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Design and Implementation of Automatic Control Acquisition System under Big Data Background

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Abstract: In recent years, with the popularization of the computer and the application of automatic control system, the production efficiency has been greatly improved, but in the manufacturing industry, the information technology is relatively backward, rarely to the production activities of information processing. This paper mainly studies the design and implementation of automatic control acquisition system under the background of big data. In this paper, the overall design of the remote monitoring system for sewage treatment is completed by combining the functional requirements of the monitoring system for small sewage treatment plants. The whole monitoring system is divided into three modules: on-site execution module, data transmission module and client monitoring module. In the data acquisition module, five sub-functions are designed: data acquisition, real-time data, data statistics, historical data query, report forms and printing. Through the experimental test, we can know that the automatic control and collection system designed in this paper can meet the daily use needs of sewage treatment plant.

1. Introduction

In recent years, the popularization of information processing and network technology has also spread to the production site, office paperless information processing technology flexible application makes the work efficiency has been a leap to improve. However, the production site mainly based on the actual operation center is still only to the extent of transferring the paper information such as operation instruction sheet, checklist, performance report and operation record into electronic documents [1-2]. Gradually, some manufacturing plants began to process the flow of products with precise schedules to achieve the goal of shortening lead times and reducing inventory. Or from the huge information data to analyze the problems occurred in the production, and then improve the quality of products, reduce the cost of production. In different production situations, can actively collect information, analyze information, give the most appropriate treatment. Due to the rapid popularization of network structure, business operations began to rely more on computer systems to operate, operating efficiency has been greatly improved. Among them, enterprises and public offices, warehouses and logistics companies have introduced a large number of ERP, SCM and other software to store a large amount of information in the information database, so that the processing of orders or the design of jobs can be further efficient [3-4]. But will find that the production in the manufacturing site, now there is no better quality management and engineering production activities such as means of information technology, even in the most into the size of the industrial and mining enterprises, the original also on a paper and a pen to record the production records, can say it is a kind of backward information technology under current information society. The advanced production system becomes an important link of information link [5]. In the past, the main purpose of computerization in the production site is to automate the equipment and devices. Each equipment and device should have a control center and a production program for management, which is quite different from the information processing in the office [6]. Therefore, a technology gap of information altercountry between the management system and the field equipment arises. In order to convey information, additional systems such as computer servers have to be used for signal transfer [7].

In the mid-1980s, American OSI Software Company accepted a project to create seven production process databases by using data compression algorithm [8]. Using this data compression technology, the amount of data needed to reproduce the production history is reduced, making it technically possible to store the production process data for a long time. On this basis, the process production real-time database and related applications are developed. This is the Plant Information System (PI), the most installed real-time database System in the world at present [9]. PI is the first real-time database product that fully adopts Microsoft Windows technology at the bottom and Windows-based interface in the client product. So far, PI system module has maintained a leading position in the industry with its powerful, flexible and easy-to-use features [10]. On the other hand, the data interface between PI system and DCS is built on a solid foundation. Not only in the developed regions of Europe and the United States, some domestic manufacturing users also began to try to use this technology, and has been praised. In addition, it is not only applied in the field of PLC, but also incorporated into other control equipment such as control panel of manufacturing equipment operation []11. From the foreign products, we can see that the data acquisition technology mainly develops in three aspects: easy to use, diverse functions and reduced volume. In order to take into account the use of users, it has the characteristics of relational database, enhances the replication function, meets the requirements of data collection speed and storage volume of the engineering team, and requires real-time and man-machine interface operation, so it extends the Structured Query Language (SQL) statement. It can be applied to a variety of platforms [12].

This article is to the production site equipment information collection. The optimal production mode is to master and control the information data of the production site effectively. When faced with problems, can quickly make a variety of judgments, and master the basic information is from these production site equipment and devices.

2. Automatic Control System Data Acquisition Design

2.1. Overall Design of Control System

This design is mainly to realize the automatic control of sewage treatment system, in the design need to first determine the controlled object and automatic device part of the automatic control system of sewage treatment. The controlled objects selected in the automatic control system of sewage treatment designed by us are mainly the valves for water flow control, centrifuges for separating sludge, pumps for pumping water and stirrers needed in the process of biological treatment, etc. In addition, there are also some other indispensable equipment, which will not be mentioned again. In addition, in order to realize the automatic control of the control system, it is necessary to determine the automatic device of the system, which generally includes the measuring part of instruments and meters, the protection device for failure, the operating device to realize automatic action, the corresponding parameter adjustment device and the alarm device to remind the personnel of failure, etc. [13-14]. The automation device is generally realized by programmable logic controller. Therefore, the design of the automatic control system of sewage treatment can be achieved through PLC, computer monitoring system and measuring instruments.

