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Analysis of Common Fault Types of Thermal Control Instrumentation in Thermal Power Plants and Troubleshooting Methods

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Abstract: *Thermal control instrumentation plays a vital role in the normal operation of thermal power plants. Under high temperature and load operating conditions for a long time, thermal control equipment is prone to occur various failures, thus affecting the operating efficiency and safety of the power plant. In order to ensure the efficient and reliable operation of thermal control instrumentation, the common types of faults of thermal control instrumentation in power plants are introduced, the causes of faults are analysed and put forward specific troubleshooting measures, aimed at providing reference for the relevant practitioners, to ensure the stability of thermal control instrumentation in thermal power plant operation.*

Keywords: *Thermal Control Equipment, Overheating Temperature Control System, Thermal Power Plants, Common Fault, Troubleshooting Method*

1. Introduction

With the implementation of the reform and opening-up policy, the domestic economy has ushered in a period of rapid development, especially the degree of dependence on electric energy, thus precisely puts forward higher requirements for the development of thermal power plants. Thermal power plants have a crucial impact on the power generation field by directly related to the supply of electricity in all regions of the country. In order to give full play to the thermal control automation devices of thermal power plants, it is very crucial to ensure the reliability of the commissioning and installation process during the operation of thermal power plants.

As one of the infrastructures of the thermal control system, the stability of the distributed control system determines the safety and stability of the thermal control system. The distributed control system consists of the grounding inspection system, the distributed power supply inspection system, the supply sequence control and the safety verification of the power supply route. In actual operation, it is necessary to equip professional personnel to carry out line inspection and maintenance to ensure the safety and accuracy of wiring, striving to receive signals normally without error. After that, by monitoring the collected data to determine whether the data is within the range of functional requirements, which ultimately guarantees that the distributed system can operate normally. In the structural design of the distributed control system, it is essential to meet the characteristics of flexible structure and use, as the DCS control system is based on the network communication system, which can achieve the whole process control.

With the progress of science and technological updates, the auxiliary control system has become an important part of the man-machine integrated control and it can achieve the unattended control state. Its working principle is that by using controllers and data switches to achieve the purpose of the operation of the automatic control commands, while using different data interfaces and other auxiliary equipment to complete the control process, finally achieving the purpose of improving the security of the system. The system has been developed so well that it is now possible to use it as a pooled digital transmission mode. Auxiliary control is mainly based on the integrated control of paper templates, inducing the use of unattended control modes, which greatly improves the operational efficiency of the electric heating control system and ensures its safety.

The video network monitoring system is the most advanced monitoring system, by which the relevant personnel can directly observe the whole process of debugging thermal control. What’s more, the system can summarize the problems and discover the causes to ensure the overall safe operation of the power

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plant. The development of the video network monitoring system can realize the service of monitor without personnel present, reducing the problems caused by the personal operation and also ensure the correctness of the thermal control process. Video monitoring systems often do not operate independently and are often used in conjunction with thermal control system integration in practice. Each part of the system is inextricably linked to the auxiliary equipment. Stable operation of the thermal control system can be achieved through interoperability. Video network monitoring systems can be used to achieve the purpose of improving the efficiency of the equipment.

During the operation of a thermal power plant, it is the thermal control equipment that is responsible for the monitor and regulation of the thermal system of the plant to ensure its normal operation. However, due to the thermal control equipment has been working for a long time, complex working conditions and external factors often result in a variety of faults and problems. In this regard, the article combines specific examples, analyses the common failure types and performance of thermal control equipment, and explores effective troubleshooting methods, which is of great significance for improving the operation efficiency and safety of thermal control equipment and guaranteeing the reliable and stable operation of thermal power plants [1].

2. Disconnection of Overheat Temperature Control System and Temperature Sensor

2.1 Fault

During the inspection process it was found that the sensor temperature parameter changed from 456.6 ℃ to 26.1 ℃, which consistent with the thermocouple cold end compensation temperature. However, the change rate of the sensor parameter dramatically exceeded the normal range.

