Research on Construction of Computer Monitoring System in Automatic Control of Sluice

Bo Tian¹, Hujun Wang¹*, Yang Wang¹, Kangjie Ning¹, Lanlan Duan¹, Jin Liu¹, Haifeng Zhang¹, Ji Zhao¹

¹Xi’an Aerospace Automation Company Ltd., Xi’an 710065, Shaanxi, China

*Corresponding author e-mail: yuanwang_1@stu.xidian.edu.cn

Abstract. In the hydraulic structures of hydropower station and water conservancy project, sluice is one of the most important parts, which undertakes the tasks of flood control, sand flushing and water inflow. The water outlet can be closed or opened completely or partially according to the need. In order to better play the role of hydropower plants and water conservancy projects, the protection of hydraulic structures. Setting up computer monitoring system at these outlets can flexibly implement the automatic control of all kinds of sluices. Therefore, this paper studies the construction of computer system in sluice automation control. The second development is mainly based on the existing computer monitoring system to meet the functions of sluice gate data acquisition and processing, simple basic control, etc. Combined with the needs of local hydropower plants, the sluice flow detection and statistics, sluice gate group control functions are constructed. In this way, multiple sluices can be controlled at one time. Through real-time monitoring of the gate status and taking data modeling, the opening size of the gate can be calculated to realize the automatic control of each gate. Through the practical test results meet the design requirements, the running condition is normal.

Keywords: Computer Monitoring, Sluice Automation, Flow Calculation, Data Modeling

1. Introduction
In recent years, with the increasing shortage of water resources and the importance of power generation economy, power generation enterprises and water conservancy project management units are required to strengthen the unified management of water resources, reduce operating costs and prevent the sustainable development of water resources. At the same time, dueing to the higher level of informatization of hydropower stations and water conservancy projects, the overall informatization of hydropower stations and water conservancy projects is becoming higher and higher. Domestic and foreign manufacturers of hydraulic monitoring have successively developed advanced functional control software platforms with stronger pertinence, more accurate control results and better control impact on the original hydropower station monitoring system. With the gradual improvement of hydropower automation level, intelligent hydropower stations and advanced application functions of
continuous improvement are gradually promoted. The sluice gate control will be more and more accurate, the monitoring and traction system will play a greater role.

At present, an important water conservancy facility is sluice [1, 2], which not only involves flood control and drainage, but also involves shipping management, water resource scheduling, water environment protection and improvement of people's living conditions. To maximize these functions is the central goal of sluice automation construction [3]. In the past water conservancy projects [4, 5], the traditional monitoring method was widely used for large and medium-sized sluices. The observation data collection was completed manually, the sluice operation status was reported manually and the sluice was operated according to the command of the control room. Nowadays, more and more projects choose to realize sluice automatic control construction on the basis of computer monitoring system [6-8]. Its main functions include sluice automatic control, hydraulic data automatic observation [9] and sluice digital video monitoring [10]. The reasonable application of sluice automation system can ensure the safe operation of sluice facilities for improving the water management level of sluice, which plays a very important role in sluice.

The main content of this paper is the construction of computer monitoring system in sluice automation control. Based on the local hydropower plant, we propose to upgrade the function of the computer monitoring system. In the hardware facilities, taking the hardware system of local hydropower plant as an example, the secondary development of software is carried out to realize the functions of data collection and processing sluice flow calculation and basic control. In addition, advanced functions such as gate group control function are further developed. The performance of the system is tested to see if it can meet the requirements of automatic control. It is found that all indexes and functions are good in the test results of local hydropower plants. The system can meet the flow calculation and group control functions of hydropower plants at home and abroad. It has certain foresight and good practicability.

2. Construction of computer monitoring system in sluice automation control

2.1. Computer monitoring system

The microcomputer monitoring system mainly includes the following aspects:

(1) The field instrument (i.e. on-site intelligent sampling unit) collects the electric quantity, non-electric quantity, switch value and other data signals of main and auxiliary machines, such as main circuit voltage, current value, main engine oil temperature, pad temperature, transformer temperature, switch position, etc. Then it is sent to the corresponding PLC cabinet through the signal line and through the signal transmission between the PLC and the rs-465 communication equipment of the upper computer, the remote monitoring of the upper computer is realized.