According to the division of functions, the automatic control system designed in this paper adopts a multi-layer control system, including three parts: control layer, monitoring layer and management layer. Its basic structure is shown in Figure 1.

The control layer mainly realizes the control function of the sewage treatment system. In order to realize the automatic control of the equipment, PLC is generally used as the main control device of the control system [15]. In order to realize real-time control of equipment information, equipment information collection is generally achieved by installing detection instruments on the equipment [16]. The main research object of the control layer is the production process of the system, which is also the main research object of this design. What this paper studies is to connect the independent equipment together to realize the automatic control of the system. Therefore, the control layer mainly collects data for the running status of the equipment in the production process, judges and processes the collected information, and analyzes what operations should be carried out next. The collected information generally comes from the data collected by the sensor, and the output is the result of the drive device stopping.

The monitoring layer mainly monitors the state of devices in operation, which is usually composed of industrial computer, information storage server and corresponding input/output devices [17]. The monitoring layer is primarily facing the operator. At the beginning of the design, the use of mature configuration software of control system software and hardware connection, make the staff can display output devices such as to observe the running status of equipment and corresponding operation parameters, so as to achieve the optimization control of the control system, further improve the control system of the state, realize optimization of the control system.

The management level is generally the management and storage of information. Usually, the historical data of equipment operation is stored in the computer terminal, which can realize the classified storage of information and facilitate the call of information at any time. The management level can realize the comprehensive treatment of related production management, cost control and quality management, as well as the comprehensive evaluation of historical database and real-time database, so as to achieve the goal of optimal combination [18].

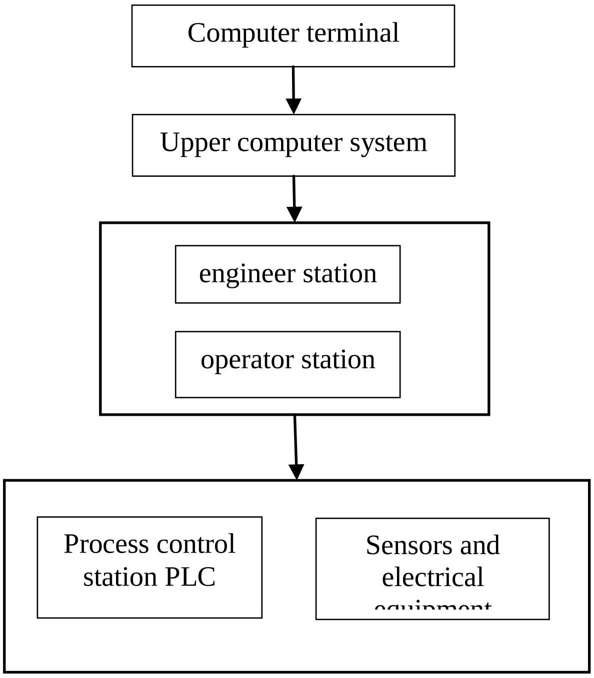

Figure 1. Control system structure diagram

2.2. Data Collection and Statistical Function Design

The whole data acquisition system is divided into three layers. The first layer is the sensor and data acquisition layer, which is responsible for converting all kinds of physical quantities to standard digital signals. The second layer is the data extraction layer, which is responsible for the acquisition and transmission of front-end data, and then transmits it to the switch after certain processing. The third layer is the record analysis layer, which is responsible for keeping the result records.

In this paper, the data extraction layer is divided into three parts: local acquisition and processing node, white rabbit switch and 10 gigabit switch. The local acquisition and processing node has the following functions: it is responsible for the synchronous sampling of multi-channel sensors in the front; Multichannel data are aggregated through on-chip network; the data is preprocessed and transmitted to the back-end network. The White Rabbit switch synchronizes the clock of each local collection and processing node in the front end and transmits data to the 10-gigabit switch in the back end. White Rabbit switching provides PTPv2 (IEEE-1588V2) protocol and synchronous Ethernet. Its synchronization accuracy is more than 1ns, which can guarantee the synchronization of the whole system. The 10-megabit switch is responsible for further aggregation of data to the back-end processing layer.