2.2 Fault Analysis

Considering that when a sensor break occurs, the temperature monitoring signal will decrease from a higher value to a lower value for a short period of time. Therefore, the direction and change rate of the signal of the temperature sensor is calculated to analyze the factors that caused sensor failure. When the temperature signal has a large negative rate of change at a certain point in time and the range of change exceeds the normal limits of the sensor, indicating that there may be a disconnection [2].

Analysis of the fault phenomenon found that the temperature parameter shows 456.6 ℃ before the fault, however, it reduced to 26.1 ℃ when the fault occurs. During 1 s diagnostic cycle, the change rate of temperature is 456.6 ℃/s, exceeding the required maximum value rate of the sensor. Therefore, it is reasonable to conclude that the fault is due to the disconnection of the secondary superheater temperature sensor.

2.3 Troubleshooting Methods

In view of the above failure disconnection problems, following processing measures were taken: (1) checking and confirming that the sensor does have a disconnection fault rather than an abnormality caused by other reasons. (2) Confirming the sensor disconnection fault and replace the sensor. (3) Locating the connecting terminals and removing the external coverings of the relevant pipelines or equipment, accompanied with locating the connecting point of the sensor. (4) Checking to find whether there is oxidation or corrosion at the location of the connecting point. Using tools such as metal brushes or sandpaper to clean and repair the connection point appropriately. (5) After cleaning the connection point, the new sensor and the positive and negative poles of the sensor were installed and connected correctly, conforming install it firmly [3]. (6) After the installation is completed, test and monitor were conducted to ensure that the sensor works properly, and the sensor temperature monitoring values are displayed normally. (7) After completing the sensor disconnection troubleshooting, the content of the maintenance treatment is recorded, laying the foundation for subsequent fault diagnosis and prevention.

3. The First Stage Spray Temperature Reducer is Viscous—Sliding Faults

3.1 Fault

The monitoring situation of the first-stage water injection temperature reducing valve is analyzed, and it is found that the command signal has a relatively smooth change curve, while the feedback signal

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curve change is presented as a step, and it is presumed that the temperature reducing valve has a viscous - sliding failure problem.

3.2 Fault Analysis

In normal condition, the movement of the valve stem is smooth and the mean and root-mean-square values of its velocity should be similar. However, when a stick-slip fault occurs, it results in a wide range of difference between the mean and Root Mean Square (RMS) values of the velocity. By comparing the relationship between the mean and RMS values of the velocities, a stick-slip fault can be detected. In the case of stick-slip, the velocity fluctuation of the valve stem increases due to the presence of viscous forces, and the root mean square value of the velocity increases significantly, while the mean value of the velocity is relatively small [4].

The results were analyzed by calculating the ratio of the mean and square root of the velocity of the commanded signals, which was approximately 1. By calculating the ratio of the mean value of the speed of the feedback signal and the root mean square, it turns out to be about 3.5 and the data has a large difference, so it can be determined that the first stage of the water injection desuperheating valve has viscous-sliding fault.

3.3 Troubleshooting Methods

Primary water injection desuperheating valve's viscous-sliding failure will lead to the emergence of the valve's movement is not smooth or stuck phenomenon. Following processes were taken for troubleshooting: (1) checking the lubrication situation to confirm whether the valve has been correctly lubricated. If the lubrication is insufficient or the lubricant is out of date, the appropriate lubricant need to add or replace in a timely manner; (2) Using the detergent to clean the valve internal, including the valve spool, bonnet and other components, to ensure that the valve operates without any foreign objects or contaminants interfere. (3) Checking the sealing surface to make sure whether the sealing surface of the valve is flat and whether there is obvious wear or damage. Grinding or replacement of the sealing surface need to be done in necessary position; (4) Checking to make sure that there is no obstruction, bending or other problems in the pipeline connected to the valve, avoiding the valve operation is not smooth.

In the specific work, if the failure problem still exists after the above treatments, it is necessary to disassemble the valve and clean each part, repair or replace worn or damaged parts.

