Research on Bolt Assemble/Disassemble Operation for Remote Handling Maintenance

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Abstract—Remote handling maintenance (RHM) is the act of monitoring and maintaining equipment in a safety zone away from the site by applying a manipulator (robot) or special equipment inside the nuclear device to reduce the exposure dose and labor intensity for personnel. RHM technology is an important and indispensable tool for maintaining radioactive parts for large-scale scientific facilities. Bolt assemble/disassemble is an operation of RHM. This paper research on bolt assemble/disassemble operation in hot cell RHM to get some the proposals for bolt design and auxiliary tooling development in RHM. Four comparing experiments including the ball hexagonal head and hexagonal head, different length of clamping handle of pneumatic wrench, with block leg and without block leg, the rigid handle and the flexible handle were conducted. Significant conclusions were obtained for bolts disassembling and reassembling, which provide a basis for auxiliary tooling development for RHM.

Keywords-nuclear device; hotcell; remote handing maintenance(RHM); bolt; assemble/disassemble

I. INTRODUCTION

Nuclear devices are associated with the research and application of high-energy physics, and typical nuclear devices globally include the Large Hadron Collider (LHC) developed by the European Organization for Nuclear Research (CERN) [1], the Spallation Neutron Source (SNS) [2], the International Thermonuclear Experimental Reactor (ITER) [3], the Beijing Electron Positron Collider (BEPC) [4], and the China Spallation Neutron Source (CSNS) which is under construction [5]. These devices provide the basic conditions for the realization of strategic, basic, and forward-looking science and technology research.

Radioactive installation (e.g., nuclear power plants and high-energy physics research institutes) generally has the characteristics of complicated structures, high speed, and heavy loads. The installation themselves and their working environments are radioactive. The aforementioned characteristics may cause failures of key equipment in radioactive installation, which seriously affect the lifetime of radioactive installation.

Maintenance refers to restoring aging or faulty equipment parts to a satisfactory operating condition. It includes inspection, testing, diagnosis, disassembly, assembly, cleaning, repair, and replacement. Key equipment of radioactive installation that provides base functions must be maintained during installation lifetime [6-7].

Remote handling maintenance [8] is the act of maintaining equipment in a safety zone away from the site by applying a manipulator (robot) or special equipment inside the hotcell to reduce the exposure dose and labor intensity for personnel. RHM has been successfully applied to radioactive installation such as the Joint European Torus [9], the ITER [10], and the European Organization for Nuclear Research [2].

Bolt is the connection component of equipment. Bolt assemble/disassemble is an operation of RHM. These paper researches on bolt assemble/disassemble operation in hot cell RHM to get some the proposals for bolt design and auxiliary tooling development in RHM. Four comparing Experiments (the ball hexagonal head and hexagonal head, different length of clamping handle of

pneumatic wrench, with block leg and without block leg, the rigid handle and the flexible handle) were conducted, and some conclusions were obtained for bolts disassembling and reassembling

II. EXPERIENCES

Wherever Times is specified, Times Roman or Times New Roman may be used. If neither is available on your word processor, please use the font closest in appearance to Times. Avoid using bit-mapped fonts if possible. True-Type 1 or Open Type fonts are preferred. Please embed symbol fonts, as well, for math, etc.

In order to observe different shapes of bolt head, different length clamping handle of pneumatic wrench, the influence of whether there is a block legs experiment and the measure of pneumatic wrench`s best work efficiency, the experiments made four group contrast experiments.

A. Comparison of Ball hexagonal bolt and hexagonal bolt

The two different types of M20 * 60 mm bolt was chosen in this test, ball hexagonal bolt was shown in Fig .a 1(a), ordinary-sized hexagonal bolt was shown in Fig .a 1(b).

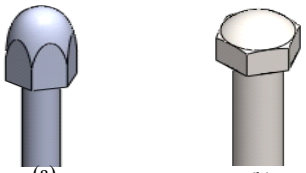

Figure 1. Ball hexagonal bolt and hexagonal bolt.

