Design of Robbing Control Logic for Auxiliary Equipment in Thermal Power Plants

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Abstract: **In order to reduce the probability of unit non-stop caused by factors such as control loop interference, open contact misoperation and low cable insulation, and to narrow the scope of system misoperation, This paper starts with the analysis of typical faults of control systems in recent years in thermal power plants, combines with the daily emergency response operation habits of operators, optimizes and adjusts the control strategy, and designs the "robbing control logic" module, which replaces the emergency operation of the operators and solves the misoperation caused by the control system abnormality, and realizes that it will not lead to the occurrence of accidents or the expansion of the range of accidents under the conditions of misoperation, so as to enhance the attribute of the control system's intrinsic safety, and to provide references for the development of the control system's intrinsic safety.**

Keywords: Misoperation; Non-Stop; Robbing Logic; Control System; Typical Event; Intrinsic Safety

1. Introduction

In recent years, Abnormal events such as non-shutdown and output reduction occur frequently in thermal power plants, and it is caused by many factors such as control loop interference, relay or open contact maloperation, circuit insulation reduction or abnormal restart of control system, resulting in unplanned outage of units, and the probability of similar incidents remains high, which is a major problem that is difficult to be solved completely in the control loop. It is also the long-term focus of power generation enterprises. The power generation groups actively organize and carry out research on the reliability of the main protection, formulate corresponding measures to prevent non-shutdown, and incorporate "zero non-shutdown", "zero anomaly" and "zero accident" into the annual assessment of grassroots power generation enterprises. Therefore, in the field of power generation, a research boom has been set off on anti-non-shutdown measures and main protection reliability improvement. In terms of equipment, reliability improvement measures are proposed from the perspectives of control equipment selection, important signal configuration, control logic optimization, equipment reliability, power supply configuration and logic configuration fault tolerance and availability to prevent equipment misoperation. Reduce the non-shutdown probability of thermal power units [1-5]. In terms of operation and operation emergency handling, the comprehensive quality training of centralized control operation personnel, the establishment of a perfect accident emergency handling system, the strengthening of team cooperation ability of centralized control operation personnel, and relevant practices and training should be improved [6]. However, equipment misoperation caused by factors such as interference and insulation reduction on the circuit should be controlled. It is incurable, and the emergency response of operators takes time, and it still cannot fundamentally solve the problem. With the increasingly severe security situation in the production field, higher requirements are put forward for the intrinsic safety of enterprises, and the safety of production enterprises focuses on the production process and process, the production process consists of many equipment and control systems, and the safety of the production field is not only controlled by the field equipment, but also depends on the safety and stability of the control system. For now, the intrinsic safety only stays in the explosion-proof function of the equipment itself, for the control system, has not yet

formed effective technical measures, once the production equipment and its system is abnormal, are based on the operating experience of the operator, artificial emergency response, reduce the scope of the accident, to avoid the accident. Therefore, based on the original control system, this paper optimizes and adjusts the control soft logic circuit, which is an effective method. The specific design idea is to analyze the fault points of the control system of auxiliary equipment, combine the operation and operation habits, To improve the control loop in the control soft logic from the perspective of the operator, design "Robbing control logic", replace the emergency response operation of the operator, and solve the misoperation caused by the abnormal control system. Realize safety functions such as not causing accidents or expanding the scope of accidents or automatic recovery in the case of misoperation, minimize the scope of accidents, repair misoperation in time, and reduce the probability of device transaction. This method is an effective measure to solve the problem, and it is also a necessary requirement for the intrinsic safety of the control system. At the same time, it also enhances the intrinsic safety of the control system, and provides a reference for the development of the intrinsic safety of the control system of thermal power plants2.Analysis of control system of auxiliary equipment in thermal power plant

2 Analysis of Control System of Auxiliary Equipment in Thermal Power Plant

2.1 Auxiliary Machinery Control

Auxiliary control of thermal power plant comprise local control and remote control, Local control includes normal start or stop and emergency shutdown. Local emergency outage has the highest priority and is not subject to remote control or local switching restrictions. Emergency outage can be realized in case of abnormal accidents. Local normal outage refers to the start-up and outage operations of local equipment in “local mode”. Remote control is in the “remote control” mode, the operation on the upper computer, to achieve the remote start-stop function, the start-stop setting is allowed to block conditions. In this paper, the design of robbing control logic is realized in the control soft logic soft loop of remote distributed control system.