4. Thermal Instrumentation Control System Malfunction

4.1 Fault

In actual operation, the common failure phenomena of the instrumentation and control system of thermal control equipment include the following aspects: (1) abnormal temperature display, with temperature values jumping, unstable or no display at all; (2) failure of control signals resulting in the equipment not being able to be adjusted in accordance with the expected requirements, which affects the normal work of the thermal control system; (3) abnormal alarm system, which is not able to detect and respond to the abnormalities in a timely manner, and increase the risk of accidents.

4.2 Fault Analysis

For the instrumentation control system with the above problems, the following fault analysis process were taken to determine the specific problems. (1) Observing the fault phenomenon of the thermal control instrumentation control system in detail, including whether there is abnormal information on the display, whether the alarm signal light is on, and guide the subsequent diagnostic steps through the above information; (2) Trying to restart the thermal control instrumentation control system to exclude abnormal operation due to temporary faults. If the problem persists, further diagnosis process is required; (3) Checking the power supply and connection to confirm whether the power supply of the thermal control instrumentation control system is normal to ensure stable power supply. At the same time, checking whether the connection between the instrument and other equipment is loose or damaged to ensure normal signal transmission; (4) Confirming the sensors status and checking whether the corresponding sensors are working properly. For example, the temperature, pressure and other sensors, which can be

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measured by using the test instrument and then compare these data with the system displayed value; (5) Checking the controller settings and reviewing the parameter settings of the controller to confirm whether it meets the production requirements; (6) Analyzing the log file and consulting the log file of the thermal control instrumentation control system to locate the possible causes of failure. The log that records the system's operating status, abnormal information and error codes, can provide important clues.

4.3 Troubleshooting Methods

(1) To handle abnormal temperature display problems, checking the sensor to ensure that the temperature sensor is working properly and is not damaged or loose. Using a test instrument to check the output signal of the sensor and make sure it matches the actual temperature. If the sensor works normally but displays abnormal temperature, it is necessary to calibrate the instrument and solve the problem of abnormal temperature display through calibration. (2) To solve the control signal failure problem, checking the connection to verify whether the connection of the control signal line is normal and make sure there is no disconnection or poor contact. Checking whether the connector part is corroded, damaged or loosed by re-plugging the cable. If the connection of the controller is normal but the control signal still fails, it is presumably that there is a problem with the controller itself. Checking whether the settings of the controller are correct and trying to reprogram or restart the controller to solve the problem. (3) To handle abnormal alarm system problems, the sensors and connections were checked to ensure that the alarm sensors are working properly and are properly connected to the control system. Checking the sensor and signal line connections to make sure there are no disconnections or poor contacts. Checking whether the alarm system settings are correct, including whether the alarm threshold is set properly and whether the alarm setting parameters are adjusted according to the actual situation. If the alarm signal is normal but the alarm does not respond, it is presumed that there is a problem with the alarm itself. Checking if the power supply of the alarm is normal and trying to trigger the alarm manually to test its working status and solve the problem.

5. Problems of Thermal Control Equipment Control System Hardware

5.1 Fault

The voltage of the branch where the thermal control unit card is located fluctuated instantaneously, causing the ‘original flue gas baffle open signal 2’ and ‘original flue gas baffle open signal 3’ of the branch card to change from 1 to 0, resulting in the tripping of the FGD booster fan and the tripping of the boiler main fuel (MFT).

5.2 Fault Analysis

The main reason for this failure is that the base fastening screws are loose, and at the same time, the branch card power supply is unstable. Circuit contact is poor or broken, which in turn affects the normal operation of the card. When the digital input signal (DI) is queried, the voltage decreases, resulting in the disappearance of the feedback signal and false protection. Due to the voltage fluctuation of the branch power supply and the change of signal status, the FGD booster fan may trip due to the triggering of abnormal signals or overload protection mechanism.

