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RESEARCH ON AUTOMATIC OPERATION OF PORTAL CRANE IN HYDROPOWER STATION

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ABSTRACT

After the hydropower station enters the operation period, the hoisting equipment is mainly used for gate opening and closing. The hoisting operation has the characteristics of lifting objects, lifting weight and fixed lifting path. Therefore, the hydropower station has fully automatic operation conditions. Taking Baihetan Hydropower Station as an example, this paper studies and analyses the technologies that have been applied to port hoisting equipment, such as walking precise positioning, automatic grabbing, remote monitoring, anti-deflection, scanning recognition of suspended objects number, etc. This paper described some technologies that can be used for the automation system of the hydropower station's gate hoisting equipment, aim at operating conditions of the hydropower station's gate hoisting equipment, those technologies will be improved to achieve the purpose of the automatic operation of the hydropower station gate hoisting equipment. Which can provide reference for other hydropower station hoist automation operation. At the same time, the automatic of gate opening and closing in hydropower station can enable dam operation to achieve standardized operation management, and provide guarantee for dam operation safety.

Keywords *: Hydropower station; Lifting equipment; Gate; Automation; Monitoring system*

In the hydropower industry, the gate opening and closing work mainly depends on manual command from the ground and the operation of the driver in the cab. Therefore, its work efficiency is low. However, for large hydropower stations such as Baihetan Hydropower Station, it achieves water layered intake function, Machines have certain requirements for operating efficiency, but looking at the entire hydropower industry, the current gate hoisting equipment of hydropower stations has not achieved really automated operation. For port lifting equipment that requires extremely high work efficiency, the entire process from berthing and unloading to loading and transportation has been fully automated, and manual operation is only responsible for the daily maintenance and repair of the lifting equipment. Based on the investigation and analysis of port equipment automation, combined with the operating conditions of mobile lifting equipment for hydropower stations, this article lists several technologies that can be maturely applied to gate hoists of hydropower stations, and introduces the technical principles and specific implementation, which can be used as reference for achieving gate hoisting equipments automation of hydropower station.

1. PROJECT PROFILE

During the operation period of the hydropower station, the lifting equipment mainly includes gantry cranes, trolleys, solid winch and bridge cranes, which are used to lift the metal equipment such as gate, generator unit maintenance parts, and sporadic supplies. Among them, the flat gate mainly depends on the portal crane for opening and closing, it has the characteristics of storage position, lifting weight, lifting point setting, and fixed lifting trajectory. So it has the conditions to realize unattended automatic operation.

Taking Baihetan Hydropower Station as an example, after impoundment, there is a difference between the surface water temperature and the deep of the reservoir. Therefore, the water intake of the hydropower station is equipped with layered water intake gates, which are operated by gantry crane, mainly to realize the function of water stratified to intake at high water level after impoundment, so as to reduce the difference between downstream water temperature and natural water temperature. There are 5 water intake gate working slots in a single generator unit, and 9 section water intake gates are set in each slots. Then, the single unit has a total of 45 sections, and 16 generator unit on the left and right bank have a total of 720 sections. Therefore, heavy workload of opening and closing the gate each section of all 16 generator units. The falling operation cycle of the layered water intake gate includes "grabbing from the gate storage slot - gantry crane carry the gate to the orifice in place - falling the gate - lifting to the orifice with empty hook - moving the gantry crane to the gate storage slot in place for grabbing again". The lifting operation follows the reverse operation of the falling, so the lifting and falling operation of the layered intake gate has a huge amount of work, a long duration and a lot of manpower. To ensure the downstream water temperature and ensure the normal operation of the generator unit, the single-layer

operation of the layered intake gate requires tight construction period and heavy tasks, so it is necessary to realize the automation of the hoisting equipment.

In this regard, the author of this paper has carried out a survey on the port hoisting equipment with a high degree of automation, according to the research results, at the same time, make some adjustments and changes to the technology, and finally comb out the system and function that can be used for the automatic operation of the hydropower station's portal crane.

2 EXECUTE SOLUTION

2.1 Positioning functions of gantry and trolley traveling mechanism

2.1.1 *Basic principles*

At present, the main means for automatic acquisition of the moving position of the hoisting equipment include the use of encoder, magnetic nail and ruler, pulse of the traveling motor, etc. the most reliable and accurate moving positioning function is the magnetic nail and ruler mode (see Figure 1). The principle is that there is a coil inside the magnetic nail (no need to power on, similar to the access card), each magnetic nail represents a position code, and the magnetic ruler is set on the portal crane (need to power on). When the portal crane moves, the magnetic ruler sweeps the magnetic nail, and the position signal is acquired. Every time a magnetic nail is detected, the position information is recalibrated. Therefore, the denser the magnetic pin is, the shorter the position signal refresh time is, and the higher the positioning accuracy is.

