

## **Disassembling maintenance practices for petrochemical equipment based on an outstanding engineers training plan**

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**ABSTRACT:** In order to improve the *Excellence Engineer* students' practical ability in petrochemical equipment disassembly and maintenance, students need to understand and participate in the *Excellence Engineering Education Programme*. They should practice disassembly, repairing, mapping and maintenance of compressors and pumps. Cohorts of excellent engineer students were trained over three years to develop the abilities of machine assembly and disassembly, surveying and mapping, CAD mapping, maintenance, and so on. Such practical training improves the students' co-operative abilities and work ethic. It provides students with the practical experience of value to them in their future careers in the petrochemical industry. Petrochemical equipment maintenance repair training is discussed in this article. The purpose, content, and execution of the practical training are reviewed. Also considered is the role of practical training in engineering higher education.

### INTRODUCTION

To transform China from being a *big* country in engineering education to a powerful one requires major initiatives to cultivate a large number of high quality engineering technical personnel. These personnel should demonstrate initiative and be innovative; hence, supporting China's economic and social development [1][2].

On 23 June 2010, the Chinese Ministry of Education held a meeting at Tianjin University on a new initiative called the *Excellence Engineering Education Programme*. This action was directed at relevant higher education departments, professional associations and industrial organisations to encourage them to carry out the *Excellence Engineering Education Programme* (hereinafter referred to as the Excellence Programme). The Excellence Programme is an important role model and guide for the country in moving down a new industrialisation road of innovation-oriented development. This should cultivate the development of appropriately qualified personnel by higher education, and improve engineering education and industrial training [3][4].

The Northeast Petroleum University (NEPU) was approved by the Ministry of Education in 2011 to be in the second batch of pilot colleges to carry out the Excellence Programme [5]. The engineering education major *Process Equipment and Control Engineering* was selected to be the first batch of excellent engineering majors. Incorporated within this major are resources from the Petro-China Daqing Oilfield Company Limited; Share Ltd; the Daqing Petrochemical Company; Daqing Refining & Chemical Company; as well as other well-known Chinese enterprises.

It was envisaged that through teaching reform and practical training, the academic personnel taking part in the programme would explore methods of training applicable to petroleum chemical equipment and machinery. Combined with *process - equipment - control* education, this would implement excellent engineering education at a national oil and petrochemical local key university. It was expected that such education and training would further enhance students' abilities to adapt to a variety of engineering applications and provide advanced engineering talent for society [6][7].

Discussed in this article is petrochemical equipment maintenance and repair training in the context of the requirements and goals of the Excellence Programme. The purpose, content and execution of the training in existing conditions are discussed, as well as the practical conduct of the Excellence Programme in higher engineering education in China.

### THE OBJECTIVES OF PETROCHEMICAL EQUIPMENT MAINTENANCE AND REPAIR TRAINING

Petrochemical equipment maintenance and repair training is included in the major *Process Equipment and Control Engineering*. Through the petrochemical equipment maintenance repair training, students will develop solid and lasting

knowledge about the maintenance and repair of chemical machinery (pump and compressor). The professional knowledge is integrated rather than being disjointed.

Through practice, teachers train students in the disassembly and assembly of machines, parts mapping, CAD drawing, repairing and maintenance. The course promotes co-operation and hard work. Through industrial training, students experience work in an enterprise that will form the basis of their future work. The specific contents include the following attributes:

1. Students can better consolidate and improve professional knowledge and practice through practical activities. Hence, their abilities to analyse and solve problems are cultivated.
2. The course develops students' abilities to carry out special inspections and diagnostics, as well as research and data collection of petrochemical equipment maintenance and repair. This lays the foundation for later improvements in maintenance and repair technology.
3. Students are taught how to remove faults in equipment and repair devices such that they are brought back into operation.
4. Students' practical abilities and communication skills are developed.
5. Teamwork and co-operative spirit is cultivated.

### TRAINING SUBJECTS AND GROUPING

Petrochemical equipment maintenance training content includes the overhaul of a removable piston compressor; a W-type air compressor and three chemical centrifugal pumps.

The process equipment and control engineering major is conducted through professional activities at the NEPU with three classes for a total of 90 students. Each class is supervised by two instructors, and students are divided into three groups of 10 students each. Students are free to form their teams for teamwork; however, each team should include at least two females. The team leader is responsible for the preparation of the work, and is responsible for the joint production of team assignments. He or she is also responsible for the election of a deputy leader and a security officer, whose tasks are to assist the group leader. The maintenance site and the disassembled parts are shown in Figure 1 and Figure 2.



Figure 1: Maintenance site.



Figure 2: Disassembled parts.

