

Design and Implementation of PLC-based Sewage Treatment System

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Abstract

PLC control is currently the most commonly used automation control method in industry, because PLC control is very simple, can work in harsh environments, so it is preferred to single-chip microcomputer control in industry. The control system adopts the Siemens STEP-7 programming language and configures the MCGS configuration software for program simulation and real-time monitoring. The system mainly realizes the process of sewage treatment, first the sewage is precipitated in the sedimentation tank through the coarse grid and fine grid to block the large suspended solids in the sewage to avoid blocking the sludge pipe of the pump and the sedimentation tank. Then the sludge and papermaking sludge before dewatering are transported through the sludge pump, and the organic matter is degraded by the action of anaerobic bacteria after entering the anaerobic tank, and finally ultraviolet disinfection is carried out through the biochemical tank and sedimentation tank. The system uses a fan to keep the sewage in a flowing state to ensure that the sewage is in full contact with the filler submerged in the waterless. The sewage treatment system designed this time adopts PLC as the control center and Siemens industrial computer as the host computer to intuitively reflect the entire working process of sewage treatment, and finally uses the configuration software for simulation demonstration to draw conclusions.

Keywords

PLC; Sewage Treatment System; MCGS.

1. Introduction

Although 70.8% of the earth's area is covered by water, freshwater resources are extremely limited, and what human beings can really use is rivers, lakes and a part of groundwater, accounting for only 0.26% of the earth's total water volume, and it is unevenly distributed[1]. After the 50s of the 20th century, the global population grew sharply and industry developed rapidly. The global water situation is deteriorating rapidly, and the "water crisis" is becoming more and more serious. On the one hand, human demand for water resources is expanding at an alarming rate; On the other hand, increasing water pollution is eating away at large quantities of water resources available for consumption. With the acceleration of China's economic development and modernization, the demand for water resources is also expanding. In this case, the field of sewage treatment has become a new type of industry, which currently has the same important influence as drinking water manufacturing, power supply, drainage pipes, industrial sewage treatment and other fields[2].

This paper introduces the basic process and specific implementation steps of the sewage treatment system, and realizes the manual automatic mode switching of the sewage treatment system based on the PLC application. This paper first introduces the process and related processes of PLC-based sewage treatment control system, hardware design and selection of control system, etc. Then the

principle of the control system and the design of the software part are explained, and the relevant processes of sewage treatment are reflected through the combination of the main program and the functional subprogram. Finally, the configuration software is used to demonstrate the entire wastewater treatment process.

2. Scheme Design

In this design, the CPU selects the CPU1214C of the Siemens 1200 series, which has 14 digital input points and 10 digital output points, and the expansion module selects SM1231, which has 16 digital inputs and 16 digital outputs to meet the point requirements[3]. Siemens CPU1214C has three types of devices that do not use power and control voltage, integrate a 24V encoder and load current source, and can connect sensors and encoders directly. Compared with S7-200 and other PLCs[4].The highlights of S7-1200 mainly reflect the convenience of Ethernet communication, the design of the command system is more simple and reasonable, only the language of ladder diagram and function block diagram, with strong fault diagnosis and display functions and other advantages. The system contains 4 fans for the flow of sewage in the pool, 3 pump motors for normal water supply, a sludge pump motor with a power of 2.2kw and a coarse and fine grid motor, the main functions completed by the system are as follows:

- (1) After the start button is pressed, the sewage treatment system starts to run, and the indicator light starts to work indicating that the system starts to run;
- (2) After the stop button is pressed, the sewage treatment system stops running, and the indicator light starts to work to indicate that the system stops running;
- (3) After the manual button is pressed, select the manual mode to control the sewage treatment process manually;
- (4) After the automatic mode starts, the automatic indication starts to work, indicating that the system is running automatically, and the coarse and fine grid motor, fan, and water pump motor rotate normally, reflecting the overall sewage treatment process. You can manually set the fan frequency and control the motor on and off;
- (5) The motor is set with thermal relay protection, when an overload fault occurs, the system automatically stops and alarms[5].