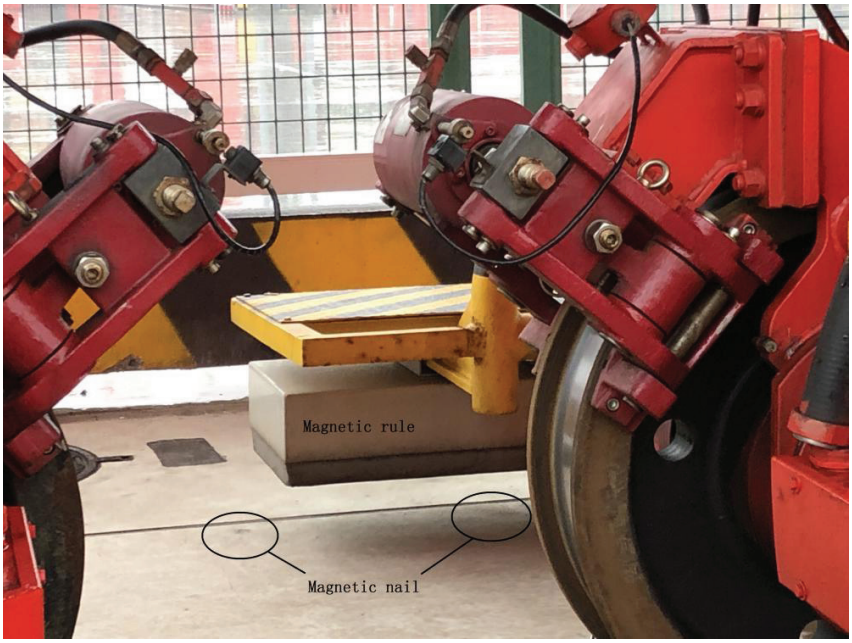

Fig. 1 : Magnetic nail-rule location sketch

2.1.2 *Specific implementation*

Set a magnetic nail every 1.5m on the ground (the distance can be increased or decreased appropriately according to the accuracy requirements), the shape of the magnetic nail is similar to that of the pushpin, and the volume is small. Before the installation of the magnetic nail, only drill a hole with a diameter of about 15mm on the concrete ground, put the magnetic nail in (it needs to be coded in advance), apply a thin layer of glue to fix the surface, and the installation and replacement are simple. The number of magnetic nails is large, which has certain fault tolerance. Even if some magnetic nails breakdown, the magnetic ruler can ignore this nail in identification, and use other nearby magnetic nails for auxiliary positioning, and submit the information of failed magnetic nails, and notify the maintenance worker to replace.

The location system of magnetic nail and ruler does not need to be embedded during concreting, but only needs to be added later. At the same time, by using the pulse counting of the traveling motor, the number of the wheels traveling can be detected, and finally the travel data can be obtained. Finally, the data obtained by the magnetic nail and ruler positioning method can be compared with each other and calibrated to ensure the positioning accuracy in the maximum extent.

2.2 Automatic gate entry

2.2.1 *Basic principles*

Under the premise of ensuring the traveling accuracy of the hoisting equipment travelling, the position information of the gate orifice is input into the control system, and the hoist automatically moves to the orifice in place and automatically enters the slot.

2.2.2 *Specific implementation*

Based on the positioning of magnetic nail and ruler, the pulse technology of the traveling motor is used to realize the precise positioning near orifice. After positioning, the empty grab beam or the grab beam with the gate can enter the slot automatically. At the same time, video monitoring is set on the girder at the bottom of the hoist (see Table 1), and the monitoring picture is transmitted to the central control room for monitoring by the worker.

2.3 Automatic hook grab

2.3.1 *Basic principles*

The hoisting point of the gate is basically fixed. After the grab beam is accurately inserted into the slot, it can be accurately connected with the gate along the steel track in slot . After the connection, the position signal is detected by the travel sensor of the magnetostatic grid, and then the pin is advanced and retreated.