The teaching methods use theory-practice, theory-practice with role-learning and teacher-onsite guidance. The training requires appropriate hardware taking account of the number of classes. Students need to grasp the structural composition of the equipment, relevant knowledge, repair, maintenance procedures and mapping areas in order to lay a solid foundation for equipment maintenance. The practical training is scheduled for four weeks, with students in each class exposed to training in one specific device, but supplemented by other kinds of devices.

### TRAINING CONTENT

#### Machine Disassembly and Mapping

Equipment disassembly linked to a specific implementation requires the instructor to explain the site, and the specific dismantling and measuring tools, equipment, working principle and the steps in equipment disassembly. Finally, based on practical experience, combined with basic theory and professional knowledge, a preparation equipment inspection

and maintenance procedure is undertaken. The disassembly process requires students to record the problems encountered and to correct any mistakes. Teachers guide the whole process.

Surveying aspects include the use of mapping and measuring tools to determine the device shape and the composition of all the components that are measured and then recorded. Through observing structural components, functions and processing technology, as well as other factors, students should be able to determine the dimensions, tolerances and surface roughness of the parts, and produce draft drawings of the parts. Finally, students use CAD software to draw a non-standard two-dimensional map, a three-dimensional assembly drawing, and a three-dimensional animation program of the disassembly and assembly of the device. This allows students to truly grasp the composition and structure of dismantling equipment and installation procedures. This makes it easy for the instructor to inspect and guide the students' work.

#### Related Lectures

To enable students to combine theory and practice more closely, schooling arrangements include a series of lectures relevant to practical training. This includes the school's programme of lectures on *maintenance repair procedures and mapping*; Daqing Petrochemical Company engineers' lectures on *equipment condition monitoring and fault diagnosis technology*; and Daqing Refining and Chemical Company engineers' seminars on *repair and maintenance tools for introduction and application*. Speakers are recruited from senior academic teachers of the University faculty and senior engineers from industry.

Maintenance repair procedures and mapping lectures involve equipment maintenance; repair procedures; disassembly of equipment and precautions; measurement of various standard parts, such as bolts, nuts, pins, retainer; measurement of various non-standard parts, such as box, cover, side panels; draft drawing methods and precautions. As well, the principles of the 2D and 3D CAD graphics rendering method, tolerances, roughness, etc, are taught.

The equipment condition monitoring and fault diagnosis technology seminar mainly explains to students the nature, importance, advantages and disadvantages of various inspection and diagnosis methods, as well as the development trends of fault diagnosis and detection.

The main purpose of the repair and maintenance tools and applications seminar is to enable students to understand petrochemical maintenance tools, such as various wrenches, pliers, screwdrivers, gage blocks, gauges, and so on. This enables students to become skilled operatives.

In order to make students understand the importance of training in petrochemical enterprises, a business technology expert should be hired to be a guide teacher. This guide teacher may come from the Daqing Petrochemical Company or the Daqing Natural Gas Controlled Company, and could deliver open lectures on petrochemical equipment operation management and maintenance at the three management levels, viz. the company level, the plant level and the workshop level. At the same time, a student excursion could be organised to the Daqing Natural Gas Training Centre to be guided by enterprise teachers on the use of petrochemical equipment. During this, students and teachers could be encouraged to interact in order to find and solve potential problems.

#### Engineering Drawing Training

Drawing machine main parts and assembly diagrams using CAD as shown in Figure 3, and the complete disassembly and assembly process using a 3D exploded diagram as shown in Figure 4, is highly beneficial for students as it fosters understanding of the operation of the machine.

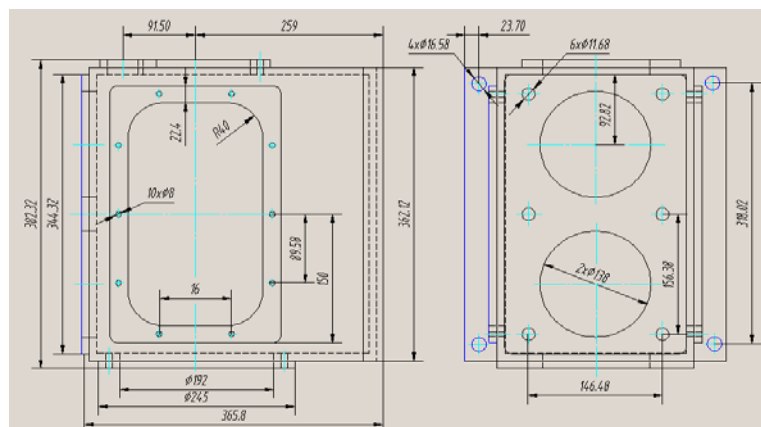


Figure 3: A 2D CAD drawing.