After starting the pneumatic compressor, use master-slave manipulator to take the suspended pneumatic wrench to the position of the maintenance bolt, then clamping the pneumatic wrench to make sleeve on the bottom set into the bolt head completely. In the end, start the pneumatic wrench switch and observe different shapes of bolt head's impact on the mounting bolts.

Conclusion can be found in the comparison: Ball hexagonal bolt is advantageous to make the ball head set in quickly by the guidance of the pneumatic wrench, comparing with ball hexagonal bolt, hexagonal bolt hexagonal bolt should rotate an angle to make it fixed. So the ball head bolt can reduce the difficulties when remote maintenance to dismount the bolt, such as auxiliary positioning when bolting, shorten the operation time;

On the other hand, due to large contact area, it is easier to set out the ball hexagonal bolt than ordinary-sized hexagonal bolt from the sleeve after completing the dismantling, prevent the ordinary-sized hexagonal bolt from locking in the sleeve , more secure.

B. Comparison of different length clamping handle

Pneumatic wrench was moved to the dismounted bolt by master-slave manipulator, then clamping the side handle of the pneumatic wrench to make its bottom set into the bolt head completely. Start the pneumatic wrench switch and observe the position when clamping the handle of 50mm, 80mm and 110mm respectively, as well as the impact on the manipulator in the process of dismantling bolt . When clamping handle is pushed by a 500N thrust and displacement diagram is shown in Fig .2.

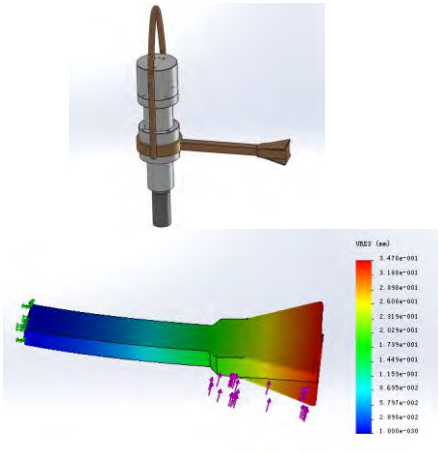

Figure 2. Clamping handle

In theory, the arm of the clamping handle should be as long as possible, because bolt torque can be very small in the process of mounting bolts, so that can avoid the mechanical damage by the high torque. However through the experiment, it prove that it is wrong, it will be more difficult to move the Pneumatic wrench to the dismantled bolt, for the barycenter of the Pneumatic wrench will move and the Pneumatic wrench can be very easy to shaking and out-of-balance in the process of mounting bolts.

C. Comparison of the Block legs

Block legs were designed to offset the huge reaction in the process of mounting bolts (as shown in Fig .3 and Fig .4) .The comparing experiment to prove the role of block legs are as follow. When block leg is stopped by a reactive force 2000N and maximum deformation is 1.721mm.

The result display: Pneumatic wrench with Block legs connect structure stability and easier to keep balance, and also can effectively cooperate with backing pin which connected the bolt to prevent the pneumatic wrench inversion, improve efficiency, reduce labor intensity. In addition, some of the vibration generated in the working process of the Pneumatic wrench will along clamping point to the manipulator joints which will cause clamping point of the manipulator excessive wear, loosing, shorten the service life of the manipulator. Block legs pneumatic wrench with auxiliary pin can largely reduce this vibration.

