Characteristics of Multi-Stage Auxiliary Equipment Linkage in Pumped Storage Power Station Under Double Carbon Target

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Abstract: The auxiliary control linkage system of the pumped storage power station has become a necessary technical means for the safe operation and production of the station. However, due to the scattered linkage control function and low control level of each subsystem of the pumped storage power station, the security system cannot play a full role, affecting the safety portion and other effects. This paper studies a multistage auxiliary equipment linkage method based on a linkage body for the pumped storage power station. In the framework of the system dividing safety intervals, five linkage bodies are constructed for multi-layer hierarchical linkage, including real-time monitoring, fire fighting, five-prevention locking, online monitoring, and video monitoring. Completing the development of the linkage method of auxiliary equipment comprehensive control based on a multi-level linkage strategy and implementing multi-stage auxiliary equipment linkage in the station can reduce the loss of auxiliary equipment in pumped storage stations and improve the carbon neutrality and carbon compliance benefit of the pumped storage stations.

Keywords: Pumping and Storage Power Station, Integrated Control of Auxiliary Equipment, Zonal Deployment, Linkage

1. Introduction

With the continuous progress of water conservancy and hydropower construction under the double carbon target, the automation level of pumped storage power stations is constantly improving; the operation modes such as "no one on duty" (few people on duty) and centralized monitoring are rapidly popularized in power stations. The importance of the intelligent power station auxiliary control linkage system has become increasingly apparent, and it has become a necessary technical means for the safe operation and production of power stations.

At present, each subsystem of the power station adopts different brands of equipment, there is no unified functional standard and interface standard, and the storage and processing of alarm information of each subsystem lack unified management. Especially in the event of a security event, each subsystem cannot effectively connect and interact in the process of alarm information, and the management personnel cannot make a correct decision quickly in the face of a large number of alarms from different systems, which leads to the failure of the power station security system to fully play its role, affecting the safety protection effect [1].

To solve the above problems, the pumped storage power station auxiliary equipment integrated monitoring and control system requires a unified design, unified planning, unified standards of comprehensive integration, design scientific and reasonable strategy of linkage to the auxiliary equipment of organic whole, in order to ensure that the auxiliary equipment does not produce misoperation, also do not produce holes, overcome the problem of artificial operation time-consuming power auxiliary equipment, and make the auxiliary equipment can run efficiently and give full play to the auxiliary role.

2. Auxiliary Equipment Architecture

2.1 Overall Architecture

The auxiliary equipment monitoring system of the pumping and storage power station adopts a hierarchical and partitioned architecture, which is based on the networked on-site measurement and control equipment system, the high-speed optical fibre transmission network as the physical backbone, the standard communication bus and unified modelling as the main support, and the integrated intelligent management and control platform as the core to deploy various intelligent application components [2]. The plant is horizontally divided into the production control area and the management information area. Among them, the production control area is divided into the control area (safe zone I) and the non-control area (safe zone II). Multi-stage auxiliary equipment linkage function Under the management and control framework of the integrated monitoring system of auxiliary equipment, the linkage function of microcomputer five prevention system, general risk control system, access control system, industrial television system, fire control system and so on is realized.

2.2 Partition Deployment

Computer monitoring system, general risk control system, fire control system, microcomputer five prevention system and so on are deployed in I area, the vibration pendulum online monitoring system is deployed in II area, and industrial television and production management system are deployed in III area. By these systems to build real-time monitoring, fire control, five prevention locking linkage.

The oscillating pendulum online monitoring system, main variable oil chromatography, SF6 micro-water monitoring, etc. are deployed in the safety II zone, and the condition monitoring linkage is constructed by these systems.

Industrial TV, access control security, production management system, human resources, file management, OA office, intelligent alarm, flood discharge alarm, debris flow alarm, etc. are deployed in security zone III. A video surveillance linkage body is constructed by these systems, and an intelligent interface is provided at the same time.

2.3 Hierarchical Linkage

Figure 1 shows the hierarchical linkage architecture of auxiliary device linkage.

