Analysis and treatment of abnormal shutdown of 150MW unit due to low feed water flow

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Abstract. The water level of NO.2 high pressure heater rised when the 150MW turbo-generator set of a power plant operated normally, it was unassembled and checked. After the high pressure heater was put into operation, the water level of the boiler drum droped. After the standby electric pump was started and the electric load was reduced, the water level of the boiler drum still dropped, resulting in the boiler feed water flow reduced to the protection action and the unit shutdown. Through inspection, it was found that the connecting rod pin of the manual valve at the outlet of the high-pressure heater was broken, which maked the manual valve at the outlet not fully open and lead to low water flow rate at the water side of the high-pressure heater. After the corresponding improvement and optimization measures were taken, the unit can be restarted and run normally.

Keywords. Boiler drum water level; Boiler feed flow; High pressure heater outlet manual valve; Fault diagnosis; Fault treatment

1. Overview of equipment
The unit of a power plant is an 150MW steam turbine generator set, the model is C150-13.24/0.981/535/535, the steam turbine is ultra-high pressure, single shaft, double cylinders, one-time intermediate reheating and extraction coagulation type. It was put into production in March 2003.

The water supply system is equipped with two steam driven feed pumps with a capacity of 50%BMCR, which are A steam pump and B steam pump respectively. The supporting steam turbine models are all 40CHTA/6SP. The rated flow is 483m³/h and maximum flow is 534 m³/. The model of supporting motor is YKS710-2, and the rated speed is 2985r/min, rated current is 390A, cooling mode is air cooling.

2. Overview of fault phenomena
At 6:00 on February 1, 2018, the unit load was 120MW, and the coordinated control mode was running. Due to the high water level of NO.2 high pressure heater, the high pressure heater was unassembled and checked.
At 14:20, the unit load was 114MW, main steam pressure was 13MPa and main steam temperature was 524℃, reheat steam temperature was 530℃, the condenser vacuum was -71.2 KPa, main steam flow was 385 t/h, feed water flow was 374 t/h, A electric feed water pump current was 305 A, feed water pump export mother tube pressure was 14.8 MPa, economizer inlet pressure was 14.4 MPa, the drum water level was 5 mm.

At 14:30, the operators began to put the high-pressure heater into operation after the maintenance of the high-pressure heater was completed.

At 14:48, the unit load was 115MW, the drum water level was -10 mm. At 14:50, the operator opened the inlet joint valve of the high-pressure heater group to feed the high-pressure heater. The drum water level was -14 mm, the main steam flow was 385 t/h, the inlet pressure of the economizer was 14.4 MPa, the current of the electric feed pump A decreased from 305 A to 243 A, the outlet pressure of the main pipe of the feed pump increased from 14.7 MPa to 20.7 MPa, and the inlet flow of the economizer decreased from 361 t/h to 120 t/h. The operator started the B electric feed pump immediately, the pressure of the main pipe at the outlet of the feed pump rose from 20.7 MPa to 21.7 MPa, the inlet flow of the economizer rose from 120 t/h to 142 t/h, and the drum water level was -107 mm.

At 14:51, the unit load target value was set from 115MW to 90MW for load reduction, and the D3, D4 and D1 power feeder was stopped. At 14:52, the drum water level dropped to -230 mm and the unit shutdown.

3. Cause analysis of fault

3.1. Reasons analysis on the shutdown of unit

Refered to related parameters of the unit operation curve (seen in figure 1), we found that the boiler steam drum water level gradually reduced, A and B electric feed water pump minimum flow valve was opened entirely when steam drum water level droped to -230 mm. The boiler steam drum water level still continued to fall until the boiler feed water flow decreased to protection value, then the boiler MFT was triggered, the unit shutdown.

![Figure1. Jump operation diagram.](image)
3.2. *Cause analysis of low feed water flow rate of boiler*

After the maintenance of the high-pressure heater, the high-pressure heater was put into operation, the inlet joint valve of the high-pressure heater group was opened and the water supply bypass of the high-pressure heater was cut off. At the same time, the manual valve at the outlet of the high-pressure heater group was not fully opened (actually two turns were opened), the water flow through the water side of the high-pressure heater was low, resulting in low feed water flow at the inlet of the economizer.

3.3. *Analysis of the manual valve at the outlet of the high-pressure heater group was not fully opened*

The operator found that the water side pressure of the high-pressure heater was 15MPa, then started to operate the manual valve at the outlet of the high-pressure heater group (valve with extended connecting rod).

Three people opened the valve for two turns, and found that the valve became lighter, one person continued to open the valve for eight turns. Then opened the forced hand wheel of the electric coupling valve at the entrance of the high-pressure heater group. The feed water flow chart of the high-pressure heater could be seen in figure 2.

![Figure 2. Feed water flow chart of the high-pressure heater.](image)

After the unit shutdown, we found that the high pressure heater group got behind electric valve without exception, but high pressure heater group export manual valve connecting rod pin broke down and fell off, seen in figure 3 (two pins were made of carbon steel, and model was M8 x 70 mm).
After opening the manual valve at the outlet of the high-pressure heater group for two turns, the fracture of the connecting rod pin was not found in time. Then continued to open eight circles until the link operation was not moving, at this time the operator thought that the valve was fully open, but in fact only opened two circles, resulting in the high-pressure heater group outlet manual valve fully open illusion.

3.4. *Analysis of fracture reason of connecting rod pin*

The connecting rod pin was worn by force for a long time and the material strength decreased. When the valve was opened, the pin was subjected to greater shear force, causing the pin to crack and gradually fracture.

3.5. *Cause analysis on failure to cut back high pressure heater bypass in time*

The manual valve at the outlet of the high-pressure heater group was not fully opened, and then the inlet coupling valve of the high-pressure heater group was opened, and the pressure of the main pipe at the outlet of the feed water pump rose to 20.7MPa. As a result, the electric coupling valve at the inlet of the high-pressure heater group could not be closed and could not be cut back to the bypass of the high-pressure heater in time to improve the feed water flow of the boiler.

4. *Exposed major problem*

The risk analysis and preventive measures of the operation of the high-pressure heater by the operators are not in place. When opening the manual valve at the outlet of the high-pressure heater group, the operator fails to check and confirm the valve opening on the spot.

The design and installation position of the manual valve at the outlet of the high-pressure heater group is not convenient for personnel to check on the spot, and no corresponding rectification measures have been taken.

Failure to timely check the wear of the connecting rod pin of the manual valve at the outlet of the high-pressure heater group during maintenance.

Insufficient understanding of the potential risks in the connection mode of valve lengthened operating rod (seen in figure 4) and insufficient risk investigation.
5. Troubleshooting measures and results achieved

Enhance the ability to analyze the operation risk of high pressure heater, formulate corresponding preventive measures and strictly implement them.

When operating the important valve which endangers the safe operation of the unit, the actual on-off state of the valve must be verified on the spot.

Train operators and standardize valve operation procedure.

Appropriate measures shall be taken to facilitate personnel to check the position of manual valve switch at the outlet of high-pressure heater group on site.

The manual valve at the outlet of the high-pressure heater group was modified, the connecting rod pin structure was cancelled, and the connecting rod of the same type of valve was investigated at the same time.

For valve connecting pin problems, carry out hidden trouble investigation and rectification.

After the implementation of the formulated treatment plan, the operator shall check the normal high-pressure heater system, and then open the inlet joint valve of the high-pressure heater group to confirm that the water side of the high-pressure heater is connected with normal water flow, and the water level of the steam drum is up to the normal level. The unit started again and connected to the network, and the operation was normal.

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