2.3.2 *Specific implementation*

The gate of the hydropower station has a fixed gate slot. As long as the gantry and trolley are parked accurately, it is not very difficult to grasp the beam into the slot without wind, and the gate slot is equipped with guide rails, which can ensure the beam and gate alignment after entering the slot. After entering the slot, the detection of grabbing beam in place and through pin in place is mainly based on magnetostatic gate travel sensor, supplemented by video monitoring (the monitoring picture is connected to the central control room) (see Table 1). After grabbing beam in place, the pin will be automatically inserted, and then grab the gate after the dowel pin is in place. If the grabbing beam in-place signal is abnormal, but the encoder shows that the height has reached, indicating that there may be objects jamming, the grabbing beam can be automatically lifted for a certain distance, and then dropped. This action can be repeated for 2-4 times, until the grabbing beam in-place signal matches the encoder height, the pin can be inserted. If the position signal and encoder height cannot be matched at the same time after multiple lifting and falling operations, the maintenance workers shall be informed automatically to check the signal module. If the signal module is normal, the debris above the gate shall be cleared

2.4 Remote monitoring function

2.4.1 *Basic principles*

Set up a control center, the control center can remotely monitor and control multiple gate hoisting equipment, an operating platform can switch to control different hoisting equipment, the hoisting equipment mainly depends on automatic operation, and appropriate manual intervention in the control center if necessary, The operation center of the control center can switch to control different hoisting equipment, and manual intervention of different equipment can be completed in this control center, reducing the field monitoring in working ground.

2.4.2 *Specific implementation*

During the design phase of the hydropower station, a studio should be planned in advance as a centralized control center for various types of gate hoists (see Figure 2), and the convenience of cable should be considered. During the construction of the hydropower station, when automatic operation system has not been perfected, the gate hoists will be responsible for lifting some materials and equipment to install. Therefore, the driver's cab of the gate hoist should be retained to ensure that the hoisting equipment is applicable throughout all period.

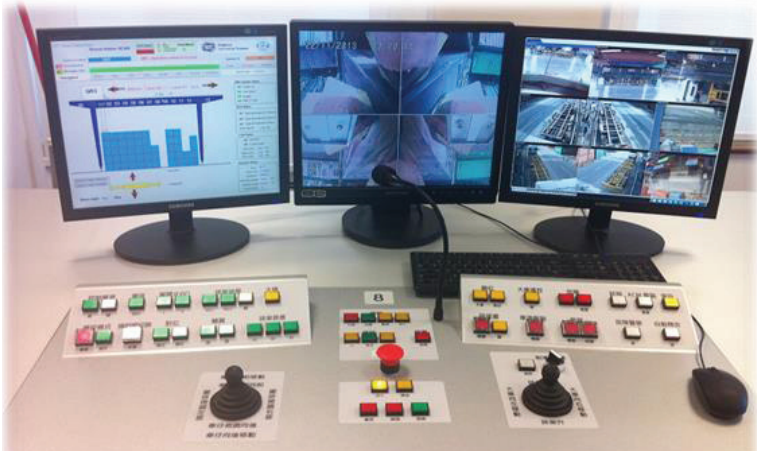

Fig. 2 : Automated centralized monitoring system

2.5 Equipment measures against heavy wind operation

2.5.1 *Basic principles*

The hoisting equipment of hydropower stations must follow the general hoists operation standards. In severe weather such as winds for level 6 above, heavy rain, thunder, and fog, outdoor lifting operations should be stopped. A wind speed sensor is installed on each outdoor hoist device, and the data of the wind speed sensor participates in the control of the opening and closing device.

2.5.2 Specific implementation

The top and bottom of the hoisting equipment is equipped with a wind speed detection device (see Table 1). The analog data is input to the hoisting control system to participate in the control. When it is detected that the wind speed is heavy than level 4 and less than level 6 (instantaneous wind speed is heavy than 7.9m/s and less than 10.8m/s), the control system of the hoists starts to run at a reduced speed. When the wind speed is detected to be heavy than level 6 (instantaneous wind speed is heavy than or equal to 10.8m/s), the device alarms and stops, and automatically anchors and locks the rail clamp.

Table 1 : Monitoring Equipment Statistics

Monitoring device	Installation site	Features
Orifice position monitoring	Hoist bottom beam	Monitoring the condition of empty grab beams or gates
OCR video scan	Hoist leg	Scan gates and orifice codes
Wind detector	Hoist top	Detection of instantaneous wind speed
Deflection angle detection	Grabbing beam	Detect the twist angle after the gate lifted
Pin in-out monitoring	Grabbing beam	Auxiliary monitoring the pin of grabbing beam open or closed

2.6 Anti-deflection measures for hanging objects

2.6.1 *Basic principles*

When the gate is lifted out of slot, the gate is exposed to a large area of wind and may be slightly twisted. In addition, the stress in the rope or the wear of the drum and pulley device may also cause the gate to deflect. The deflection of the gate is mainly determined by detecting the horizontal and vertical rotation angles of the gate, and the deflection angle data participates in the control system.