3. Sewage Treatment Control Part Design

3.1 Sewage Treatment Control Part Selection

3.1.1 PLC Selection of Sewage Treatment Control System

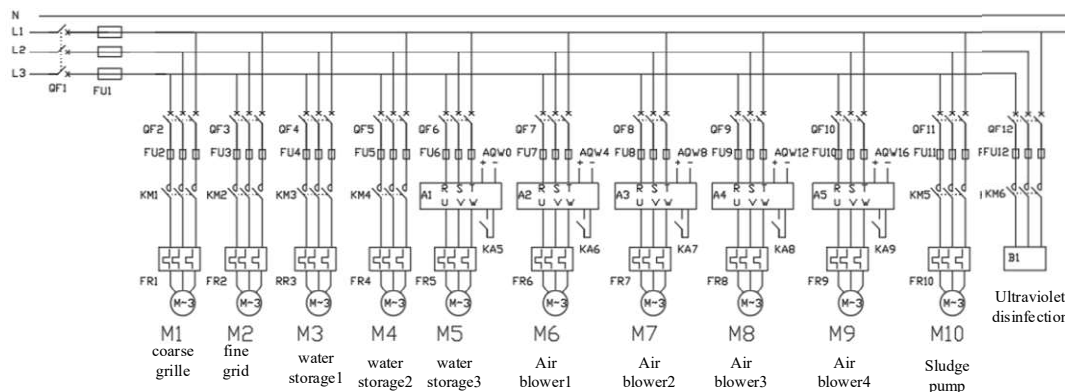


Figure 1. Schematic diagram of the control system

The CPU uses the 1214C series of the Siemens 1200. The 1214C CPU has 14 digital inputs and 10 digital outputs, with additional extended RS485 or RS232 communication interfaces. The PLC uses

the Botu programming language for programming[6]. The control circuit relies on traditional electrical components such as normally open buttons, relays, normally closed buttons, and contactors to be controlled by logical combinations such as self-locking and interlocking, and is equipped with motor operation indicators. A schematic of the control system is shown in Figure 1.

3.1.2 Peripheral Equipment Selection of Sewage Treatment System

The sewage treatment system mainly includes the host, controller, operation button, motor, indicator light, sensor, etc. The host computer is the main operation interface of the control system and has the function of data query[7]. A host computer is a computer that can issue specific control commands. By operating the preset instructions, the instructions are sent to the lower computer, and then the lower computer controls the equipment to complete the next operations. The upper computer adopts Siemens industrial computer, and the upper computer development system installs MCGS software. Contactors can be used to quickly turn on or off AC and DC circuits, this system has a total of four contactors KM1 to KM4.

The system uses FL110BYG115 stepper motor, which is mainly used for water pumps, thick and thin grids and fans, which rotate and select the direction through the number of pulses output by the PLC[8]. This design adopts the high and low level sensor C352. The input voltage is 100V-220V, the working frequency is 50 or 60Hz, the working current is $\leq 110\text{mA}$, and the output form is normally open or normally closed and can input a total of three signals, which are low level sensor signal input, high level sensor signal input, pump idling detection signal input. CW750 high-performance vector inverter is adopted, its power range is 4.0kQW-5.5kW, and the rated voltage is 380V. The selection of peripheral device options is shown in the following table 1:

Table 1. Peripheral device selection

number	Name	Remark
1	motor	Stepper motor
2	Thermal relays	Overload protection circuit
3	Fuse	RT-18 fuse
4	Contactors	LC1D AC contactor
6	Light	Coil voltage: 220V
7	Frequency converters	CW750 vector inverter

3.2 Control Circuit Design of Sewage Treatment System

3.2.1 Schematic Diagram of Sewage Treatment System

Through the analysis and comparison of various design components, the control methods used in each design system are expounded, in the sewage treatment control system, PLC as the main controller to achieve the overall control of sewage treatment, and has a normal working command signal, can realize communication with the host computer, realize data transmission and issue control commands[9]. In addition, the display output signal is analog, an external analog expansion module is required, the expansion module selects SM1231, with 16 digital input points and 16 digital output points, with this expansion module can provide enough input and output points, convenient for the successful design of the future. The input end of the sewage treatment control system is connected to an AC 380V voltage, and the output end is connected to a DC 24V voltage. The solenoid valve adopts AC 24V switch valve, which has low cost, reliable performance, simple control and easy operation. PLC wiring control schematic diagram and analog input wiring diagram, as shown in Figure 2 and Figure 3.

