

Waterworks comprehensive monitoring management system design based on T-S model

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Keywords: PLC; T-S Model; configuration software; PID

Abstract: This paper designs a set of PLC technology, network information technology, configuration technology in the integrated monitoring and management system, which has the advantages of unified management, reasonable open source, optimizing the configuration and overall saving. In the process of water treatment, T-S model and PID algorithm are combined to solve the problem of nonlinear and time delay.

Introduction

Water is the source of life, and all things grow from the nourishment of water. For a city, water not only determines the degree of economic prosperity of a city but also determines the living standards of the people. The water has become the industry's constant pursuit of the goal. This paper takes a waterworks, a set of integrated monitoring and management system is built by using PLC, inverter, configuration software and other automation equipment and software. Through the advanced control algorithm to achieve the optimal control effect, successfully solved the technical difficulties of water treatment, the need to the people's living water.

Hardware control system design of water plant

A. The hardware system of Waterworks

The monitoring and management system of water plant is divided into: security system, control system and central control room. The control system is composed of three parts: chlorine adding system, filter system, pump system. Communication between PROFIBUS bus and Ethernet and central control room, it adopts the control method of variable frequency, variable pressure and variable flow, according to the flow of water to choose a suitable pump type, frequency conversion water supply to ensure that the factory pressure. The security system mainly includes tap water plant and ancillary PTZ camera, the central control room has a large screen, which focuses on the status of each link. The central control room is the core of the whole plant, centralized control of the entire plant to show the operation of all equipment. At the same time with the following functions:

- (1) The operating state of all control devices is visually displayed.
- (2) Data display records
- (3) The display and record of the security equipment
- (4) Provide a good man-machine interface\
- (5) Alarm

B. Water treatment steps

1. The first choice of high-quality water, through the pipeline water is transported to a pumping station , the chlorination system in a pump house, for small plants in the water, killing algae, shellfish biology [1].
2. After a water pumping station sent to the tap water factory processing system. After reaction, precipitation, filtration, disinfection and a series of processing technology. After filtration, the general disinfection chlorination, with dosing of disinfectant water after purifying pond in the pool and stay within a period of time to become a qualified water for life.
3. After passing the water again after two water supply pump pressure delivered to the tap water pipe network, for people to use.

C. Water treatment process and equipment

1. water transfer process

The water plant water capacity of about 100 thousand tons per day, by four sets of centrifugal pumps and four motor components, each pump design flow of 1621 cubic meters per hour. Unit running status through the S7-200PLC acquisition signal is displayed on the upper computer, automatic generation of data report[2].

2. Coagulation process

Coagulant is a very important part of water purification, the process is composed of liquid level meter, metering pump and other automation equipment. The coagulation process is through flocculation of particles, so that alum grains grew gradually and precipitation. The schematic diagram of the grid flocculation tank and the physical map are shown in Figure 1 .

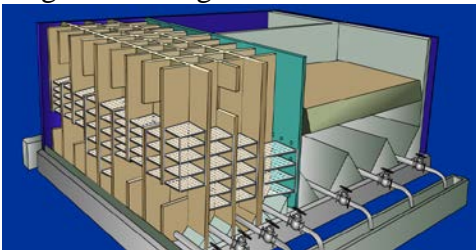


Fig.1. schematic diagram of the grid flocculation tank

3. flocculation (precipitation)

Flocculation stage formed by gravity separated from water, after entering the sedimentation tank, the particles sink to the bottom of the pool, and the sludge is accumulated and concentrated. The precipitation process is shown in Figure 2, and the motor is shown in Figure 3.



Fig .2. sedimentation process diagram



Fig.3. the motor of the mud scraper

4. Filtration and disinfection

Water treatment process is the last of the filter and disinfection, the water of bacteria and Escherichia coli and other bacteria to wipe out the whole water treatment process is completed. And the treatment of the water delivered to the plant's internal regulator wells [3-4].

Design of electrical control system for water plant

A. Control scheme design

The integrated monitoring and management system of water plant is made up of the host computer, PLC, field test instrument and so on. Host computer to complete the entire water plant management and monitoring, to achieve online detection, graphics display, fault alarm, online modify control parameters. SIEMENS S7-300 PLC as the main controller and communication central control room to achieve human-computer interaction, through the DP to achieve synchronous operation with the field device, according to the actual measurement and control point with the corresponding I/O module, DP constitute a functional and efficient DCS system, the entire production process of real-time data acquisition and automatic control.

B. Control process of filtration process

In this paper, the process of water filtration process is the case, the whole filtering process is divided into two parts: the process of air and water back flushing after normal constant water level filtration and meet the conditions. The normal constant water level filter process using the ladder diagram of the main program to achieve, according to the logic of the main program to call the subroutine of the air water reverse flushing process. To achieve the smooth implementation of the control process.