Figure 1. Hierarchical Linkage Architecture of Auxiliary Device Linkage

2.3.1 Monitoring linkage in real time

1) Linkage between the server and the monitoring system to obtain information such as the online monitoring system and the communication risk control system of the pendulum, as well as the operation status and alarm information of auxiliary equipment.

2) The communication between the server and the microcomputer five-proof device is connected, and the position signal of the high-voltage switch is collected and transmitted to the microcomputer five-proof device so that the microcomputer five-proof device can know the actual working state of the switch in time and complete the five-proof program and locking logic function.

3) The communication between the server and the monitoring system is coordinated to collect fire alarm signals from all parts of the fire control system, as well as the operation status signals and alarm signals of fire extinguishing equipment such as rain valves and gas fire extinguishing devices. In case of fire in electrical equipment closely related to power production, an industrial television system can be quickly located at the fire location through linkage server control. The fire control system triggers the monitoring system to immediately remove the instruction of electrical equipment operation, and the electrical equipment will send the signal to the fire control system after the signal is removed. Start the fire extinguishing equipment under the condition of ensuring the safety of the electrical equipment and not leading to the expansion of the loss, so as to realize the linkage control and electrical locking between the fire extinguishing system and the monitoring system of the unit [3].

4) Linkage server and industrial TV communication, the system will send important alarm information and key operation command to industrial TV, to realize the alarm of the computing monitoring system, operation personnel and industrial TV picture automatic roll-out and linkage switch. The intelligent linkage server can also be used for daily operations. In case of accident warning and accident tripping, the linkage server will send instructions to the industrial TV to adjust the camera to the corresponding position to monitor and start recording.

5) Linkage between the server and the production management system to transmit the operation parameters and information of the power station to the production management system for the management personnel to understand the operation of the power station.

2.3.2 Fire extinguishing linkage

1) Linkage server and monitoring system communication, fire alarm signals of various parts, as well as the operation status signals and alarm signals of fire extinguishing equipment such as rain valve and gas fire extinguishing device.

2) The linkage server communicates with the monitoring system to obtain information on the general risk control system and fire signal. In case of fire, the hard contact point of the general risk control system receives the fire alarm instruction, takes appropriate measures, and shuts down other ventilation system equipment. The automatic linkage control between the fire control system and the general risk control system is realized.

3) Linkage server communicates with access control and security system. When the fire and confirmed, the linkage server can be in the management station (sub) control to open the need to open the channel door for escape, but also automatically open the preset door on the escape channel.

4) Linkage server communicates with the industrial TV system, in the case of fire and emergency, the industrial TV can automatically switch the picture to the monitoring terminal, and send out alarm information.

2.3.3 Five anti-locking linkage

1) Obtain real-time position information of the circuit breaker, disconnecting switch and grounding switch through hard contacts.

2) One-way communication between the linkage server and the production management system, that is, the five-defence operation ticket automatically generated by the microcomputer is sent to the linkage server and then transmitted to the production management system through the forward isolation device.

3) The locking logic of the microcomputer five-proof system is consistent with the operation locking logic of the monitoring system, which does not affect the operation of the monitoring system. The five-proof operation is only effective when the circuit breaker, disconnecting switch, earthing switch, quick earthing switch and grounding wire are manually operated on the spot.

2.3.4 Status detection linkage

1) The linkage server obtains active power, reactive power, relay stroke, excitation voltage, excitation current, oil temperature, tile temperature, stator temperature, upstream water level, downstream water level and other parameters through communication.

2) Linkage server with SF6 gas micro-water online monitoring system and main transformer oil chromatographic monitoring system to obtain relevant data and realize the status monitoring of main transformer, GIS and reactor.

2.3.5 Video monitoring linkage

1) Linkage server and monitoring system communication, accept alarm signals from the monitoring system, fire control system, in case of fire and emergency, can automatically switch the screen to the monitoring terminal, and send out alarm information.

