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To cite this article: Wanjun Li *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **300** 042013

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Analysis and treatment of the shutdown reasons of ultra-supercritical 1000MW steam turbine generator set

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Abstract. When a power plant ultra-supercritical 1000MW steam turbine generator set is running normally, the electric valve at the outlet of A steam feed pump appears serious leakage. Through on-site inspection and inspection of maintenance records, starting from the structure of the electric valve, the leakage fault of the electric valve at the outlet of A steam feed pump is diagnosed and investigated, and the cause of the fault is accurately analyzed. The leakage problem of the electric valve at the outlet of A steam feed pump has been thoroughly solved by taking effective measures such as changing the packing type, arrangement and improving the installation process.

Keywords. Steam feed pump outlet electric valve; Serious leakage; Fault analysis; Fault treatment.

1. Overview of equipment and system

The unit of A power plant is ultra-supercritical 1000MW steam turbine generator set, equipped with two steam feed pumps (A and B) with capacity of 50%BMCR. Both of them are horizontal multi-stage cylinder pumps produced by Shanghai electric power repairing general factory co., LTD. The models are HPT400-390-6S/33A.

The export electric valves of A and B steam feed pump are provided by Harbin power station valve co., LTD. The types of A and B steam feed pump outlet electric valve are DN400, PN42 gate valve, which are parallel gate structures (seen in figure1). The valves are arranged on the running floor (17m) of the steam turbine room. The inlet of the outlet electric valve is connected to the outlet pipe of the steam feed pump, valve seal adopts packing graphite packing type. The valve consists of valve body, spring, left disc, right disc, packing chamber seat, packing seat ring, stem, packing gland, guide plate, electric device, support, clamping ring, gate, presser plate, pressing ring, pad block, four-way ring, sealing ring, locating pin, stud and nut, etc. There are two main types of sealing packing, top and bottom of the outermost for braided graphite packing, the middle layer for flexible graphite packing [1].

2. Description of fault phenomenon

At 5:02 on June 20, 2018, the load was 458 MW, the B steam feed pump was running at a speed of 3596r/min, and the feed water pressure at the pump outlet was 15.4Mpa. A steam feed pump started to run. At 5:28, the load was 566MW, the speed of B steam feed pump was 3656r/min, and the feed pressure at the pump outlet was 19.01Mpa, the speed of A steam feed pump was 3631r/min, and the



feed pressure at the pump outlet was 19.02Mpa (seen in figure2).A and B steam feed pumps were running together. Field inspection showed that external leakage of the electric valve at the outlet of A steam feed pump gradually intensifies.

At 16:18, the load was 534MW, the speed of B steam feed pump was 4220r/min, the feed water pressure at the pump outlet was 18.7Mpa, A steam feed pump was out of operation, the electric valve at the pump outlet was closed, the leakage was still serious, and it could not be repaired online. The power plant applied to the provincial power grid for temporary maintenance shutdown. After the approval, the unit started to reduce the load and shut down manually.

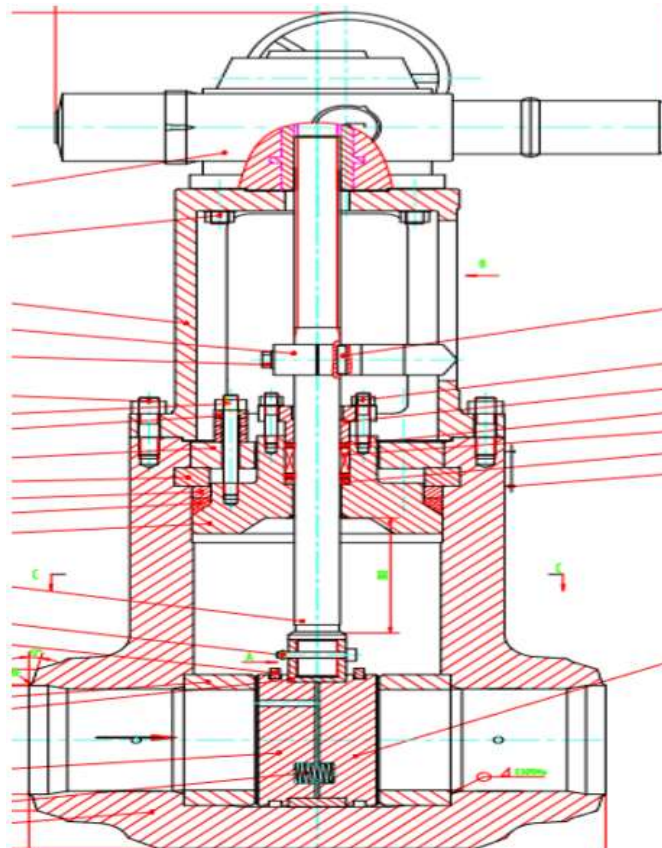


Figure 1. Profile of the A electric valve at the outlet of the steam feed pump the connection.