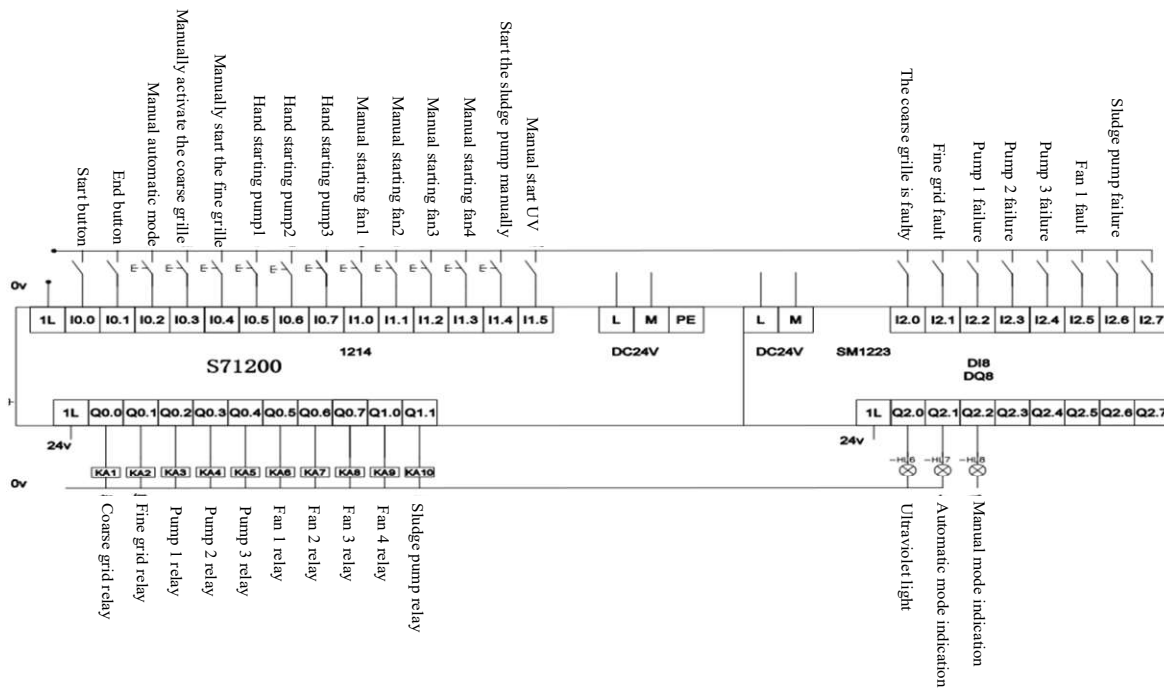


Figure 2. PLC control wiring schematic

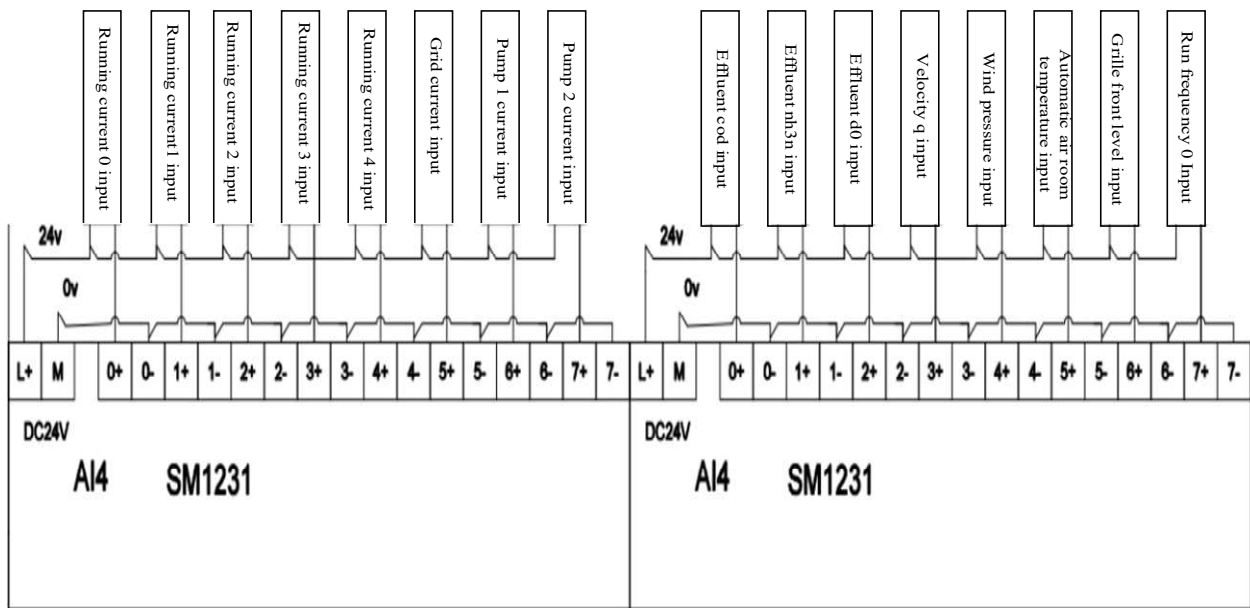


Figure 3. Analog input wiring diagram

3.2.2 Main Program Structure Flow

Based on PLC principle, basic programming principle, hardware configuration selection, automatic control system, circuit principle, etc., this system realizes the whole process of sewage treatment with PLC as the control core. The workflow diagram of all system software is formulated according to the design scheme, which can more clearly understand the entire design process of sewage treatment, and the main process of sewage treatment system, as shown in Figure 4.