2.2 Device Control Loop Analysis

The equipment control loop mainly includes two categories, one is the relay control hard loop, the other is the PLC or microcomputer control, But the control instructions are from the control system, The drive is powered by the control system DO board.

The hard circuit of relay control is a control circuit built by relays [7]. The circuit structure is complex and the main components are relays. There are the following failure points:(1)Improper selection of relays, insufficient load capacity, too small contact gap, insufficient cleanliness, etc., will lead to the shutdown loop contact turn-on, forcing the operation equipment to shut down.(2) When the control cabinet vibrates, the hard circuit contacts of the relay are also easy to close, resulting in misoperation of the shutdown control circuit.(3) The abnormal fluctuation of the power supply of the relay drive circuit is also easy to cause the action of the control loop relay, resulting in equipment outage.(4) When the CPU of the remote control system restarts or fails, the open signal cannot be maintained, and there is a reversal, resulting in the misoperation of the field equipment.

The PLC or microcomputer control loop is a remote start-stop command that receives the equipment start-stop hard loop or the local control start-stop loop, Which has the following fault points:(1) Abnormal fluctuation of the power supply of the control system, causing the control loop relay to operate, resulting in equipment outage.(2) When the opening node is a thyristor or diode, the insulation of the contact decreases, Which will also lead to misoperation of the control loop.(3) When the CPU of the remote or local control system restarts or fails, The open signal cannot be maintained, and it turns over, Resulting in the misoperation of the field device.(4) The control hard circuit is subjected to strong electrical interference along the way, or the signal is grounded, Which will cause the local PLC to collect remote control instructions, thereby triggering the shutdown loop and equipment outage.

The vast majority of devices are equipped with local control cabinets, and are equipped with normal start or stop and emergency stop buttons, etc. The tight stop button is also called

the emergency stop button, which is not subject to remote/local switching restrictions. Outage, emergency shutdown when the circuit is abnormal, it will lead to abnormal equipment outage.

In summary, the faults described above are abnormal outages, and other outages can be identified as normal equipment outages.

3. Design of Robbing Control Logic for Auxiliary Equipment in Thermal Power Plant

3.1 Robbing Control Logic for Auxiliary Equipment

The so-called snap-in control logic refers to adding a snap-in control logic on the basis of the control loop of auxiliary equipment. In the case of interference in the control loop of auxiliary equipment or misoperation caused by the failure of non-main equipment, the auxiliary snap-in control command is issued in time to replace the emergency operation of the operator and grab the auxiliary machinery that is about to be shut down. Avoid the expansion of the scope of equipment misoperation. It is widely used in the oil pump control circuit of 300MW grade thermal power plants, But the conditions considered are relatively simple, only considering the instantaneous shutdown signal of the oil pump, Using a single stop signal to judge the state of the oil pump, and does not consider the start-up permit of the oil pump and the local operation. When the local accident emergency shutdown operation, the problem of oil pump restart again, there is the risk of equipment misstart. In order to improve the reliability of auxiliary equipment scramble control logic, this paper studies and discusses the shutdown operation of auxiliary equipment, start-up conditions of scramble control and scramble logic design. Finally, a scramble control module is designed and packaged to facilitate the configuration of distributed control system auxiliary control loop in thermal power plant. The block diagram of its snatch structure is shown in Figure 1 follow.

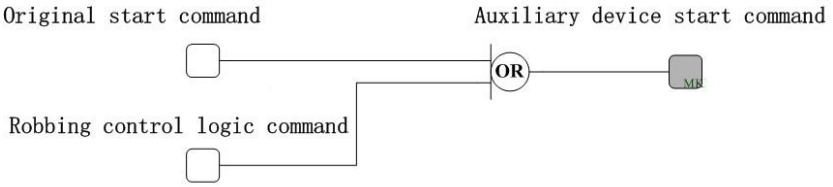

Figure 1. Grab the Structural Block Diagram

3.2 Design of Robbing Control Logic for Auxiliary Equipment in Thermal Power Plants

3.2.1 Abnormal outage judgment of auxiliary engine

From the above analysis of the control loop, it can be seen that the error range of the auxiliary equipment is mainly in the local tight outage, local normal outage and remote outage. Therefore, the auxiliary contact of the local emergency and normal outage operation button is connected to the distributed control system to realize the abnormal outage operation judgment of the auxiliary equipment, that is, the abnormal outage signal is “True”, and the judgment logic is shown in Figure 2 below.