5.3 Troubleshooting Methods

To solve this problem, checking the base fastening screws and tighten them to ensure that the clips are firmly connected and to eliminate the possibility of circuit failure caused by looseness. Checking the branch power lines and power supply system to ensure stable power supply and reduce voltage fluctuations. Checking the connection and wiring of relevant cards and equipment to ensure good signal transmission and status feedback. Redundant I/O measurement points for the OVATION control system were assigned on different cards and make sure that the cards are on different backplane branches.

6. Thermal Control Equipment Control System Software Failure

6.1 Fault

When switching the oil pumps of the feedwater pumps in the thermal power plant, the oil pumps were

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stopped directly without confirming the pressure, current and other parameters after the start of the standby oil pumps, resulting in a low-pressure trip of the lubricating oil, which triggered the auxiliary engine's faulty load shedding (RB) action. There was a large deviation between the actual speed of the steam pump and the target speed, resulting in the remote control withdrawal of the steam pump, which changed into the automatic control mode of the small turbine electro-hydraulic control system (MEH). During the inspection, it was found that the speed setting value of the PID module of the steam pump was obviously larger than the actual speed and there was a large deviation. Observing the PID output, it appeared that it became smaller in the opposite direction within a few seconds, resulting in a continuous drop in the low-pressure inlet steam regulator command. Further, the total water supply was obviously lower than the protection limit value and the boiler MFT action appeared.

6.2 Fault Analysis

By using the remote control method, the closed-loop control is triggered again and the set value of the PID module changes abruptly. At the same time, the operating state of the PID module changes from tracking to automatic. Due to timing pitfalls, the output value of the PID module is abnormally adjusted during this process.

6.3 Troubleshooting Methods

To solve this problem, checking the logic of the already exited remote control mode to ensure that the logic and operation are correct. When exiting the remote control mode, stop the remote control signal input in a timely manner and ensure a smooth transition to the closed-loop control mode. At the same time, optimize the logic of closed-loop control triggering, and carefully review the conditions and logic of closed-loop control triggering to ensure correct switching to closed-loop control mode. The acquisition and processing of sensor data is checked to ensure that the data is accurate and reliable, and that the closed-loop control is correctly triggered. In addition, the timing of the MEH closed-loop control judgment should be optimized to ensure the accuracy and stability of the timing, and the logic and algorithm of the judgment should be redesigned and optimized to avoid similar problems.

7. Thermal Control Local Equipment Failure

7.1 Fault

A unit in a power plant was found to have low level signals of 1, 2 and 3 in the EH tank, while the first oil pump tripped, the second oil pump failed to start, the EH oil pressure was low, and the turbine had a tripping fault.

7.2 Fault Analysis

As the EH tank has not been cleaned for a long time, there are a lot of metal particles in the float, and the magnetic float will magnetize the metal particles and the float. Before start-up, the EH oil has been in a static state for a long time, and replenishing the oil will increase the oil level, which will disturb the magnetized metal particles adsorbed on the wall of the float, thus causing the magnetic switch to operate.

7.3 Troubleshooting Methods

In response to the above problems, a reliable differential pressure level meter or guided wave radar level meter is selected as the liquid level measurement method. Differential pressure level gauge measures based on the difference between liquid level and static pressure of liquid, does not depend on magnetic switch and float, and avoids false operation caused by magnetisation of metal particles. Guided wave radar level gauge, on the other hand, uses the principle of microwave signal transmission through waveguide tube for level measurement, effectively avoiding the influence of magnetisation of metal particles.

8. Conclusions

Thermal control equipment plays a key role in ensuring the safe operation of thermal power plants, and through in-depth research on common problrms in the operation and maintenance of thermal control

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equipment, more accurate, fast and effective fault handling can be achieved to improve the reliability and stability of the equipment. In the future, it is also necessary to further explore the intrinsic laws and potential problems of thermal control equipment fault handling methods. Establishing more accurate and credible fault prediction models through large-scale data acquisition and analysis, combined with machine learning and model optimization techniques will further improve the automated maintenance system of the equipment and provide more stable and efficient support for industrial production.

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