The local acquisition and processing node is mainly composed of four parts: configurable interface controller, network module, network output interface and synchronization module that controls synchronous sampling. The main function of the configurable interface controller is to convert the data of various types, rates and bit widths of the front-end sensors into unified network protocol format packets that can be transmitted over the on-chip network. In the process of system operation, the configurable interface controller can also control the data collection of front-end sensor through the control signal, so that the system can achieve the purpose of synchronous sampling.

The output network interface completes the caching, preprocessing and transmission of data to the back-end Ethernet. The output interface of the network will also be controlled by the synchronization module to ensure the synchronization of the data transmission and processing steps. In addition, it controls the synchronization of the front-end configurable interface controller based on the state it is in.

The synchronization module is composed of WR nodes. Together with the White Rabbit switch on the backend, it synchronizes the local node. The WR node provides a synchronized clock signal and a synchronized second pulse. Enable the system to complete the clock synchronization of multiple boards.

The synchronization controller controls the read and write of on-chip network data through the synchronization clock (CLK), second pulse (PPS) of WR node and UDP_ON signal from external network adapter. The synchronization clock and second pulse of the WR node are highly synchronized with the synchronization clock and second pulse of the WR node of other local acquisition and processing nodes. The synchronization controller can be highly synchronized with other local acquisition and processing nodes by detecting the second pulse and working the synchronization clock. The UDP_ON signal indicates that the host computer enables the local collection and processing node to start UDP transmission. In this case, the UDP_ON is raised. When UDP_ON is raised, the state value of the synchronization controller starts to change only after the next second pulse. Synchronizing controller status values to control data read and write.

3. Data Collection and Testing for Automatic Control of Wastewater Treatment

After the overall design and implementation of the remote monitoring system for sewage treatment, in order to verify the stability and reliability of the system and the accuracy of remote monitoring, relevant tests are carried out on the remote monitoring system, including the field control board process control test and the remote client data real-time test.

3.1. Field Test Environment

The reliability and stability of the field control board determine whether the bottom sewage treatment control system is practical or not. The field test equipment is shown in Table 1.

Table 1. Field test environment

Device under test	Type
Switching power supply	HF55W-S-24
Controller	Digital version
Emulator	MSP-FET430UIF
Serial debugging tool	Z-TEK RS485

3.2. Test Contents

After the field data is transmitted through the GPRS communication board, the data is uploaded to the database, and then the client obtains the real-time state information and historical data by requesting the Web server. Before communication, the Socket server, Web server and MySQL database are deployed. When the GPRS module signal indicator flashes, it indicates that the GPRS module has established a connection with the server and started to upload data. The test content has the client login and registration function. Real-time status monitoring and historical data query function.

The following formula is used in the system test:

$$C = nL/T \tag{1}$$

Where C is the average number of concurrent users, N is the average number of users per day (login session), and L is the average time from login to logout within a day (average login session time).

$$D = VU * R \tag{2}$$

F is the throughput, VU is the number of virtual users, and R is the number of requests made by each virtual user.