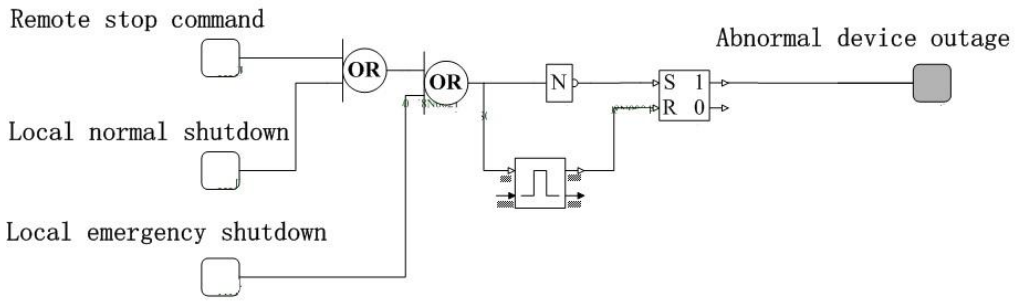

Figure 2. Fault Diagnosis Logic of Abnormal Device Outage

3.2.2 Robbing control logic condition

The abnormal outage of the device and the device in the “remote mode”control mode are the first considerations of the logic design, and also the premise of the effective activation of the module. If the host computer or logic

interlock does not issue a shutdown command, the control system is normal, the device has no fault, the tight stop, normal shutdown button has not been pressed, and there is no remote device shutdown command, it can be judged that the device is abnormal shutdown, and the device startup permit conditions are met.

3.2.3 Design of robbing control logic

When the system determines that the equipment is abnormal outage, the equipment running or full on signal disappears, and the equipment stop or full off signal feedback returns at the moment, and the standby interlock has not been put into operation, the equipment will immediately issue the device snap start command, and the stopped equipment will snap together again, and the snap control logic command judgment is shown in Figure 3 below.