(2) The control signal of the main circuit switch operating mechanism is collected and processed by the control cable through PLC and uploaded to the upper computer to check its working state. The remote control of the main switch can be realized by the main switch. The whole set of microcomputer monitoring system is equipped with standby power supply protection of SANTEK on-line uninterruptable power supply (8KVA, 4h).

Control and adjustment objects: the control and regulation objects mainly include 4 water pump sets, water supply pumps, 4 microcomputer excitation devices, 5-hole diversion gate, 5-hole diversion valve, 4-hole control valve, 4-hole flood control gate, 20kV power station transformer, incoming line and other high-voltage and low-voltage electrical equipment.

(1) Hardware facilities: monitoring workbench, programmable controller, control unit of each sluice gate, pressure sensor, sluice opening meter, temperature conversion module, analog conversion, and water level sensor.

(2) Software configuration: the system software is Microsoft Windows 2018, the monitoring software is Cimplicity HMI 9.0 software of GE Company, the database management software is Microsoft SQL Server 2012, and the video software is AS6400dDS.
2.2. Sluice discharge calculation

Working characteristics of sluice: it can be seen from the outlet energy curve that there is a certain correlation between the total water head \( H \) and the water flow \( Q \):

\[
H_{all} = H(Q)
\]  

(1)

In order to transport water to a certain height, the outlet should not only improve the water purification head, but also overcome the pipeline resistance. According to the pumping principle of sluice, the expression of required lift \( H_{need} \) can be obtained

\[
H_{need} = H_{clean} + \frac{SQ^2}{2}
\]  

(2)

Among them, \( H_{clean} \) is the net head of sluice outlet; \( s \) is the resistance of outlet pipe.

The intersection of the required head curve and the head discharge characteristic curve of the sluice gate is the actual working point of the sluice gate.

\[
H_{all} = H_{clean} + SQ^2
\]  

(3)

Where \( H_{clean} \) is the water level difference between the inlet and outlet of the sluice gate, which is easy to measure on site, so formula (3) can be transformed into the following:

\[
H_{clean} = H_{all} - SQ^2
\]  

(4)

Then the flow rate is calculated. In this paper, the linear interpolation method is used to calculate. In order to accurately measure the water level data, we have taken the following measures. The measurement accuracy of water level sensor should be within \( \pm 5 \) cm. In order to ensure the reliability of water level data, the datum level of water level sensor is adjusted regularly to eliminate zero drift. In order to eliminate the influence of surface wave on water level measurement, caisson method is used to measure water level. Multi value average method and instantaneous mutation of water level monitoring data are used to reduce measurement error and eliminate interference.

If the diversion operation is improper, the internal river water may flow backward the external river water will be polluted. Therefore, the computer monitoring system must be confirmed by the officer on duty before operation to control the sluice.

2.3. Automatic control of sluice

Sluice automatic control is to use sensors and cameras to collect field information (such as water level, gate opening height, site conditions, etc.) by computer. Each remote workstation can independently use the designed control software to automatically control the gate according to certain instructions (such as flow or water level index).

2.4. Add function design

The system can realize real-time, accurate and effective safety monitoring of hydropower. Referring to the successful design experience of hydropower station computer monitoring system, according to the requirements of sluice control room automatic control, the main functions of sluice control room automatic control system include the following parts;

(1) Data acquisition and processing, safe operation monitoring, emergency alarm;

(2) Adjust and maintain the running state of each machine in time to avoid trouble;

(3) Accident, fault alarm and record, all alarm and event warning records are stored, and the next time the same thing occurs, it can be solved more quickly;

(4) Rich vivid and intuitive man-machine interface, dynamic display of Min port operation process and operation experience;

(5) Software development and maintenance, operation guidance.

(6) The automatic control of sluice can realize operation by inputting command, which is
convenient for operation and greatly reduces the error of human operation;
(7) Automatically collect the water level of each orifice and upstream and downstream, accumulate and save the flow of each orifice;
(8) According to the detected flow, the appropriate opening is allocated, the number and opening of each outlet are automatically allocated.

3. Experimental ideas and design

3.1. Experimental ideas
In order to verify the advanced function design of computer monitoring system, the design indexes and functions are tested and verified in the commissioning of local hydropower station monitoring system. The test results meet the design requirements and they are approved by the expert group. It can check the data collection situation of the local control unit of the monitoring system, test the switch value input, switch value output and imitate input and other field data text alarm and voice alarm functions of each control unit of the sluice monitoring system. Test whether the time of local control unit switching displacement transmission to the upper computer of sluice monitoring system and the time when the analog quantity of sluice monitoring system exceeds the set value meet the design requirements. According to the flow (set by human-machine interface or inflow flow) and automatic collection of upstream and downstream water level parameters, the opening of each sluice is automatically allocated, the water flow that meets the requirements is detected.