2) Linkage server and access control security communication to realize the image capture and monitoring function of the abnormal situation of the door. When the access control security system sends out an alarm or abnormal personnel activity, the industrial television system will start the camera near the scene and automatically switch the picture to the alarm area or personnel activity area.

3) The linkage server obtains the online monitoring information of the main device from the monitoring system. When the vibration and swing of the auxiliary device exceed the standard, the corresponding camera of the auxiliary device will be called to the current to check the device status.

4) The communication between the server and the production management system can realize the formal ticket generated by the production management system after the operation. The bill is downloaded to the intelligent terminal, and the operator can use the intelligent terminal to work electronically. The information is returned to the production management system in time along with the steps, and continuous tracking is formed through the continuous linkage camera production management system.

5) The linkage server communicates with the intelligent inspection system to display the status, information, values, and abnormal conditions of inspection objects, realizing the video header control of inspection objects. The screen includes visible light, infrared segmentation, image proportion, and image transmission functions. In each inspection site, the image information collected by various image acquisition devices, including inspection robots, cameras, drones, etc., is identified. The intelligent analysis algorithm is used to perform intelligent analysis, alarm and alarm video playback. The inspection result is displayed in a value table, image, and curve. The inspection result can be queried by object, time, or fault [4].

3. Development of the Linkage System

Intelligent multi-system linkage method should be based on the unified design, unified planning, unified standards, and comprehensive integration of the object to ensure the linkage works together, effectively integrate system resources, improve the detection precision of the hydropower station security incidents and the processing efficiency, so as to cope with increasingly complex and changeable equipment failure, network security threats, and many uncertain factors. It becomes the core of the dynamic security device management model. The linkage method must be based on the appropriate policy management framework and security device linkage system model. Based on practical experience and habits, the linkage policy between the monitoring system and each linkage object must be thoroughly studied, including the description, verification, search, and execution of the linkage policy.

3.1 Linkage Development Mode

The linkage mode uses standard modules, protocols, interfaces, data structures, etc., to realize information interaction between the linkage object and the integrated management and control platform, and to perform corresponding operations according to predetermined policies to realize joint actions, shown as figure 2 [5].

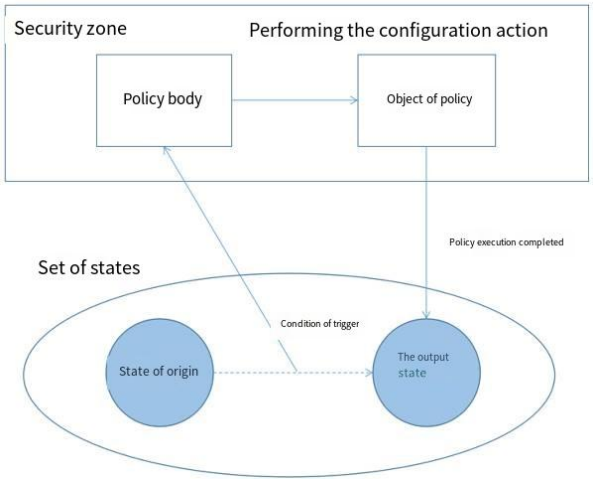

Figure 2. Configure the Action Schematic in a Linkage Policy Rule Set

3.2 Standardization of Function Modules

The standard function modules of a multilevel auxiliary equipment linkage system include data acquisition and transmission, data processing, fault tolerance management, alarm management, report management, permission management, message service, log service, resource supervision, human-computer interaction, model management, etc. This modular design method can effectively reduce the complexity of the program and simplify the operation of program design, debugging and maintenance. A loose coupling mode is adopted between each linkage object and the integrated management and control platform, and only the corresponding module can be changed to change a sub-function.

Each function module provides a common data interface. Functions can be invoked as long as the input and output data are provided. Internal interfaces of function modules are not required.

3.3 Data Structure Standardization

In order to meet the requirements of digital security, digital production and digital safety management of hydropower station operators, it is necessary to standardize the data structure

of each linkage object and carry out data management and linkage control. The data content of each linkage object should include:

1) Microcomputer five-proof system: circuit breaker, disconnector and other components of the combined state, line live state, line and equipment current, voltage, power, frequency and other information.