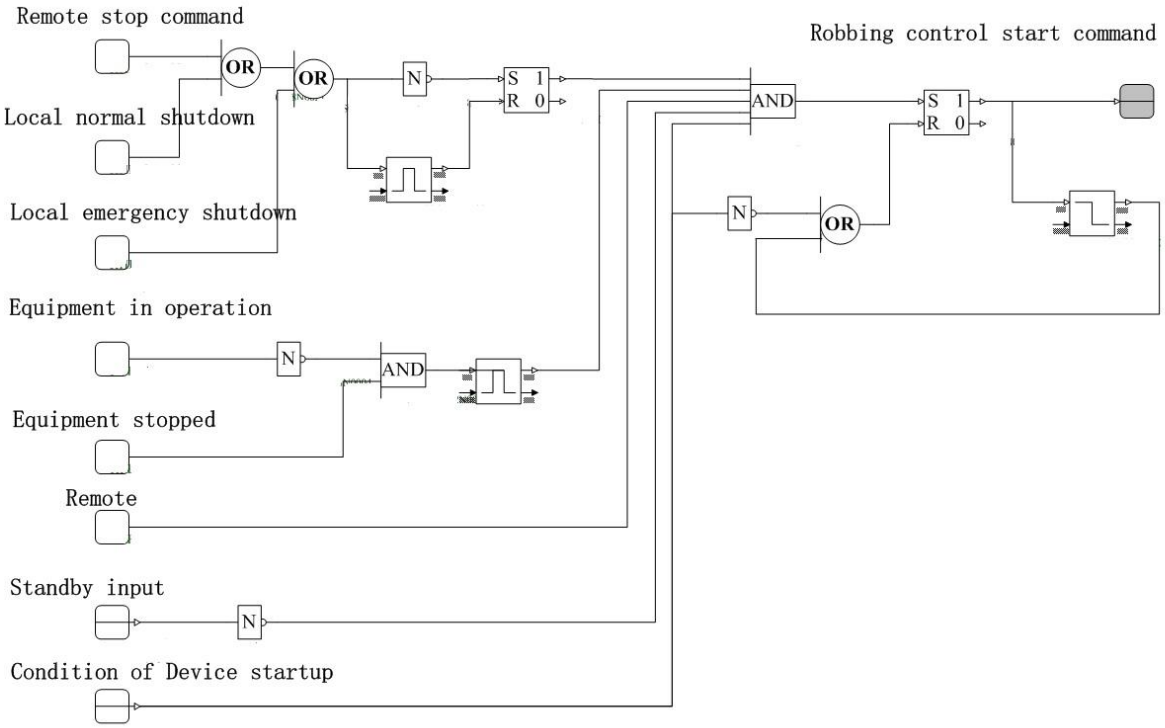

Figure 3. Design of Robbing Control Logic

3.2.4 Robbing logic package and description

The above operation logic is encapsulated to form an independent block of grab control logic function, which is convenient to control logic configuration.The output command of the grab module is in phase with the original start command. Since the distributed control system (DCS) used in thermal power plants is different,it is module package is also different, but the pin and description remain unchanged after the control logic package, the function is the same, and the logic is packaged into an independent module according to Figure 3,as shown in Figure 4.

Each pin of the module is described in detail as follows:

(1) 0 pin: Robbing control logic command, phase with the control loop start instruction, to achieve the abnormal shutdown device snatch, the default value is False.

(2) 1 pin: Remote stop command, used to monitor whether the device exists remote outage or system interlock outage. The default value is False.

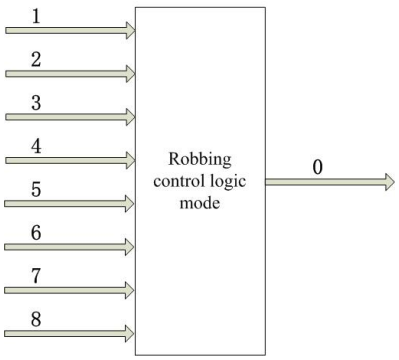

Figure 4. Module Mask

(3) 2 Pin: local normal shutdown, monitoring whether the local normal shutdown button is

pressed, the default value is False.
(4) 3 Pin: local emergency shutdown, monitoring the local emergency button is pressed, he default value is False.
(5) 4 Pin: Equipment in operation, monitors the device running status. The default value is False.
(6) 5 Pin: Equipment stopped. Monitor the device running status. The default value is False.
(7) 6 Pin: Remote mode, whether the signal access, depending on the case, the default value is True.
(8) 7 pin: Standby input, mainly used for 380 auxiliary machinery, pump and fan outlet baffle, the signal is not applicable, the default value is False.
(9) 8 Pin: conditions of the device starts, again determine whether the device is allowed to start, if the start conditions are met, the start command is issued, the default value is False.
Pin 1, Pin 2, and Pin 3 signals are mainly used to determine whether the device is in normal outage, and further diagnose whether the device is in normal outage. If the output of the judgment is “True”, it is an abnormal outage of the device. The equipment is operated at a distance, and the equipment is allowed to start, and the chain backup is not put in, and the equipment is out of service instantaneously (the running signal disappears, and the equipment has stopped), the equipment is immediately issued the device robbing control logic start command, and the equipment is rescued.
Pin 4 and Pin 5: It is mainly used to determine the operating status of the equipment, using the running or opened signal to invert, and equipment shutdown or closed signal phase, to avoid misjudgment of equipment operating status.
When the scramble self-judgment logic does not meet the conditions, the device startup task is handed over to the upper computer operator station, and the normal startup of the device is not allowed, because the scramble control instruction and the device startup instruction share the same channel. In order to prevent the upper relay drive circuit from being charged for a long time, the equipment outage state and the control logic command signal are set as pulse signals, and the automatic starting of the equipment under outage condition is also eliminated. Due to the large number of auxiliary machines used in thermal power units and the different control systems, the delay block is adopted to reset the command output of the logic function block, so as to facilitate the setting of the pulse width of the output command and meet the requirements of the local drive command time of different devices.
As for the pulse and delay time, it can be set on the spot according to needs, and the pulse width of the grab output command can also be controlled by the delay block. The default value is 3 second, that is, when the command is issued for 3 second, the grab output command will be automatically reset, or if the grab permission is not met, the grab output will be blocked.

