Analysis and Treatment Process of abnormal manual Shutdown of 1000MW thermal Power Unit

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Abstract: The unit 2 of a power plant was shut down manually due to the fire detection fault of coal seam and oil layer. The paper analyzes the specific causes of the incident, points out the problems exposed in the production process, and puts forward the handling and preventive measures.

1. Introduction
The Unit 2 of a company is ultra supercritical unit, and the steam turbine is manufactured by Shanghai Steam Turbine Factory, which is ultra supercritical, one intermediate reheat, single shaft, four cylinder four exhaust, double back pressure and condensing unit. The generator is manufactured by Shanghai Electric Machinery Factory, model THDF125/67, rated capacity 1030MW. The boiler is designed and manufactured by Dongfang Boiler Factory, and the model is DG3024/28.25-II1. It is a once reheatig, single chamber, balanced ventilation, front and back wall opposed combustion mode[1].

The combustion equipment is a swirl pulverized coal burner with front and back wall opposed combustion mode. There are 48 swirl pulverized coal burners arranged in three layers of front wall and back wall, 8 swirl pulverized coal burners for each floor, equipped with 6 medium speed mills ZGM133G. Each mill is 8 in the same layer, and the pulverized coal burner provides air powder mixture. When the designed coal is burned under BMCR condition, 5 mills are put into operation and 1 is standby. The combustion air of pulverized coal burner is divided into four parts: primary air, internal secondary air, external secondary air and central air. The internal secondary air and external secondary air are injected into the furnace at different stages of combustion through the concentric internal secondary air and external secondary air annular channels in the burner (the external secondary air is the external secondary air), so as to realize staged air supply and reduce the generation of NOx. The central air pipe is composed of the central air main pipe and branch pipe[2].

2. Event Experience
Before the manual shutdown, the load of unit 2 is 840mw in AGC mode. The mill A, B, D, E and F were running. At 14:22, the thermal control personnel found that the central air pipe of the burner D3 in the layer D (the third layer) was red, and the central air pipe at the inlet end of the burner D3 was red, so the mill D shuld be stopped (stop the mill at 14:35), then the mill C was started, and the personnel was organized to deal with the connection area at the tail end of the burner D3. The central air pipe of the burner was burned hot, then the hot air smoked to the nearby D3 coal fire detection cable.

At 15:04:05, coal mill C was tripped due to fire detection, RB triggered and the unit switched to TF
mode. The micro oil gun of layer F was put into operation automatically, and the operators manually put the large oil gun of layer A into operation. At 15:04:21, coal mill A was tripped due to fire detection. After 40 seconds, coal mill F, coal mill E and coal mill B were tripped successively for several seconds as shown in Figure 1. Three oil guns in layer A (A1, A2, A4), seven micro oil guns in layer F (F1, F2, F3, F4, F6, F7, F8) were running. DCS scanned that there were fire in seven micro oil guns in F layer, logic calculation did not generate "micro oil without flame", so MFT is not triggered, unit load was rapidly reduced from 811MW to 422MW, and main steam temperature at furnace side was rapidly reduced to 471℃, and main steam temperature at turbine side was rapidly reduced from 601℃ to 520℃. At 15:09, then the operator manually tripped the steam turbine and the boiler MFT acted[3].

![Figure 1: Coal Mill Tripping Trend](image)

### 3. Inspection situation

#### 3.1 Check fire detection Power supply cabinet

On site check the fire detection power supply cabinet of front wall and rear wall of boiler 2. After inspection, two circuits of 220V power supply and 24V control power supply in the fire detection power cabinet are normal.

#### 3.2 Check DCS card and power supply

Check the DCS cabinet of "fire" signal and "flame intensity" signal of all fault fire detectors in the electronic room of boiler 2. The 24V and 48V power supply in the cabinet are normal, and the DI and AI module where the fire detection signal is located are normal[4].

#### 3.3 Check the fire detection equipment

Check the fire detection field equipment of boiler 2, and find that the prefabricated cable of D3 coal fire detection probe is damaged at 2D3 burner (at 14:38, because D3 burner burned red, the operator stopped D coal mill). Through measurement, the 24 V power supply of line 6 and the switching value of line 9 in the prefabricated cable of D3 coal fire detection are grounded.

#### 3.4 Check the parameters of fire detection equipment

Connect the flame detection probe with the flame detection debugging software to check the
equipment parameters. It is found that there were 3 flame detectors in layer B, and 5 in layer C, and 5 in layer D, and 5 in layer E, and 6 in layer F (24 in total) faults are reported. Reset the fault signal through software, and the fault signal of C1, C2, C4, C5, C8 flame detector disappears. But the fault signals of other flame detection probes are not disappeared. Then the remaining fault flame detection probes are powered off and reset one by one, and all fault signals except layer D disappear[5].