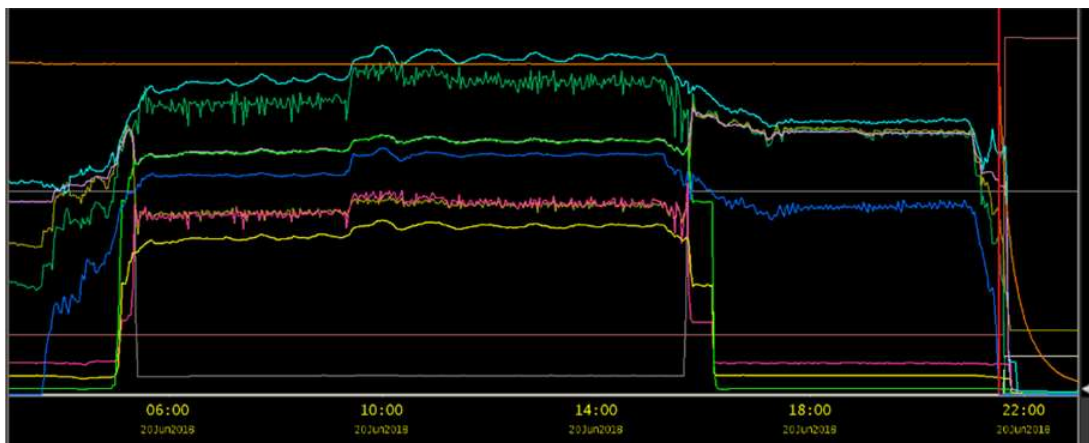


Figure 2. Unit load, feed pump speed trend chart.

3. Analysis of Fault cause

3.1. Reason analysis of shutdown

The shutdown of the unit was caused by severe external leakage of high-temperature and high-pressure feed water through the outlet electric valve of a steam feed pump along the direction of the valve stem (seen in figure3). Feed water of high-temperature and pressure leaked, then vaporized into high - temperature steam rapidly. A steam feed pump outlet electric valve could not be repaired online, thus the unit can only be shut down for the corresponding treatment.



Figure 3. Leakage diagram of the electric valve at the outlet of a steam feed pump.

After on-site investigation, diagnosis and analysis, the main reason for the leakage of the electric valve at the outlet of A steam feed pump was the serious leakage at the root of the electric valve.

3.2. Analysis of the root leakage of the electric valve at the outlet of A steam feed pump

Combined with practical maintenance and operation experience, there may be the following reasons towards A steam feed pump outlet electric valve root leakage, one by one for investigation.

- 1) Checked the gland of the electric valve at the outlet of A steam feed pump

The gland of the electric valve at the outlet of A steam feed pump was checked and no damage was found.

- 2) Checked the packing of the electric valve at the outlet of the steam feed pump

Disassembled the packing gland of the outlet electric valve, removed the connecting bolts, nuts and gaskets, etc., checked the flexible graphite packing, and found that the outer diameter of the most strengthened flexible graphite packing has local damage along the circumference (seen if figure4).



Figure 4. Diagram of the upper packing of the electric valve at the outlet of a steam feed pump.

3) Checked the outlet electric valve stem of a steam feed pump

Checked the outlet electric valve stem of a steam feed pump, there were no damage or corrosion, and the bending of the valve stem was measured to eliminate the influence of the valve stem.

Based on the above analysis, the main reason for the leakage of the coil root of the electric valve at the outlet of A steam feed pump was the local damage along the circumference of the outer diameter of the reinforced flexible graphite.