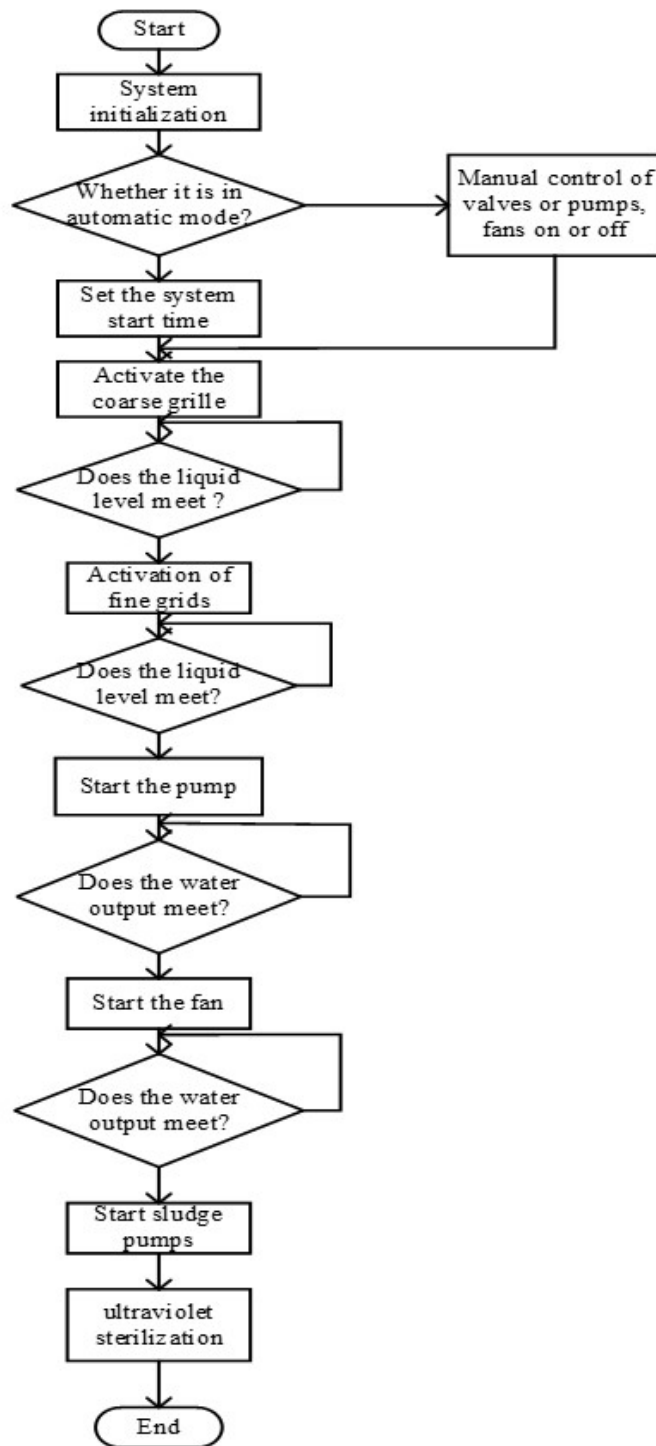


Figure 4. Schematic diagram of the system flow

4. Configuration interface design

The monitoring system designed and developed by MCGS is a new type of industrial production automation technology automatic control system[10]. It replaces the traditional control mode with standardized industrial production electronic information technology and software and hardware integration system, which has the advantages of strong adaptability, good openness, easy expansion and short design and development cycle. The configuration screen of the monitoring simulation system is drawn as shown in Figure 5.

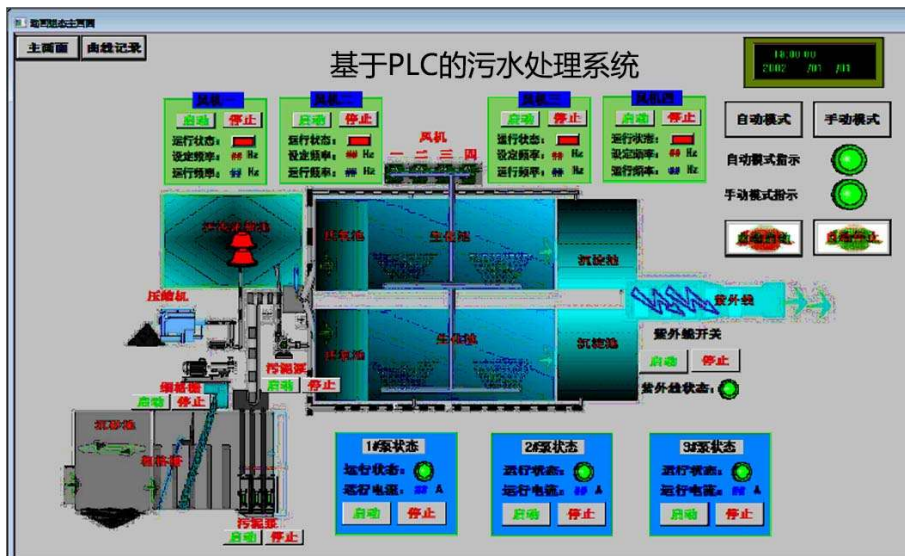


Figure 5. System configuration diagram

5. Summary

This system takes PLC as the control core, giving full play to its advantages of high reliability, strong control ability and flexible composition, which can simplify the complex contactor control circuit, easy to troubleshoot and greatly reduce the system failure rate. Through the rational configuration of external equipment, the degree of automation of the sewage treatment system is improved. The whole control system has automatic operation and manual operation mode, and is equipped with status display and alarm system, which strengthens the reliability of the system. The configuration simulation operation solves the logic problems in the operation process and lays a good foundation for field applications.

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