2) The risk control system: fan, ventilation pipe, split energy recovery equipment, fresh air treatment equipment and other equipment working state, indoor air quality parameters such as temperature and pressure, automatic control of the main fan and branch fan speed, adjust the air supply and exhaust volume and other information.

3) Access control system: user information, vehicle information, etc.

4) Industrial TV monitoring system: images, sounds, etc., of the monitored place.

5) Fire protection system: detector perception information, alarm strategy, alarm information, automatic sprinkler information, broadcast and intercom information, etc.

3.4 Linkage Development

The linkage component is an intelligent application component running on the integrated management and control platform. It is connected to the monitoring system of the pumping and storage station through the isolation device and to the corresponding security defence subsystem through the firewall. Taking the water threshold scenario as an example, the linkage component is shown in Figure 3. The linkage component shall have the following functions:

1. The linkage component is deployed in the management information area of the integrated management and control platform and has the ability to exchange and process information with the platform and realize data sharing. The result can be called by other systems.

2. The linkage component configures linkage policies, creates, edits, and stores linkage policies as required, and provides the later extension function.

3. After receiving the linkage signal, the linkage component completes the linkage policy calculation in a very short time and sends the linkage action command to the corresponding security subsystem based on the calculation result.

4. When the linkage component is linked, it sends relevant information on the monitoring screen and records and stores the information about the linkage execution process. The information shall include but not be limited to the name of linkage operation start signal, signal action time, linkage operation naming and issuing record, corresponding security subsystem equipment action completion, completion time, abnormal situation alarm, etc.

5. The linkage component interacts with each security defence subsystem for communication.

6. Linkage component draws the electronic map of the security system of the whole factory, and displays the arrangement and operation status of subsystems including the access control system, fire control system, video monitoring system, ventilation system, electronic fence system, personnel positioning system, and records and stores the operation status of each security subsystem.

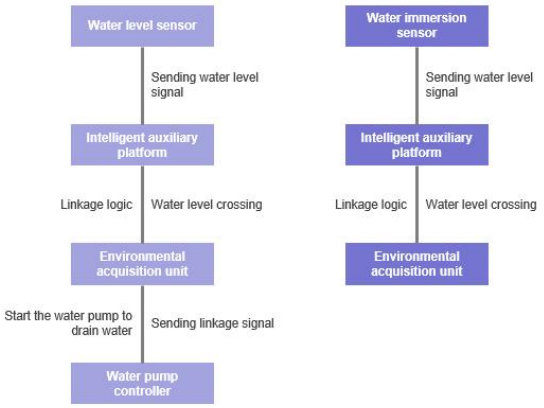

Figure 3. Linkage Componet in the Water Threshold Scenario

4. Conclusion

The auxiliary control system of the pumping and storage power station is divided into large linkage areas according to the deployment of the safety zone. In each linkage area, five linkage bodies are constructed for multi-level hierarchical linkage, including real-time monitoring, fire fighting, five-prevention locking, online monitoring and video monitoring.

The development of the auxiliary device linkage system based on a multi-level linkage strategy can integrate all auxiliary devices into an organic whole to ensure that auxiliary devices do not occur misoperation and leakage,

which is conducive to reducing the incidence of safety accidents, more accurate handling of equipment faults, efficient operation of auxiliary devices, and lower management costs. The implementation of multi-stage auxiliary equipment linkage in a pumping and storage power station is conducive to reducing the loss of auxiliary equipment and main equipment in a pumping and storage power station and improving the carbon neutrality and carbon compliance benefit of the pumping and storage power station.

In the future development of the monitoring system of auxiliary equipment of pumped storage power stations, the distribution model of the monitoring video terminal can be further optimized. The characteristics of the plant area and the upstream and downstream areas of the reservoir are analyzed to provide a theoretical basis for the reasonable deployment of terminal equipment, so as to maximize the production and safety requirements under the premise of ensuring the deployment quantity and location at the minimum cost.

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