PID control is a simple structure of the controlled object, a simple structure of the algorithm, the control methods is:

$$u(t) = K_p \left(e(t) + \frac{1}{T_i} \int_0^t e(t) dt + \frac{T_d e(t)}{dt} \right) \quad (1)$$

In type (1) K_p for the proportional coefficient; T_i for the integral time constant; T_d for the differential time constant; $e(t)$ for the signal deviation, type (1) change for the transfer function is:

$$G(s) = \frac{U(s)}{E(s)} = K_p \left(1 + \frac{1}{T_i s} + T_d s \right) \quad (2)$$

Incremental PID control method is generally used in the constant pressure water supply water supply, and its discrete form is:

$$\Delta u(k) = K_p [e(k) - e(k-1)] + K_i e(k) + K_d [e(k) - 2e(k-1) + e(k-2)] \quad (3)$$

PID control needs to determine the mathematical model of the controlled object, from urban water supply process analysis, the normal water supply needs to experience two processes, one is the water pump to the water from the underground pump to the water supply pipeline, which is a lagging link, the pressure is 0, two is filled with water supply pipeline, which is the inertia of the link, so the water supply system as a combination of lagging and an inertia link, then its transfer function is:

$$G(s) = \frac{K}{TS + 1} e^{-\tau s} \quad (4)$$

K is the gain; T is the time constant; τ for the time delay

Set the use of time, set the water pressure and simulation time after simulation, the simulation curve is shown in Figure 4. From the results of the simulation (PID), the stability of the PID system is relatively poor.

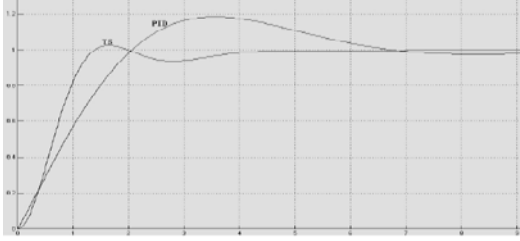


Fig.4. simulation results

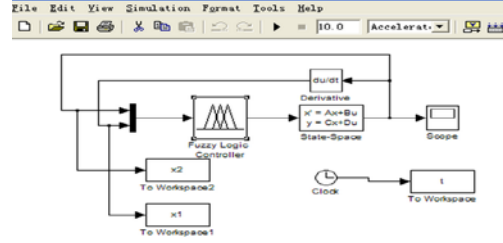


Fig.5. simulation model

T-S model is an effective model to solve the nonlinear problem, which can describe the dynamic characteristics of the nonlinear system, so it has been widely used. The T-S model and PID control can be used to control the constant pressure water supply system. TS-PID is more effective than PID in parameter adjustment, which is assumed to have M rule, then the rule is:

$$R^i : \text{if } h_3 \text{ is } A^i, \text{ then} \quad (4)$$

$$k_p = k_p^i, k_i = k_i^i, k_d = k_d^i, (i = 1, 2, \dots) \quad (5)$$

$$K_p = \frac{\sum_{i=1}^n w_{A^i} k_p^i}{\sum_{i=1}^n w_{A^i}}; K_i = \frac{\sum_{i=1}^n w_{A^i} k_i^i}{\sum_{i=1}^n w_{A^i}}; K_d = \frac{\sum_{i=1}^n w_{A^i} k_d^i}{\sum_{i=1}^n w_{A^i}} \quad (6)$$

A is a fuzzy subset; h is the output variable; k_p, k_i, k_d is the parameter value of PID for the state of the controlled object. The simulation model is shown in Figure 5. The PID control algorithm and the T-S model are combined to get a good control effect[5]. The simulation results are shown in Figure 6.

C. Configuration software design

The central control room of the upper computer monitoring configuration software using German SIEMENS WINCC6.2 configuration software. The software is powerful, the interface is beautiful, the design process is simple. At the same time, the central control room is also equipped with a large scale simulation screen, which reflects the process of the display, the security of the unified display, fault alarm immediately display the advantages. The simulation screen is shown in Figure 7.

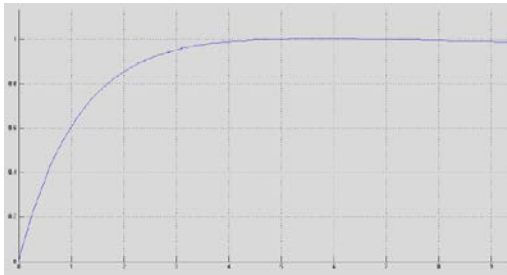


Fig.6. simulation results

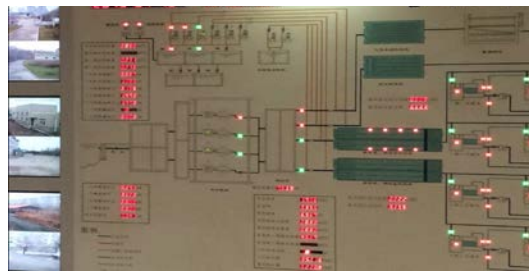


Fig .7. simulation screen

conclusion

The comprehensive monitoring and management system of water plant is perfect, with the advantages of data management, equipment optimization, energy saving, it not only improves the

utilization of equipment, but also reduces the labor intensity of workers, so it has a certain practical value.

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