3.3. Analysis of damage of flexible graphite reinforced by electric valve at the outlet of steam driven feed pump

Checked the maintenance records and ledger of the unit, it was found that the outlet electric valve of A steam feed pump has been in operation for 6 years since it was put into operation, without any disassembly inspection and graphite packing has not been replaced. The physical and mechanical properties of graphite packing changed, aging and compressible properties became worse. When the valve was in cold state, under the compression of the axial force of packing gland, the axial compression deformation of packing root decreased, resulting in the reduction of radial expansion deformation of packing root, unable to completely fill the gap between the stem and packing packing root, so unable to play a good sealing effect.

When the valve was in hot state, it worked under high temperature and pressure environment, the resilience of graphite packing roots changed worse due to the aging, which makes the thermal expansion of packing roots uneven. As a result, the radial expansion deformation of packing root was not even, and the radial tight contact degree along the stem was not even. The radial force produced by packing packing was not uniform, and then the axial friction on the surface of the stem was not uniform. Some areas were large, and some areas were small, which could not completely balance with the feed water pressure.

High pressure feed water leaked along the stem surface area of small axial friction, flushing of packing surface near stem, resulting in packing volume reduction, aggravate reduced packing sealing effect, made high pressure feed water along the stem surface leakage gradually aggravate[2-3].

4. Exposed major problems

The operator does not fully understand the structure of the equipment, lack of vigilance towards the feed pump outlet electric valve packing problems and there is no effective means of inspection, supervision. Turbine professional experience is insufficient, the hidden trouble of the equipment troubleshooting is not complete, technical level is not comprehensive, failed to timely troubleshooting potential hidden trouble of the equipment, for the pump outlet electric valve packing packing root leakage problem lack of adequate knowledge

Maintenance procedures are not perfect, and lack of effective maintenance work .

5. Treatment measures and effects

After the unit was shut down, the electric valve at the outlet of A steam feed pump shall be repaired urgently:

1) Removed the packing gland of a steam feed pump outlet electric valve, and digged out the inner graphite packing.

2) Cleaned the inner chamber of the packing seat with compressed air or high-pressure water, and polished the inner chamber of the packing seat to ensure no burrs.

3) Checked stem surface to ensure no burrs and prevent damage to packing packing.

4) Checked the gland of packing to ensure that the gland has no wear and crack, used wire brush and file to clean the gland bolts, and applied anti-biting agent when reinstalling.

5) Replaced the packing, using compound packing type, using braided graphite packing at upper and lower ends, using reinforced flexible graphite packing at the middle layer, joint filler packing the incision should be cut into 45° , the joint filler packing should be 180° staggered.

6) Checked the upper surface of the packing seat ring before packing and repacking to ensure that the upper surface was smooth and without inclination.

7) Packing chamber, pressure ring, snap ring, pressure plate and sealing ring shall be tightened before packing and reassembly to ensure complete contact of sealing surface.

8) Adjusted the clearance between the dressing gland and the inner wall of the stem and the packing chamber to meet the design requirements before the packing gland was installed. To prevent the packing root from being extruded due to excessive clearance and axial force compression, affecting the sealing effect;

9) After packing back, tighten the packing gland bolts diagonally to ensure the packing packing was under uniform stress and the packing gland must not tilt. And leaved enough compression margin, so that the entire packing assembly was compressed by 30%, packing gland pressed into the depth of the packing base for its height of $1/4 \sim 1/3$ [4-5].

Disassembled the electric valve at the outlet of A steam feed pump, checked the bending of the valve stem, the flatness of the upper and lower surface of the packing seat ring, and the contact area between the packing seat ring and the packing seat chamber to ensure even contact.

Improved the maintenance procedures, the development of feed pump outlet electric valve detailed maintenance content, including maintenance category, cycle and time limit, maintenance items, maintenance steps, process methods and quality standards, test items and standards after maintenance, regular maintenance items, cycles and standards in the operation process, and the specific contents of operation inspection and maintenance inspection.

Strengthened the training of technical skills of steam turbine personnel, timely understand the equipment failure of other manufacturers, done a good job in troubleshooting equipment hidden trouble.

Take advantage of the opportunity of mediation, checked the B steam feed pump outlet electric valve and replaced packing.

According to the formulated emergency repair plan, after relevant treatment of the electric valve at the outlet of a steam feed pump, starts the machine again. The electric valve at the outlet of A steam feed pump has no leakage and the unit operates normally.

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