3.2. Experimental design
(1) Arc opening position, arc opening position and arc closing position. In the local LCU, the above measuring points are operated manually, the displacement and alarm information of corresponding measuring points are observed in the monitoring system. The data collection period was 5-40 Ms.
(2) In the flow control test, we select three groups as the experimental objects in the sluice monitoring system, the starting sequence is also carried out according to the group number. Set the start-up practice interval between each group as 10, 20, 30 seconds. The original set water flow height is 1.5 meters, 1 meter, 1 meter, send the command, observe whether the reported information is correct, and observe whether the operation of the sluice gate is normal; then start the water gate flow detection.
(3) The purpose of sluice gate group control function detection is to prove whether the secondary development function based on computer monitoring system can work normally. In the local computer monitoring system, shallow water is divided into the first group and the second group, the deep water is divided into the third group. The starting time interval of each group is set as 10s, 20s and 30s, the opening degree is 3M. Send the command to observe whether the reported information is correct and whether the operation of sluice gate is normal, then start to test the effect of sluice group control function.

4. Discussion

4.1. Data acquisition and processing test

| Switch point name                  | Transposition | Call the police | Sign in | Briefing | Displacement response time(ms) |
|-----------------------------------|---------------|----------------|--------|----------|--------------------------------|
| The power supply of arc port disappears | Normal       | Normal         | Normal | Normal   | 9                              |
| Fulling open position of arc mouth          | Normal       | Normal         | Normal | Normal   | 10                             |
| Arc mouth falling action                          | Normal       | Normal         | Normal | Normal   | 6                              |
| Fully closed position of arc mouth                    | Normal       | Normal         | Normal | Normal   | 18                             |
Shown as Table 1, the test results show that each detection point in the switch input test is normal, the response time of each measurement content is between 5-40ms. This test is the basis for the next experiment, which is convenient for the following experimental results to be more real and effective.

4.2. Flow control test

![Figure 1. Flow test results.](image)

Shown as Figure 1, the experimental data of the three groups all meet the water flow demand. Because each group has different start-up intervals, it is concluded that no matter what time interval is based, the water flow will not be affected. In the first group, the opening is 1.43 meters with 10 seconds interval, but the actual setting value is 1.5 meters. Although the error is very small, it still has some influence. The other two groups were also compared with the real value, the error was very small. In the second group, the time interval was 20s and the opening was 1.02, which was slightly higher than the real value. The time interval of the third group was 30s, the opening was 0.82. Compared with the actual setting value, the gap was still larger. We optimized the operation control of long times interval again to avoid the difference between the setting opening value and the real water flow. And further improved the algorithm, set appropriate parameters and finally found that although the time interval is very large, but the opening error is very small compared with the actual setting value, which achieves the effect of sluice automatic control.

4.3. Function test of sluice gate group control

Shown as Figure 2, the water level is set at 3M. In the first group, the time interval between the sluice gates in the shallow water area is 10s. After calculation, the system automatically distributes the sluice gates and flows into the shallow water area at different flow rates. The results are basically consistent with the required values. In the second group, the time interval of sluice mouth in shallow water area is 20s. By calculating the flow rate of each sluice mouth automatically, it is found that the flow rate of each sluice is different, but the final result is similar to the real value. Computer monitoring system plays an irreplaceable role in resisting flood discharge and disaster prevention, water conservancy and power generation, etc. When the river or lake floods, the water level data changes greatly and changes rapidly. At this time, it is also required to realize the accurate control of the sluice gate quickly and accurately, so as to prevent the flood damage caused by the rapid change of water level.
5. Conclusion
In this paper, through the secondary upgrade of the computer monitoring system, it can accurately measure the water flow and give warning in the sluice automatic control and can also control the sluice gate in group. Through the experimental test, it is found that the error between the measured data and the real value is very small when the real drainage level and time interval are set. The detection of each switch also showed normal. The results of sluice group control test show that the water level of each sluice is very close to the real value in different water level areas. The standardization of computer monitoring system and the development of more refined and intelligent sluice automatic control have made a good attempt and accumulated good development experience.

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