Shutdown analysis and treatment of 150MW steam extraction heating unit due to low oil fuel level

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Abstract. When the 150MW steam turbine generator set of a power plant operates normally, the pressure of EH oil system gradually decreases and the fuel level drops in the tank, then switching to standby EH oil pump, the pressure of EH oil system continues to drop to the protection action, and the unit shutdown. Through on-site inspection and inspection of maintenance records, it was found that there was serious oil leakage at the oil outlet of mobile oil filter and the oil outlet pipe of EH oil cooling pump. The cause of the fault was analyzed accurately. Effective measures such as changing the connection mode between mobile oil filter and EH oil to eliminate the potential safety hazards in equipment operation.

Keywords. Mobile oil filter; EH oil leakage; Fault treatment.

1. Overview of equipment and system

The unit of a power plant is 150MW steam turbine generator set, and the steam turbine model is C150-13.24/0.981/535/535 (ultra-high pressure, single shaft, double cylinder, primary and intermediate reheat, and extraction and coagulation). It was put into operation in March 2003.

The high-pressure oil pump sucks oil from the EH oil tank, enters the high-pressure accumulator through the pressure filter and one-way valve, and then sends it to the actuator and the critical blocking system. The mobile EH oil filter is a KZTZ-2 type produced by xi'an thermal engineering research institute co., LTD. 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 EH oil system of steam turbine is recycled and filtered monthly. The inlet of oil filter is the inlet of cooling oil pump at the bottom of EH oil tank, and the outlet of oil filter is between the outlet of cooling oil pump and EH oil cooler.
2. Description of fault phenomenon
At 20:46, July 1, 2018, the unit load was 111.9MW, EH oil pump operated normally, and the pressure of EH oil system was 14.3Mpa, the fuel level of the oil tank was 509mm, the oil temperature was 54.7°C. After three minutes, the fuel level of the oil tank began to decline. At 20:51, operation supervisor found low EH oil level alarm and started to check the EH oil system, at this time, the fuel level of the oil tank was 438mm. At 20:57, operation supervisor started the standby EH oil pump immediately, but the oil pressure continued to decline. At 21:02, the oil pressure decined to 9.3Mpa (shown in figure 2), then the unit shutdown. The speed of steam turbine was up to 3145r/min (shown in figure 3).

![Figure 1. Flow chart of EH mobile oil filter.](image1)

![Figure 2. Variation curve of oil level and oil pressure in EH oil system.](image2)

![Figure 3. Turbine speed change curve after shutdown.](image3)
3. Fault analysis

The shutdown reason of the unit was that the pressure of EH oil system reduced to the protection action value. The pressure decrease of EH oil system was mainly due to the gradual decrease of oil fuel level.

3.1. Analysis of oil level drop of EH oil tank

The oil fuel level of EH oil tank began to drop, and still dropped after starting the standby pump. The main reason may be the external leakage of EH oil system. Therefore, the possible leakage locations in EH oil system were emphatically investigated one by one.

1) Critical block module leakage inspection

The critical blocking module of EH oil system was inspected, focusing on the inspection of OPC solenoid valve, AST solenoid valve and live joint, etc. No leakage points were found, and the possibility of external leakage of critical blocking module was excluded.

2) Oil engine and control block leakage inspection

Checked the oil motor, control block, servo valve, unloading valve and other related components of the high pressure main valve, high pressure regulating valve, medium pressure main valve and medium pressure regulating valve of the main engine as well as the regulating valve of the feed pump steam turbine. No leakage points were found. The possibility of oil motor, control block, servo valve and unloading valve was excluded.

3) Accumulator inspection

After the unit shutdown, all the accumulators in the EH oil system were inspected. The inlet and outlet valves of the accumulator were inspected, and no leakage was found. The possibility of leakage of the accumulator in the EH oil system was excluded.

4) Checked the leakage of diaphragm valve

After the unit shutdown, the diaphragm valve and its pipe near the front bearing box of the steam turbine were checked for external leakage. No leakage phenomenon was found, and the possibility of external leakage of the diaphragm valve was excluded.