3.3 Application of Robbing Control Logic

In the normal operation of the unit, the valve at the outlet of the pump or fan or the pump or pump that needs to be continuously operated, such as the fan oil station, the stator cooling pump, the circulating pump and the outlet valve, the turbine lubrication pump and the sealing fan, once the abnormal outage or shutdown occurs, the safe and stable operation of the unit will be destroyed, resulting in the unplanned outage of the unit. In this case, experienced operators need time for emergency treatment, which is easy to lead to the outage of the unit or the expansion of the fault scope, therefore, it is more suitable to increase the grab control logic in the auxiliary engine control system, in the moment of abnormal occurrence, automatic and timely remedial measures are taken, the outage equipment grab together, and the fault scope is reduced. Therefore, optimizing the control strategy from the soft logic and adding the grab control logic have far-reaching significance for improving the intrinsic safety of the control system. The application mainly includes the following aspects:
(1) Fan exit baffle plate: The abnormal closure of the fan exit baffle plate of the primary fan, induced draft fan, supply fan, cooling fan and sealing air in the thermal power plant will cause the fan to trip, therefore, at the exit of such fans, you can consider the control logic design to grab the abnormal closure baffle plate in a period of time. In terms of its logical design, the “spare uninvested” signal is removed and the rest remains unchanged.

(2) Pump outlet valve: thermal power plant stator cooling pump, auxiliary oil station oil pump, circulating water pump, open water pump and closed water pump outlet valve, abnormal closure, will also lead to pump trip, spread large accident range. Therefore, the valve design at the pump outlet grab the control logic, but also effectively avoid the valve accidental closure to expand the scope of equipment misoperation.

(3) 380 volt auxiliary machine: Coal mill, primary fan, induced draft fan and supply fan have lubricating oil station, oil pump abnormal outage, not timely, will lead to the corresponding coal mill, primary fan, induced draft fan and supply fan trip, causing the unit unplanned outage, expand the scope of the accident. Therefore, in this kind of auxiliary machine control soft loop, adding the scrambling control logic to replace the emergency operation of the operator can be in a shorter time, the abnormal outage of the auxiliary machine together to avoid the expansion of the accident scope, which is also an effective measure.

In short, if the auxiliary equipment is allowed to start, it is feasible to seize the auxiliary equipment, and it is also the most effective emergency measure at present.

4. Summary

In the original control logic loop, it is an effective measure to add the optimization and adjustment of the grab control logic, replace the emergency response operation of the operator, minimize the fault range, and even avoid the non-shutdown of the unit. At present, it has been applied in 300MW thermal power plant auxiliary oil station system, cooling water system, fan outlet baffle and pump outlet valve, and its effect is also more significant, worthy of promotion and application. At the same time, it is also a direction of the expansion of intrinsic safety from the field of equipment to the control system of equipment, which has far-reaching significance.

References

[1] Wang, H.B & Wang, H.Q. (2016). Research on thermal control reliability of auxiliary equipment of single system in thermal power plant. Shanxi Electric Power (06), 66-68.

[2] Zheng, L. (2022). Solution measures and case analysis of thermal protection misoperation and rejection in thermal power plant. Modern industrial economy and informatization (02), 250-252. doi:10.16525/j.cnki.14-1362/n.2022.02.096.

[3] Ma, Y.S, Guo, J & Zhang, C. (2014). Problems in thermal protection of 600MW unit and measures for improvement. (eds.) 2014 China Power Plant Thermal Automation Technology Forum Proceedings (Volume 2) (pp.216-221). Han, X.J & Han, X.C. (2022). Discussion on reliability improvement of thermal protection control system in thermal power plant. Energy technology (05), 54-58.

[4] Di, R.B, Liu, L.H, Li, J.L & Hao, W. (2022). Some pre-control measures for reducing non-shutdown of units in thermal engineering specialty of thermal power plant. Instrument user (10), 93-96+62.

[5] Tian, Z.Q. (2019). Improve the accident handling ability of centralized control operators in thermal power plants. Digital communication world (11), 221.

[6] Dai, W.G. (2021). Study on fault characteristics and structure optimization of mechanical system of electromagnetic relay. (master's thesis, Liaoning Project Technology University) .https://elib.cqlib.cn:8081/interlibSSO/goto/10/+jmr9bmjh9mds/KCMS/detail/detail.aspx?dbname=CMFD202301&filename=1022704104.nh