4. Test Results

4.1. Interface Data and Field Data

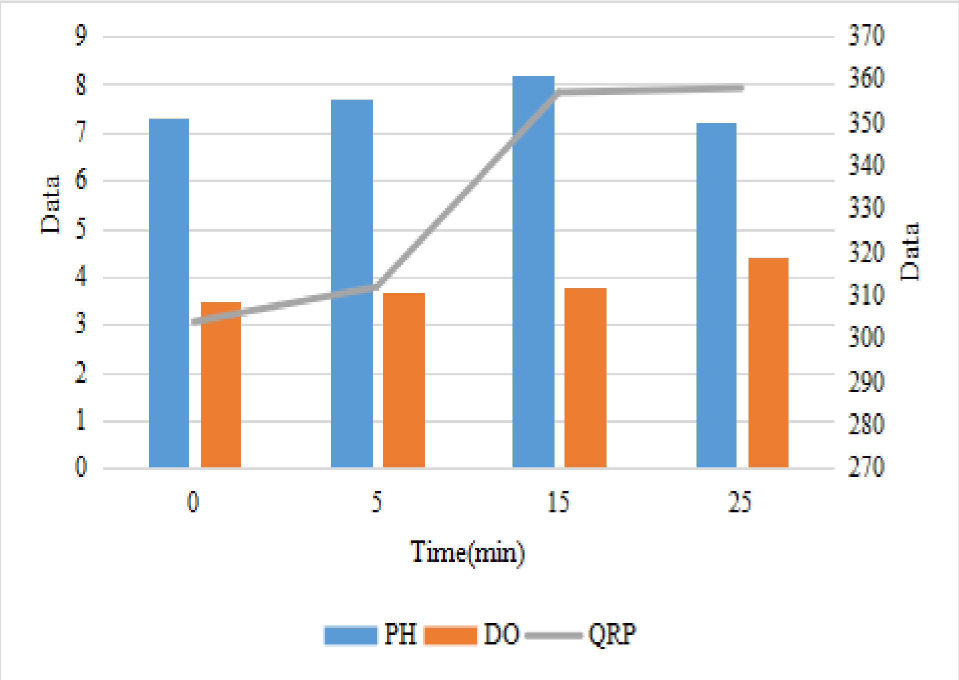

Figure 2. Collect real-time data on the interface

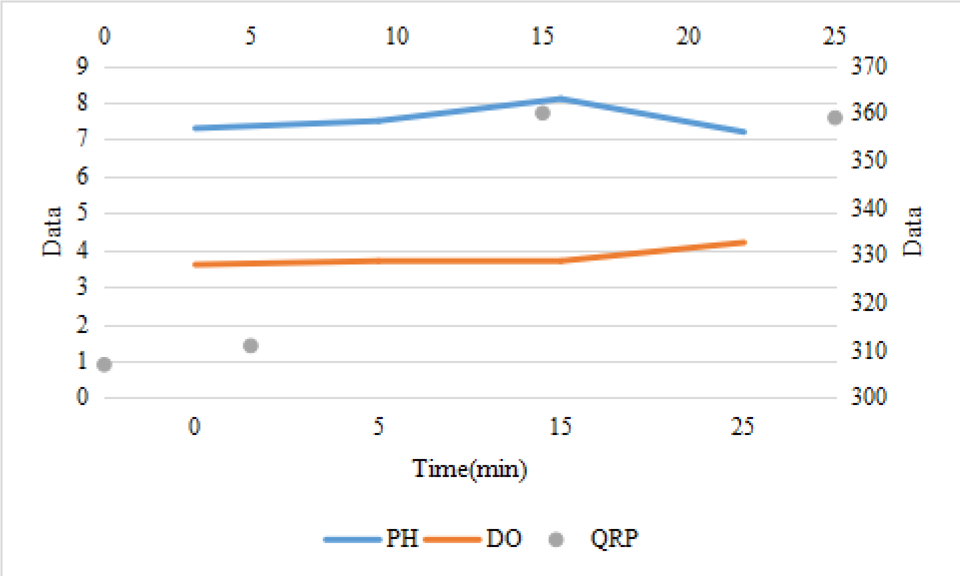

Figure 3. On-site data acquisition

As shown in Figure 2 and Figure 3, are the records of the data displayed by the client and the data obtained on site within 25 minutes. The test results show that the error between the displayed information on the client interface and the control information on site is small, and the relative error is kept within 5%. The monitoring system has good real-time performance and high accuracy in data acquisition.

4.2. Remote Control Result

Table 2. Remote control test

Test content	Test results	Response time(ms)
Lift pump	Response to success	612
Reflux pump	Response to success	547
Air pump	Response to success	691
Circulating pump	Response to success	552
Booster pump	Response to success	653

As shown in Table 2, the test results show that the response time of the remote control is not more than one second, which meets the real-time requirements of the remote control, and each response is successful. There is no data loss during the data transmission between the client and the field terminal, and the remote control of the monitoring system has good reliability.

5. Conclusion

This paper designed a remote monitoring system of sewage treatment, according to the on-site execution module, the data transmission module and client remote monitoring module of the whole system has carried on the detailed elaboration, considering the need to complete the function of the sewage treatment monitoring system and needs, to develop a monitoring and control system of the overall scheme design, the system is divided into three layers: Field execution module, data transmission module and client monitoring module, the whole system workflow is described in detail, and the key technology in the design of the system is introduced. There are still some shortcomings in the practical application of this system: although the interface of the client can basically meet the needs, it is not beautiful enough. We can show users a more beautiful, pleasing and clear monitoring interface by using some interface beautification tools.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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