5) Leakage inspection of EH oil tank

All interface of EH oil tank were checked on-site, the hose connecting the EH oil tank with the mobile oil filter was disconnected and there was a lot of leakage (shown in figure 5), the position was the part where the oil outlet of the mobile oil filter connected with the oil outlet pipe of the EH oil cooling pump. The oil inlet of the mobile oil filter did not leak.

The oil level indicator of EH oil tank was checked, and the oil level display value was consistent with the far oil transmission level. The leakage position of EH oil system was determined to be the interface position between the oil outlet of mobile oil filter and the oil outlet pipe of EH oil cooling pump.

Figure 4. Site leakage location.
3.2. Reason analysis on the connecting hose of mobile oil filter was disconnected
The mobile oil filter was connected to the outlet pipe of the cooling oil pump of the EH oil system, and was tied with two strands of NO.12 iron wire (diameter is 2.64mm), without anti-stripping fixation. When EH oil tank temperature rised to 55 ℃, EH oil cooling oil pump started to work, the oil pressure in the outlet pump rised sharply, it caused the binding iron wire loosed in the position of movable filter oil machine hoses under cooling oil pump outlet pressure, then connecting hoses released.[1]-[4]

3.3. Reason analysis on the turbine speed increase
Checked the startup operation record of the unit and found that the main steam parameters failed to meet the requirements of cold startup when the unit was started in a cold state. In the process of temperature rising and pressure increasing, the turbine speed rised automatically, which was basically maintained at about 300r/min when the valve was not opened.

Referring to the shutdown operation record of the unit, it was found that the idle running time of the last two downtime was 150min and 89min respectively, while the designed idle running time of the whole vacuum idle running curve of the steam turbine is 45min. It fully showed that the steam turbine valve was not qualified and steam leakage existed.

After the turbine shutdown, high and medium pressure main valves and regulating doors were closed, leakage steam with high temperature and high pressure which carried a lot of heat flowed into the cylinder, the generator has been dismounted, steam heat can only be converted into the rotor's kinetic energy, making the rotor speed increased [5].

4. Treatment measures and effects
Improve the oil filter management regulations and the oil filter start and stop operation cards, clear specification of oil filter start, stop operation steps, and according to the operation card to operate, check, to ensure the safe operation of oil filter.

Regularly supervise the operation, start and stop operation, maintenance process and daily oil filtering work of the oil filter.

Organize special training on oil filter operation and maintenance for maintenance personnel.

The connection between the mobile oil filter and the EH oil system is changed into a stainless steel metal hose, and the connection adopts the special live connection method of the EH oil system, and adopts the sealing ring made of fluorine rubber material. The installation and disassembly of the live connection shall be carried out in strict accordance with the established process to ensure that the live connection is firm.

The monitoring and inspection of oil level in the oil system should be strengthened, and the fluctuation of oil level can be detected and checked in time.

In view of the steam turbine valve tightness is not strict, as early as possible to formulate the steam turbine anti-overspeed prevention measures, to avoid the steam turbine overspeed incidents occur again. And as soon as possible to use the unit overhaul opportunity to steam turbine valve for a comprehensive inspection and repair treatment, the valve seat of the high-profile valve for a detailed inspection, the seat of the erosion part of the valve seat for welding repair treatment, the high-profile valve disc and valve seat sealing surface for on-site grinding, to ensure that the sealing surface is tight, in line with the design requirements.

In strict accordance with the requirements of China huadian group steam turbine technical supervision and implementation rules, regularly carry out valve tightness, valve activities, overspeed test and critical safety device oil injection test, as well as valve closing time test.

Fill oil in the EH oil tank, test the oil quality of the new EH oil, and filter oil to ensure that the oil quality meets the standard requirements.

According to the established emergency repair plan, the EH oil system and the mobile oil filter are processed, and then the unit is started. Until the rated load is taken, the pressure of the EH oil system is normal, and the unit runs normally.
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