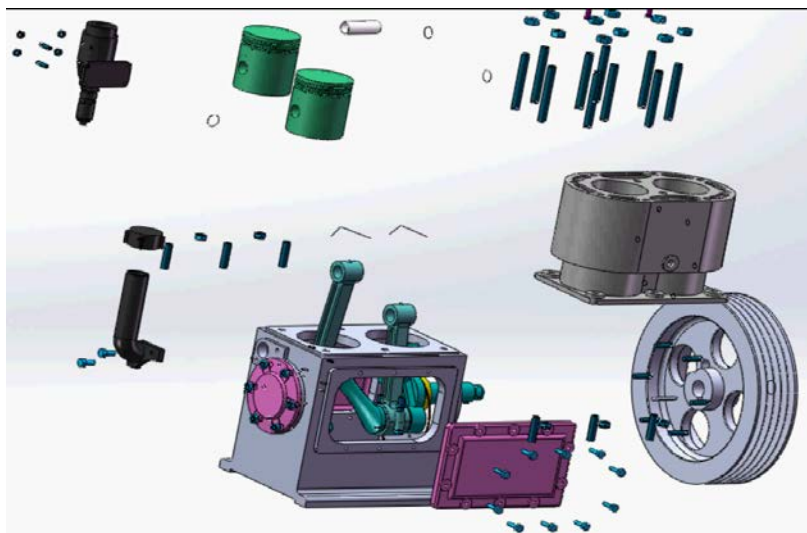


Figure 4: A 3D CAD exploded diagram.

#### MAINTENANCE AND REPAIR TRAINING CONTENT AND EVALUATION

The petrochemical equipment maintenance training content and assessments are shown in Table 1. The assessment is out of 100 points.

Table 1: Assessment and the allocation of marks.

	Assessment	Allocation of marks %
Individual	Attendance	5
	Enterprise and lecture experience	5
	Sketch mapping of equipment and its main parts (each person at least one component)	15
	Disassembly and assembly of the equipment	15
Team	3D animation of the disassembly and assembly of the equipment	10
	Training report (with the following content): 1. Summarise the main technical parameters, main structural characteristics and the main parts of the maintenance model, and produce the corresponding diagram; 2. Drawings of compressed gas equipment, cooling water and lubricating oil flow chart; 3. According to the maintenance requirements, describe the preparatory work and the existence of any insufficiencies; 4. According to the training objectives, compile maintenance and repair procedures; 5. Summarise the method for using the disassembly tool and demonstrate the dismantling process; 6. Update the record of the dismantling and measurement process; 7. Produce equipment assembly drawings, and surveying and mapping diagrams of the main parts (at least 10 A4 papers).	40
	Students' answers to teacher's questions	10

In order to ensure a fair score for a team, six teachers mark the work, and the assessment is the average of the six marks. In addition, a self-evaluation method by members of the group can be used, and reflected in the final total score by assigning a weight  $K$  to the self-evaluation score.

The meaning and purpose of the self-evaluation within the group is as follows:

- The evaluation measures the different contributions of the group members.
- It helps to mobilise the enthusiasm of the group members.
- Outstanding students are encouraged to greater effort.
- It guarantees the successful completion of the team-learning task.

The specific rules are:

- In accordance with the principles of fairness the given grades are according to contribution.
- The team leader organises the scoring method for the group.
- The level weights,  $K$ , are respectively  $A = 1.1$  (excellent);  $B = 0.9$  (very good);  $C = 0.8$  (good).
- The final score of each person = group total score  $\times K$ .

The guide teacher will give a *group total score* out of 90 for every group. The group members will allocate a  $K$ -value to each other. Finally,  $90 \times K$  is the final score for each member.

#### APPLICATION EFFECT

The course of petrochemical equipment maintenance was conducted in 2013, 2014 and 2015 for the Process Equipment and Control Engineering major. This particular practical training or practice has been widely approved by the students. Students participating were highly motivated, and with good learning effect. There has been a good level of mastery of professional knowledge and an excellent degree of co-operation between students, as well as between students and instructors.

#### CONCLUSIONS

A trial of revised petrochemical equipment maintenance repair practical training was conducted in 2013 to 2015 at Northeast Petroleum University. The training was part of the Process Equipment and Control Engineering major. The revised training was guided by the implementation guidelines of the *Excellence Engineering Education Programme*.

After four weeks of practical training, students learned the disassembly and assembly of mechanical parts of machines, surveying and mapping, CAD mapping, repair and maintenance. Furthermore, the students improved their ability to interact and co-operate, have advanced their communication skills, and developed an ethic of hard work. Through practical training, the students experienced the content and methods of enterprise work, to lay a solid foundation for their future engagement in petrochemical equipment repair, maintenance and management.

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