Practical training Equipment for Flange Tightening Force Fluctuation due to Temperature Difference

1. Introduction

A countless number of flanges are used in petroleum refineries to connect pipes. Because there is little leakage of internal fluid from these flange connection parts, the plants are operated with little awareness of leakage of internal fluid from the flange. In addition, although we know as general knowledge that metal materials expand and contract due to temperature changes, it seems that knowledge and experience largely determine whether or not the operation is performed in relation to the flange tightening force.

Although veteran employees recognize that flanges leak from past failure experiences, young employees with little experience cannot imagine that leaks will occur from the flange connecting parts.

It is essential a the safe operation of the plant to learn that when a piping changes in temperature, the flange tightening force is affected, and in some cases, the internal fluid leaks from the decrease in the surface pressure, and this knowledge must be learnt by the personnel involved in the operation of a plant.

At this refinery, there have been past cases where flushing oil (light oil) leaked from the flange fastening part during the start-up operation. Leakage occurs when flushing oil (about 25 ℃) is introduced, a sudden temperature drop occurs at the connected hot pipe flange connection (about 200 ℃) , the surface pressure at the pipe flange connection decreases due to the change in the pipe's thermal strain.

From the above discussion, it is indispensable for safe operation of the plant to learn the decrease in surface pressure of the flange connecting part due to temperature change and the subsequent leakage of internal fluid through practical training and to know the mechanism. We asked Valqua Co., Ltd. to manufacture practical training equipment and develop a training program using that equipment.

In this paper, we are going to report the summary of the practical training program by using this equipment.

2. Overview of practical training equipment

2-1) Design specification

In examining the specifications of the practical training equipment, we adopted a fluid temperature (high temperature, low temperature) close to our case, and considered safety for use as training. The equipment was designed based on the training program, and both companies discussed the design proposal, and the equipment which reflected the result of the consultation was produced.

2-2) Outline of equipmentt

Outline of the completed equipment is shown in Figure1. The central part is a flange for monitoring the flange tightening force, and the tightening force of

Figure1 Educational hands-on training equipment
(The left side is the high temperature part, the right side is the low temperature part)

each bolt is displayed on the monitor on the left hand desk.

2-3) Training procedures (see Figure2)

① Set the fluid temperature on the high temperature side to about 200 ℃, monitor the flange tightening force online without the fluid on the low temperature side (about 20 ℃), and check the tightening status (balance) on the monitor.

②Introduce the low-temperature side fluid gradually, and visually check the level inside the pipe from the peephole (right flange in Figure1).

③Check how the flange tightening force (balance) changes by adding low-temperature fluid.

④Through this experience, each person will experience a decrease in flange tightening force that leads to leakage of internal fluid, and each person should be careful when operating the plant equipment in charge.

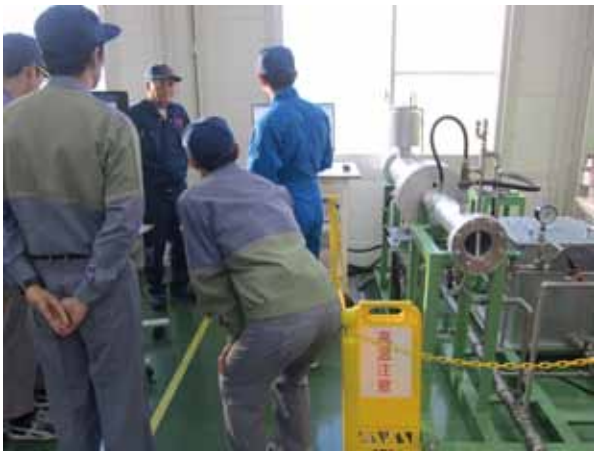

Figure2 Demonstration of practical training program by using new equipment
(Trainee in the front and lecturer in the back)

3. Training program

We asked STC Nara to install this practical training equipment and consider a training program that combines this training with the existing equipment and training program related to flange tightening. The training program is different for the manufacturing department and the construction department. (The manufacturing department allocates about one hour more for tightening flanges than the construction department because the gasket replacement and tightening of small-diameter pipes are carried out by the trainees themselves.)

3-1) Manufacturing Department

Lecture program 1.5 hours (see Figure 3)

- What is a gasket?
  (What is a seal/allowable leakage/ required characteristics, etc.)
- Type of gasket and Tightening
  (Tightening method/retightening, etc.)
- Failure cases
  (Poor tightening, selection mistakes, etc.)