3.5 Check RB logic of Coal mill, loss of all fuel logic, loss of all furnace flame logic

Check the RB logic of the mill. When RB is triggered, and the mill F is running, the micro oil in layer F will be put into operation automatically according to the layer feeding sequence, with a time interval of 1s. When the mill F is not running, the F layer oil will not be started and other oil layers will not be put into operation. In the event, mill 2C tripped due to fire detection, then RB triggered, micro oil in layer F was put into operation automatically according to the layer feeding sequence, micro oil gun was put into operation successfully, and fire detection was normal[6].

Check the loss of all fuel logic of boiler 2. When any of the following conditions are met, it is considered that coal bed fuel is lost: a) All coal feeders tripped, b) all mills tripped, c) all primary fans stopped. When any of the following conditions are met, it is considered that the oil layer fuel is lost: a) All oil valves are closed (including micro oil) (delay 5S), b) fuel inlet quick closing valve is closed (delay 5S). When the reservoir is put into operation or the micro oil is put into operation or any coal seam is put into operation, the operation memory will be generated. When there is operation memory, the coal fuel and oil fuel will be lost, and then all fuel protection actions will be triggered. In the event that the mill tripped, seven tiny oil guns in layer F were put into operation, seven tiny oil angle valves were fully opened, and the main oil supply pipe valve in layer F was opened, so the MFT of total fuel loss was not triggered.

Check that boiler 2 has lost the full furnace flame logic: a) When there is no flame detection for oil burner, it is considered that there is no flame detection for oil burner, b) When there is no flame detection for coal burner, it is considered that there is no flame detection for coal burner, c) When there is no oil flame detection and no coal flame detection, it is considered that there is no flame detection. Micro oil fire detection is independent of coal fire detection and oil fire detection, and micro oil fire detection is not affected. During the event, seven micro oil guns of layer F were put into operation, and the fire detection operation circuit could detect that seven micro oil guns of layer F were on fire, and the micro oil guns of layer F were on fire, so the whole furnace flame was not triggered and the MFT was lost[7].

3.6 Check the central air duct of burner

The maintenance personnel extracted out the D3 burner central air duct and found that the central air duct was thoroughly worn.

4 Cause analysis

4.1 Direct cause

The powder in the central air duct of D3 burner ignites, and the central air duct burns hot. The hot air fumes the D3 coal flame detection cable nearby, result short circuit in the prefabricated cable of D3 coal flame detection probe.

Since all flame detection probes are connected in series to the flame detection debugging device, ComA is coal fire detection communication link, ComB is the oil flame detection communication link as shown in Figure2. D3 is short circuit and grounding of fire detection prefabricated cable due to burning loss. The interference signal is connected to the fire detection operation circuit through the communication link in series, resulting in overload of multiple fire detection buffers sharing the link. Finally, it causes a large area interruption and failure of coal fire detection signal. Thus, all mills is tripped, result a sharp drop of the main steam temperature, and the operators manually shut down the unit[8].
4.2 Indirect cause

The central air duct of burner of boiler 2 is inserted into the burner at a horizontal angle, and the secondary air is in the central air duct. The primary air powder pipe enters the burner from the lower part at a vertical angle, so that the primary air powder continuously scours the central air duct at a 90° angle, causing the central air duct to wear through gradually. Because the pressure of the primary air powder is higher than the secondary air pressure, part of the coal powder enters the central air duct from the wear through place and accumulates in the central air duct. Due to the high air temperature of the central air duct (the central air duct is connected to the secondary air box, and the secondary air temperature is about 300 °C when the load is 840MW), sufficient ignition temperature and combustion supporting air are provided for the powder accumulation in the central air duct, which causes the powder accumulation in the central air duct to ignite and burn, and the central air duct burns hot.

Because the installation position of the cables for coal fire detection and oil fire detection is very close to the burner, when the D3 burner abnormally produces high temperature, it is easy to cause the cables to be burnt out by high temperature radiation\textsuperscript{[9]}.

All fire detection probes are sent to the fire detection by the debugging device through 485 series communication. When the fire detection power supply is grounded, the power supply of all probes in the whole communication link will be affected, result in the loss of fire detection signal.

5. Handling and preventive measures

The flame detection communication cable is only used for the convenience of flame detection file configuration, which is unnecessary and can be removed. Therefore, remove all communication cables of coal and oil flame detector to prevent large area loss of fire detection signal caused by communication cable grounding and other factors.

In combination with the unit maintenance opportunity, the central air duct of all burners shall be inspected regularly, In case of any wear and thinning, handle it in time to prevent the central air duct
from being worn.

Strengthen the regular temperature measurement of all burners. In case of burning red, fire, sparks and other phenomena, report immediately and stop the mill in time, immediately close the center windshield of this layer, close all smoke and air baffles of the mill, and conduct purging[10].

Check the thermal control cable passing through the high temperature area, the protective isolation measures shall be taken to avoid cable damage due to high temperature.

6. Conclusion
The analysis process and the cause are accurate. After handling and taking preventive measures, it can effectively ensure the safe and stable operation of the unit. The process of exception analysis, inspection and handling of this manual shutdown can be used for reference to other similar exceptions.

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