2.6.2 *Specific implementation*

Grabbing beam installed a camera of detecting the shutter inclination angle, used to detecting a tilt angle after lift the gate, the angle information is fed back to the control system. Slight wind sway can be stabilized by short pauses before resetting to the next action When the long deflection not automatically reset that cause gate can't be lifted to slot, alert to central control station, ask maintenance personnel to adjust and repair of the mechanical device.

At the same time, the hoisting equipment is set with double drums and double wire ropes. The two wire ropes are twisted in opposite directions. The internal stress of the wire ropes will restrain each other, making it difficult for the torsion caused by the internal stress of the wire rope or the breeze, but when the wind level is heavy, It should only be run at a reduced speed or stopped according to relevant standards.

2.7 Hanging code recognition

2.7.1 *Basic principles*

Each gate lifting unit has the same lifting point and lifting weight, and each gate lifting unit has a unique bar code in the same position. The orifice of working slot and the storage slot are also provided with a barcode to identification of the storage position of the gate. OCR video scanning is installed on the legs of the portal crane (see Table 1 for various monitoring equipment and functions), which can scan the bar code of the gate and the barcode of the position of the orifice. After the gate is lifted, the barcode is automatically scanned and entered into the control system to storage.

2.7.2 *Specific implementation*

In order to ensure the convenience of operation, when the gates are piled up on the ground when they arrive, each lifting unit is coated with a different bar code. At the same time, the orifice of working gate slot and storage slot are also coated with bar codes. The OCR video scanning system is installed on the legs of the portal crane, and the barcode of each lifting unit and the barcode of the orifice position are entered into the control system. During the operation of the hoists, the control system can automatically identify the quantity of gates in the working slot and storage slot, and show on the central control display. For example: To lift all the gates in the storage slot to the working slot, after the lifting equipment

is operated according to this instruction, for each gate lifted by the hoist, the quantity of gates in the storage tank is reduced by 1, and the quantity of gates in the working slot is increased by 1. Until the quantity of gates in the storage slot is reduced to zero, the hoists travel to next storage slot position to lift gates into another working slot. In this way, the gates are hoisted from the storage slot to the working slot until all the gates are transfered.

3. GUARANTEE EQUIPMENT RELIABILITY

3.1 Electrical system stability guarantee

To achieve PLC hot standby redundancy, two sets of PLCs are configured. During normal operation, two PLCs are controlled by one of them and data is synchronized to the other in real time. If the working PLC fails, the other PLC is started to continue to work. Because there was data synchronization before, and the device can continue the previous action after a short automatic switchover to ensure the continuity of the equipment operation.

3.2 Mechanical structure guarantee

Establish weekly, monthly, and quarterly maintenance systems, and strictly implement them. The maintenance priorities of different maintenance cycles are different to ensure the reliability of the equipment.

3.3 Spare parts guarantee

Sufficient spare parts should be prepared, and the fragile parts should be prepared more. For parts and components that have been discontinued by some manufacturers, parts of other brands or models should be studied and re-selected to ensure timely supply of spare parts.

4. EXPECTED EFFECT

4.1 Wide applicability

The automation of the hoisting equipment of the hydropower station can be used for all gates with fixed orifice positions, including pollution barriers, layered water intake gates, maintenance gates, curved gates, etc., and has a wide range of applications.

4.2 Efficiency improvement

Changed the traditional hoisting method using manual command and operation. After automation transformation, it can greatly reduce the consumption of human resources. The automatic operation can be performed regardless of day and night. Only a small number of people need to be placed in the centralized control room to monitor, and minimal manual intervention if necessary. Finally, intervention greatly improved the efficiency of gate transfering.

4.3 Reduced security risks

After the automation of the equipment is smoothly, the reliability is high, which reduces the safety risks such as falling and drowning caused by the workers' long-term operation near the gate orifice. At the same time, the realization of automation of mobile hoist equipment for hydropower stations can ensure dam standardized operation and improve dam safety.

5. CONCLUSION

China's hydropower station construction technology has reached world-class technology, but the automation of the hydropower station's hoisting equipment is developing slowly. Compared with the port equipment that has been completely unattended, it has a lower degree of automation. This article is based on technologies that have matured in other industries, through certain optimizations and improvements, it can be applied to the automatic operation of gate hoists. At the same time, if such automation research ideas can be successfully applied to more hydropower station hoist equipment, it can be used as a technical innovation of the gate hoist in the hydropower industry.

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