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Design of Offshore Platform Polymer Dispensing System based on PLC

LIANG Ke
Yangtze University
Jingzhou, Hubei, China

Abstract: The traditional polymer liquid dispensing system is difficult to automatically adjust the water volume and motor speed, complicated operation, low automation degree, and cannot meet the requirements of polymer oil dispersal system on offshore platform. In view of the above problems, the polymer liquid dispensing system is controlled by PLC, and the hardware adopts Siemens PLC, pressure sensors, liquid level sensors, electromagnetic flow meters, flow regulating valves, inverter motors and actuators, and the PLC control program is written by protherm software, which realises the input/output processing of analogue and digital quantities, and the PID automatic adjustment of the speed of inverter motors and the opening of flow regulating valves; WinCC software is used for interface design to realise on-line dynamic monitoring and control of the polymer liquid dispensing system.

Keywords: Polymer dispensing; PID; PLC; frequency control; valve opening

1. INTRODUCTORY

With the continuous breakthrough of offshore platform technology, offshore drilling technology and offshore oil recovery technology difficulties, the extraction process of offshore oil and gas resources is becoming more and more mature, and the offshore oil field is considered to be an area of great potential for development, and the liquid dispensing system is a crucial link in the oil field extraction process [1]. The traditional dispensing system has a low degree of automation, in the production process, often due to the production of water and materials can not be effectively controlled, resulting in liquid dispensing beyond the set level value, resulting in the dispensing of liquid concentration does not match the requirements at the same time the efficiency of dispensing decreased, and offshore platforms are far from land, equipment maintenance is inconvenient, so it can not meet the offshore platform oil drive on the requirements of the liquid dispensing system. Therefore, in the core link of the liquid dispensing system, PID automatic adjustment control is adopted for the liquid level and pressure associated with the flow regulating valve; PID automatic adjustment control is adopted for the liquid level associated with the inverter motor, and the size of the feeding volume and water flow rate is controlled by adjusting the frequency of the motor and the opening of the valve, so as to realise the control of the liquid level of the liquid dispensing system and to increase the degree of automation of the liquid dispensing system.

2. POLYMER DISPENSING SYSTEMS

The principle of polymer oil drive is through the addition of water-soluble polymer to the water, can make the water thickening, which reduces the water flow rate, reduces the water-oil flow rate ratio, can make the formation permeability reduction, the injected polymer solution will flow to the part containing residual oil, to achieve the purpose of improving the oil recovery rate [2].

Polymer drive dispensing system is based on this principle, formulated to meet the offshore platform oil drive needs of the concentration of the polymer solution, the system through the production of incoming water volume and polymer loading volume and other process links, to achieve automated control. All operating processes are controlled by PLC, and the on-site data are collected, analysed and processed.

The design adopts remote control system, on-line monitoring instrument, PLC controller to realise the automatic preparation of polymer solution. The liquid dispensing system adopts a 3-layer network structure, including on-site equipment layer, process control layer, monitoring layer, the on-site equipment layer includes pressure sensors, electromagnetic flowmeter, flow regulating valves, liquid level sensors, and variable frequency motors; the process control layer adopts Siemens 1500 series PLCs; the

monitoring layer adopts Siemens configuration software Win software. The process control layer adopts Siemens 1500 series PLC; the monitoring layer adopts Siemens configuration software WinCC [3].

The configuration of the liquid distribution system includes two parts: software and hardware, the hardware part of the Siemens 1500 series PLC, analogue and digital processing modules, industrial computer and switch; software part of the upper machine WinCC configuration software and the lower machine programming software TIA PortalV19 (for the development of PID control functions).

3. AUTOMATED PROCESS CONTROL FOR POLYMER DISPENSING SYSTEMS

Polymer liquid dispensing process is shown in Figure 1. This process platform to the production of water through the press ure sensor, electromagnetic flow meter, flow control valve int o the liquid distribution tank, polymer (mostly particles or du st) through the frequency converter motor-driven screw feede r transported to the liquid distribution tank, and the two are fu sed to form a polymer solution in the liquid distribution tank. The liquid level meter is installed in the liquid dispensing tan k to realise the automatic control of the opening degree of the flow regulating valve and the automatic control of the invert er motor, so as to control the amount of water and polymer in the liquid dispensing tank to achieve the function of dispensi ng polymer solutions of different concentrations and continuo us dispensing of solutions.