Figure3 Trainees attending a lecture program

Practical training program 4.5 hours (see Figures4, 5 and 6)

- Flange tightening methods for gaskets
  (Compare the tightening force actually tightened by each trainee against the target tightening force, and determine their own skill.)
- Gasket creep relaxation, sealing performance, compression failure
  (Experience of defects due to creep phenomenon, which are the thermal characteristic of gaskets, excessive or insufficient tightening force.)
- Influence of bolt management
- Practical training using new equipment
  (mentioned above)

Figure4　Demonstration of practical training program by using existing equipment (Torque checker)

Figure5　Demonstration of practical training program by using existing equipment (Flange tightening equipment)

Figure6　Demonstration of practical training program by using existing equipment (Seal performance equipment)

3-2) Construction Department

Lecture program 2.5 hours

・What is a gasket?

・Gasket types, selection, and tightening

Practical training program 3.5 hours

・Fange tightening methods for gaskets

・Gasket creep relaxation, sealing performance

・Influence of bolt management

・Practical training using new equipment (mentioned above)

The training is conducted in small groups of four in order to reinforce the lecture program with the practical training program, and to enable each participant to think about and experience the purpose of practical training, and to fully understand the results. The participants are engaged in practical training with a sense of tension. In addition, although safety measures have been taken into consideration in advance, it is also intended that a small number of people will maintain a sense of tension and prevent accidental injuries.

The standard training hours are from 9:00 to 17：00, and it takes about 2 hours one way from our company in Yokkaichi to Nara Pref. (Valqua), and the work load for shift workers is particularly heavy. For this reason, lecture programs are held multiple time at Yokkaichi City (our company), and practical training programs are performed at Nara STC (Valqua).

4. Results of training

At the end of the training, VALQUA, Ltd. conducts a survey and the feedback from the participants is used in subsequent courses.

To summarize the results of our 12 participants' so far

①Overall satisfaction：Average 4.7
(5 levels of satisfaction　high 5 ⇔ low 1)

②Difference between initial expectation and actual content：Average 4.8
(5 levels of expectation as expected 5 ⇔ disappointing 1)

③Understanding of lecture program：Average 4.3
(5 levels of understanding well understood 5 ⇔ not understood 1)

④Understanding of practical training program：Average 4.7
(5 levels of understanding well understood 5 ⇔ not understood 1)

The average understanding level of the practical training program is 4.7, which is a high level of understanding.

Comments from the participants

"I was surprised at the faster change in tightening force due to flange quenching than expected."

"It was easy to understand because we were able to confirm the decrease in tightening force due to cooling in real time."

"By experiencing equipment that simulated an actual case it reinforced the dangers in me for the next 10, 20 years or more."

It seems that they had a favorable impression of the practical training equipment.

Most participants have the impression that they would like to introduce this training to their colleagues (especially junior colleagues) in the workplace. Because of the high level of satisfaction and understanding mentioned above, it is considered effective in strengthening management of flange tightening force by participating in this training, and the participation of those who have not yet participated in this training is planned as part of our educational program in the future.

5. Conclusion

We have installed piping and valve facilities on our premises, and as part of our training for new employees, we have taught them about the importance of gasket replacement and flange tightening by basic operations training such as flange tightening as voluntary maintenance activities. A decrease in surface pressure at the pipe flange connection may cause a leakage of the internal fluid which may lead to a major accident. On the other hand, even if you are in charge of the operation and maintenance of a refinery, you rarely have the opportunity to actually experience the mechanism of surface pressure reduction, and in many cases when trouble occurs you are reminded of its importance.

In this study, VALQUA, Ltd. developed practical training equipment and by developing a practical training program with the equipment it teaches the mechanism of reduction of surface pressure at the pipe flange connection part due to temperature-change which causes leakage of internal fluid and this is essential to the safe operation of the plant.

As a result of conducting employee education using the practical training equipment, its effectiveness could be verified, so we will continue to educate employees on the importance of managing flange tightening force utilising this equipment and the practical training program. In addition, we hope that many other companies will take this program to prevent similar trouble at their factories.

Finally, we would like to thank Valqua, Ltd. and Toyo Sangyo Co., Ltd., for manufacturing this equipment and for giving us the opportunity to publish our findings and experience.

6. Reference

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