Abnormal shutdown analysis and treatment of sub-critical 300MW unit due to low EH oil pressure

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Abstract. When the sub-critical 300MW steam turbine generator set of a power plant operates normally, the pressure of EH oil system gradually decreases when the B EH oil pump operates, then switching to A EH oil pump, the pressure of EH oil system rises and then gradually decreases to the protection action, and the unit shutdown. Through on-site inspection and inspection of maintenance records, it was found that the EH oil particles seriously exceeded the standard. The leakage fault of the absorbent in the regenerated filter element of the external oil filter was diagnosed and investigated. After replacing the EH oil pump inlet and outlet filters, the inlet filter of the main valve and the regulating valve oil motor control block, the EH oil system was flushed with a large flow of EH oil and replaced with a new EH oil, and other effective measures were taken to eliminate the potential safety hazards in equipment operation.

Keywords. External oil filter; EH oil particle size exceeds standard; Fault diagnosis; Fault treatment.

1. Overview of equipment and system

The unit of A power plant is a sub-critical 300MW steam turbine generator set. The EH oil system is equipped with two EH pumps, A and B EH pumps, both of pumps are pressure compensated variable plunger pumps. The unit is equipped with an external oil filter, which can filter anti-fuel oil online. This oil filter is a KZTZ-2 type produced by xi'an thermal engineering research institute co., LTD. (the system diagram shown in figure 1). The pump flow is 0.6m3/h, the operating temperature is from 35 to 60°C, the system pressure is no more than 2.5Mpa, the pressure difference of dehydrator is no more than 0.5Mpa, the differential pressure of regenerator is no more than 1.3Mpa, the differential pressure of coarse and fine filter is no more than 0.35Mpa, the power is 1.5KW, and the power supply voltage is 380V[1].
2. Description of fault phenomenon
At 9:28 a.m., November 13, 2017, the pressure of the EH oil system started to decrease from 14.7 MPa to 12 MPa when the B EH oil pump was in operation. The unit load was 202 MW, the main steam pressure was 13.4 MPa. Then started the A EH oil pump immediately, the pressure of the EH oil system rose again to 14.7 MPa and then began to slow down after two pumps were running in parallel. In order to verify the output of the oil pump, the B EH oil pump was shut down manually and the system pressure dropped rapidly. One minute later, the system pressure continued to drop after manually starting the B EH oil pump. After ten minutes, the pressure of EH oil system dropped to 9.31 MPa (shown in figure 2), and the unit shutdown. The first reason was "low EH oil pressure".
3. Analysis of Fault cause

3.1. Cause analysis of pressure reduction in EH oil system

The field inspection of EH oil system was carried out, and the possible causes were investigated one by one.

1) Checked leakage of overflow valve on top of EH oil tank

Through checking the overflow valve on the top of the EH oil tank, measuring the temperature of the pipeline behind the overflow valve on site, comparing it with the temperature of the EH oil tank, the pipe temperature behind the overflow valve was lower than the temperature of the oil tank, so the possibility of internal leakage of the overflow valve opening could be eliminated.

2) Leakage inspection of external EH oil system

Inspected EH oil system, focusing on the pipeline weld, flange, live joint and solenoid valve inspection, there were no leakage points. At the same time, checked the oil level of EH oil tank, without any change before and after shutdown, so the possibility of leakage of EH oil could be eliminated.

3) Leakage inspection of EH oil system

When the EH oil pressure of the unit began to drop, in order to check the leakage in the system, the oil inlet isolation door of #6, #3 and #4 high-regulating valve oil motor were closed successively, and #1 oil inlet isolation door of oil motor was also closed, the EH oil pressure still showed a downward trend, so the possibility of leakage in the system could be eliminated.

4) Checked the filter screen blockage at the outlet of EH oil pump

When the pressure of EH oil system of the unit drops, the motor current of EH oil pump also began to decrease. Because EH oil pump is a kind of plunger pump, the flow rate of EH oil pump could be judged to decrease, and the pressure of EH oil system could not be maintained constant. Since there were filters before and after the EH oil pump, the possibility of clogging the outlet filter has been eliminated. There was no differential pressure measuring point in the inlet filter of the EH oil pump, so it is impossible to accurately judge the clogging situation of the inlet filter. In order to accurately judge the blockage of the inlet filter of EH oil pump, the inlet filter of A and B oil pump was disassembled and inspected, and it was found that the inlet filter was seriously blocked with a large number of fine granular impurities attached to the filter (shown in figure 3). As a result, EH oil flow at the inlet of EH oil pump was greatly reduced, and pressure of EH oil system was reduced.
7) EH oil particle size test
The EH oil is tested, focusing on the examination of the particle size index. According to the report sheet, the particle size was 12, the standard requirement was no more than 6, and the particle size index exceeded the standard seriously.

The particle size index in EH oil exceeded the standard seriously, then blocked inlet screen of EH oil pump, so reduced the EH oil flow, the servo valve of EH oil system was more, there were certain leakage (design allowed a certain amount of leakage), it could not maintain EH oil pressure of the system, and caused EH oil system pressure gradually decreases.

