-dimensional modeling of mechanical parts: polygon modeling, surface modeling, parametric modeling, reverse modelling.<br>2. Optimized design: unconstrained optimization, constrained optimization, multi-objective function optimization, optimization of discrete variables and fuzzy optimization.<br>3. Finite element method: high nonlinear analysis, contact analysis, failure and fracture analysis, and time-dependent dynamic analysis. | Modern manufacturing methods<br><br>1. Ultra-precision machining technology: ultraprecision grinding, ultraprecision cutting, ultraprecision special machining, composite machining.<br>2. CNC lathes.<br>3. Nondestructive testing technology: a liquid penetration test, ultrasonic test, radiographic test and magnetic particle test. | 1. Design of special threads.<br>2. Modeling of special thread: thread using hook thread, joint sealing surface for metal - metal form.<br>3. Optimization of special thread: structural optimization and mechanical analysis of geometric parameters.<br>4. Manufacture of special threads.<br>5. Detection of special threads: detection of sealing effect. | 1. Model features of special thread are created by parametric modeling module of UG.<br>2. The three-dimensional model is imported into the finite element software to simulate and optimize the structure and mechanical analysis of the special thread, and the dynamic deduction results are used to verify whether the special thread meets the engineering practice.<br>3. Through computer-aided engineering control CNC lathe, using ultra-precision machining technology for the production of special thread entities.<br>4. The liquid penetration test method in non-destructive testing technology was used to evaluate the sealing of solid special thread joints. |

The oil downhole tool special thread design case, describes the development of special thread joints, structural characteristics, the role of each part of the structure, joint connection mode and other theoretical knowledge. And also integrated into the modern design and manufacturing methods of computer-aided design technology, simulation, rapid prototyping manufacturing technology, ultra-precision machining technology and other theoretical knowledge and

nondestructive testing technology. This case presents the design, development, experiment, manufacturing and testing process of petroleum machinery products. It not only realizes the multidisciplinary integration, optimizes the allocation of school hours, but also combines theory with practice, effectively integrates the frontier technology and theoretical knowledge of the petroleum industry, and improves students' interest in this industry course.

### 4.3. Teaching Cases of Integrating Advanced Fault Diagnosis Technology and Oil and Gas Transmission Fluid Equipment

With the increasing difficulty of oil exploitation and the decline in the quality of crude oil, in order to ensure the high yield of crude oil exploitation, the oilfield water injection technology is produced [13]. At present, the centrifugal pump used for oilfield water injection is replaced by the piston pump. The piston pump injects the water with qualified quality into the oil layer from the water injection well. Relying on the reciprocating motion of the piston in the cylinder body, it changes the sealing volume formed by the end face of the piston and the hole in the rigid body and realizes oil absorption and oil pressure. Piston pump complex structure, process parameters, design and manufacturing process, the use of mechanical engineering disciplines many modern design and manufacturing technology and methods. And piston pump into practical engineering operation, often appear vibration, noise and other phenomena, serious weld cracking, so that the piston pump failure, there are security risks. It is necessary to study and analyze the causes and components of vibration

through the fault diagnosis technology of pump vibration spectrum analysis, so as to realize fault elimination and real-time fault monitoring [14].

In the process of piston pump design and manufacture, the modern design technology and method in the process of design and manufacture are integrated into the vibration case of piston pump in petroleum characteristic course. The teaching content of piston pumps from design and manufacture to maintenance is shown in Table 2.

In this case, the knowledge of piston pump in petroleum machinery is introduced, and the troubleshooting of vibration fault of the piston pump is interspersed [15]. The fault diagnosis technology of pump vibration spectrum analysis is integrated into the fault diagnosis technology, which makes the discipline better cross fusion. Not only can students fully understand the structure, working principle and use of piston pump, but also can understand the relevant knowledge of fault diagnosis and the method of troubleshooting of concrete piston pump, the best bridge of combining theory and practice [16]. It also enables students to integrate their knowledge into each course of petroleum machinery and also improves their ability to analyze and solve practical engineering problems.

**Table 2.** Design scheme of integration of advanced mechanical fault diagnosis technology and petroleum piston pump teaching knowledge.

| Frontier knowledge points in mechanical engineering   |   | The knowledge points of 'petroleum piston pump' in mechanical professional courses  | The integration method of new knowledge of mechanical engineering and knowledge points of petroleum specialty characteristic course  |
|---|---|---|--|
| Modern design method  | Mechanical fault diagnosis technique<br>1. Time-domain waveform diagnostic method   | 1. Structure of piston pumps<br>2. Working principle of piston pumps<br>3. The vibration of piston pumps<br>4. Reasons for vibration of piston pump | 1. Using UG software surface modeling to create the three-dimensional model design of piston pump, and optimize the structural parameters.<br>2. Through the finite element software ANSYS Fluent piston pump fluid dynamics analysis.<br>3. In the process of fault diagnosis, the spectrum analysis method is used. The vibration signal of the piston pump is collected by the sensor, and the amplitude-frequency characteristic curve of the vibration source is analyzed to determine the causes of vibration, so as to eliminate the fault of the pump. |
| 1. Three-dimensional modeling: polygon modeling, surface modelling<br>2. Optimized design<br>3. Finite element method: computational fluid dynamics<br>4. Reliability design. | 2. Diagnostic method for fluctuations in time-domain indicators<br>3. Shock pulse method<br>4. Spectral analysis<br>5. Fault isolation diagnosis method |   |  |

### 4.4. Practical Analysis of Case Teaching Method

In order to test the effect of the reform of teaching methods proposed in this paper, the author carried out the case teaching practice of mechanical specialty courses in grades 2015 and 2016 of Xi'an Shiyou University and achieved good results. From the quality analysis of the course assessment, in the case of no increase in science, students master more knowledge points, and students' ability to apply new knowledge and new technology to solve complex engineering problems has also been improved. It optimizes the distribution of scientific time in petroleum colleges and universities, enriches the breadth and depth of students' cognition of petroleum machinery, and achieves the purpose of improving teaching quality.

## 5. Conclusion

This paper proposes a case-based teaching method that integrates new knowledge and new technology of mechanical

engineering into the characteristic courses of petroleum specialty. This teaching method has the characteristics of not increasing credit hours and clever compatibility between mechanical engineering and petroleum characteristic courses.

From the perspective of theoretical research, it enables students to master more new theoretical knowledge in the process of learning, and fully solves the problem of tense credit hours. The case teaching method of integrating the new knowledge of mechanical engineering into the characteristic course of petroleum machinery specialty not only solves the problem that the ordinary professional courses and the characteristic professional courses are not closely linked, but also achieves the teaching goal of combining theoretical knowledge with practical engineering problems. From the perspective of practical research, students' ability to master and apply new knowledge of professional courses has been improved, and the quality of curriculum assessment has been further improved. Practice proves that the teaching method is feasible and the teaching effect is good.

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