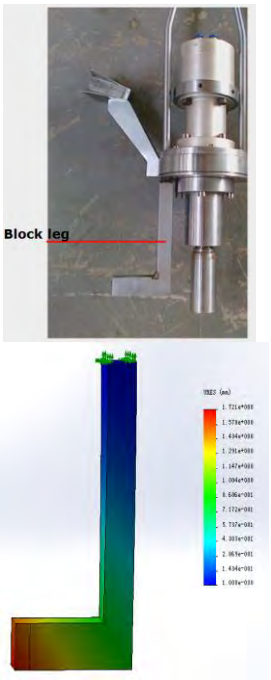

Figure 3. Pneumatic wrench with block legs

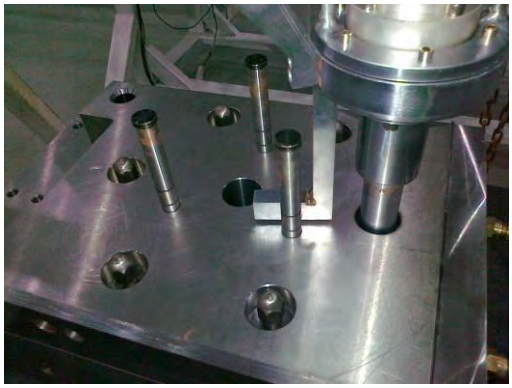

Figure 4. Block legs working condition

D. Comparison of the rigid handle and the flexible handle

After starting the pneumatic compressor, use master-slave manipulator and hold the handle (as shown in Fig.5) to move the pneumatic wrench to the dismounted bolt, and put the bottom of the pneumatic wrench into the most deep place, and then start the pneumatic wrench switch.

Figure 5. Master-slave manipulator clamping handles

Conclusion can be found in the comparison: the design of the handle is necessary, it is difficult to locate if control the fuselage of pneumatic wrench directly, at the same time, it is not easy to grasp firmly for the holding torque is large, not easy to use manipulator clamping rapidly and accurately. The pneumatic wrench with rigid handle`s (as shown in Fig .6) process is simple, but in the use, the performance of the pneumatic wrench with flexible handle (as shown in Fig .7) is better. The vibration generated in the working process of the Pneumatic wrench will along clamping point to the manipulator joints which will cause clamping point of the manipulator excessive wear, loosing, shorten the service life of the manipulator. Block legs pneumatic wrench with auxiliary pin can largely reduce this vibration.

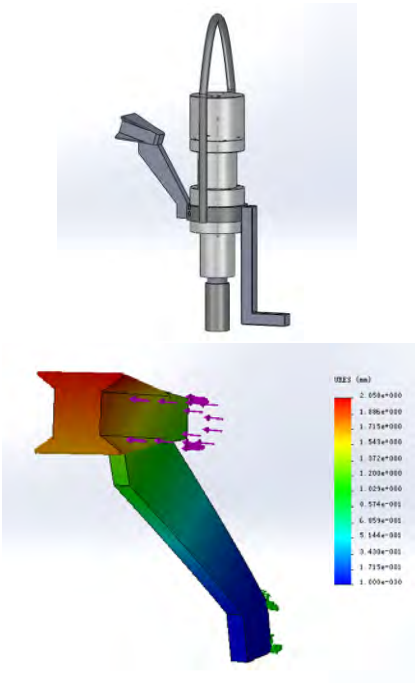

Figure 6. Rigid handle

Figure 7. Flexible handle

III. CONCLUSIONS

To sum up, the conclusions can be drawn as follow:

1) Comparing with hexagonal bolt, Ball hexagonal bolt is advantageous to make the ball head set in quickly by the guidance of the pneumatic wrench, and easier to set out.

2) Through the experiment, one point can be proved that the arm of force shouldn't be as long as possible, it will be more difficult to move the pneumatic wrench to the dismantled bolt when the arm is long, for the barycenter of the Pneumatic wrench will move and the Pneumatic wrench can be very easy to shaking and out-of-balance in the process of mounting bolts.

3) Block legs and auxiliary pin can greatly reduce pneumatic wrench vibration.

4) Through the experiment, the design of the handle is necessary, some of the vibration generated in the working process of the rigid handle in the Pneumatic wrench will along clamping point to the manipulator joints which will cause clamping point of the manipulator excessive wear, loosing, shorten the service life of the manipulator.

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