3.2. Analysis of EH oil particle size exceeding standard
After EH oil pump shutdown, the fine particle substance attached to the inlet filter net was inspected, and it was found that the substance was brought into the system instead of generated in the system. At the same time, the upper end cover of the EH oil tank was removed, and it was found that there were a large number of fine particles at the bottom of the EH oil tank, and it was brought in from the return pipe connected with the EH oil tank and the external oil filter.

After field inspection, it was found that the inlet and return pipes of the external oil filter were connected with the EH oil tank. Checked the maintenance, operation and inspection records and found that all the filter elements of the oil filter were replaced on October 8, 2017. On October 31, solstice carried out the oil filtration work of the hydraulic oil system of the butterfly valve for heating of other units, and then connected the oil filter to the unit for oil filtration work. Next, it focused on the inspection of the external oil filter.

1) Checked the top cover of the dehydrator of the oil filter (1.9cm thick stainlesssteel), obvious deformation could be fouled.
2) Field inspection found that the multiple pressure gauges installed in the external oil filter device could not return to zero due to the overrange. Where, the pointer of the pressure gauge before the coarse and fine filter elements stayed at the overrange position, and the pointer of the system pressure gauge stayed at the position of 2.5MPa (shown in figure 4).
3) Checked the pressure alarm control system before the fine filter element of the oil filter. The circuit and relay worked normally and the pressure switch was damaged (the normal operating value is 0.35MPa).
4) After disintegrating and inspecting the filter element of the oil filter, it was found that the metal inner cylinder of a regenerated filter element was seriously deformed (shown in figure 5), and the sealant of the upper end cover of the filter element cracked, causing the leakage of fine particle regenerated adsorbent inside the filter element.
5) Through inspection, it was found that the refined filter core exported by the oil filter was seriously deformed (shown in figure 6), and the coarse filter core was not the original filter core.
produced by xi'an thermal engineering research institute co., LTD., and the filtration accuracy grade exceeded the design requirements, failing to meet the system filtration requirements.

![Pressure gauge with coarse strainer and fine strainer](image)

**Figure 4.** Pressure gauge for external oil filter.

![Regenerated filter element with serious deformation](image)

**Figure 5.** Regenerated filter element with serious deformation of external oil filter.

![Highly deformed fine filter element](image)

**Figure 6.** Highly deformed fine filter element of external oil filter.

Based on the above analysis, the adsorbent inside the filter element of the oil filter regeneration is hard and poor in fluidity. After the oil filter is started, the system is seriously overpressure, resulting in deformation and damage of the filter element of the oil filter regeneration, cracking of the sealant of the filter element upper end cover, and leakage of the adsorbent[2-4]. After the external leakage adsorbent
passes through the coarse filter core which does not meet the design requirements, it is attached to the surface of the fine filter core, causing the pressure increase before the fine filter core of the oil filter.

The high pressure of the fine filter element of the oil filter fails to protect, resulting in the deformation failure of the fine filter element. The absorbent of the regenerative filter element enters the EH oil tank after passing through the fine filter element, resulting in the excessive particle size of the EH oil[5]. As EH oil is pumped along the pipeline by EH oil pump to the inlet filter screen before EH oil pump, the inlet filter screen is blocked, the EH oil flow into EH oil pump is reduced, and the oil pressure of EH oil system is gradually reduced until the protection action, and then the unit trips.

4. Treatment measures and effects
1) Develop management measures related to the operation and maintenance of oil filter, and strengthen the monitoring of important operating parameters such as oil pressure and screen pressure difference of oil filter system.
2) Organize special training on oil filter operation and maintenance for maintenance personnel to improve their business skills.
3) Eliminate the filter element pressure high alarm stop failure and other defects existing in the filter; And by analogy, the other filter to carry out hidden trouble investigation.
4) Work out operation inspection card of oil filter, define inspection items and ensure safe operation of oil filter.
5) Regularly check the overflow valve and control protection device of oil filter system.
6) Standardize the acceptance of filter elements upon arrival, focus on the inspection of quality assurance documents such as certificates, and check the authenticity with the manufacturer in time.
7) This type of oil filter is upgraded and transformed, adding the alarm and stop pump protection function of high pump outlet pressure, adding the alarm and warning device of oil filter to effectively remind the monitoring personnel to find faults in time.
8) Drain and clean the EH oil tank. After cleaning the oil tank, flush the system with high-flow oil.
9) Replace the EH oil pump inlet and outlet filters, replace the main valve, the valve oil control block inlet filter, replace the EH oil.

According to the established emergency repair plan, after the relevant treatment of EH oil system, after starting the B EH oil pump, the pressure of EH oil system is normal, and then switch to A EH oil pump, the pressure of EH oil system is unchanged. The EH oil system pressure is normal and the unit runs normally until the unit is loaded.

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