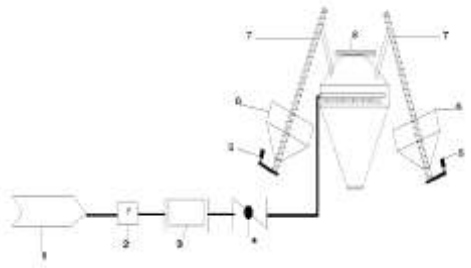

Figure 1. Polymer liquid dispensing process flow diagram

1.Platform to produce water 2.Pressure sensor 3.Electromagnetic flowmeter 4.Flow control valve 5.Frequency conversion motor 6.Feeding hopper 7.Screw feeder 8.Liquid dispensing tank

4. PLC CONTROL DESIGN FOR POLYMER DISPENSING SYSTEM

4.1 How polymer dispensing systems work

Polymer driven liquid dispensing system is coordinated by three aspects: sensor detection, PLC controller processing and actuator control. Firstly, the pipeline of the polymer driven liquid dispensing system for transporting the production water is installed with electromagnetic flow meter and pressure sensor respectively, which are used to detect the water flow rate of the pipeline and the pressure value of the water flow; there is a liquid level sensor installed in the liquid dispensing tank, which is used to detect the value of the liquid level in the liquid dispensing tank. Secondly, after the PLC controller receives the data transmitted from the sensor, it will judge and compare with the pre-set liquid level value and pressure value, and then process them. If the pressure value is higher than the preset value, the controller will reduce the opening of the flow control valve to reduce the flow of water.

The controller also needs to compare the measured liquid level value of the dispensing tank with the preset level value, combined with the inverter motor for the corresponding processing and PID adjustment, to achieve the control of the motor frequency [4]. Finally, the actuator control, PLC controller through the transmission of data, to achieve the control of the water valve opening and motor frequency given to achieve the control of the liquid distribution system. The actuators include motors and so on, which operate accordingly to the instructions of the controller. This control method can not only improve the efficiency and stability of the liquid dispensing equipment, but also meet the needs of different users and improve the comfort of users.

4.2 Polymer dispensing system control requirements

According to the above introduction, the liquid dispensing system is mainly through the valve control water flow size, through the frequency conversion motor control to control the feeding fast and slow, and then control the liquid level of the liquid dispensing tank operation, so that the control requirements here have:

(1) In order to make the production water from the platform to be able to meet the water pressure required for liquid dispensing, install pressure sensors at the water supply pipeline and set a certain threshold, where the threshold

interval is set between 0.3MPa and 0.5MPa. When the on-site pressure sensor detects that the pressure value is greater than 0.5MPa or less than 0.3MPa, an alarm will be generated, and the touch screen screen will also have an alarm display. When the system generates the alarm, it is necessary for the site staff to confirm the water supply pressure and adjust the water pressure to the threshold range before performing subsequent operations.

(2) By installing a liquid level sensor in the liquid distribution tank and a regulating water valve at the water pipeline, the regulating water valve is associated with the liquid level control of the liquid distribution tank [5], where the liquid level of the liquid distribution tank is set at 3m from the bottom of the tank. The regulating water valve is associated with the liquid level of the liquid dispensing tank for PID automatic adjustment control. In the automatic case: when the liquid level of the liquid dispensing tank is higher than the target set level, the regulating valve should gradually reduce the valve opening output, so that the liquid level of the liquid dispensing tank gradually decreases; when the liquid level of the liquid dispensing tank is lower than the target set level, the regulating valve should gradually increase the valve opening output, so that the liquid level of the liquid dispensing tank gradually rises back to the target liquid level. When the liquid level of the dispensing tank is lower than the target setting level, the regulating valve should gradually increase the valve opening output, so that the liquid level of the dispensing tank will gradually rise to the target level. In manual case, the water valve opening can be given arbitrarily in the touch screen or programme.

(3) By adjusting the frequency of motor operation to achieve the size of the amount of material [6], here the same frequency converter motor associated with the liquid level of the liquid distribution tank for PID automatic adjustment and control, automatic and frequency converter for remote control: when the liquid level of the liquid distribution tank is higher than the target level, the frequency converter should be gradually reduce the output frequency until the frequency is reduced to the lowest operating frequency set by the system; when the liquid level of the liquid distribution tank When the liquid level of the liquid distribution tank is lower than the target level, the frequency converter should gradually increase the output frequency. When the frequency converter is manually and remotely controlled, the output frequency of the frequency converter can be given arbitrarily on the touch screen or in the programme.

4.3 Sensor Selection Instructions

According to the polymer dispensing system PLC control requirements, the sensor selection.

(1) Pressure sensor selection: the selection of high-precision pressure transmitter S-20, range 0~1MPa, power supply voltage: DC 24V; analogue signal: 4~20mA current, accuracy of 0.5% FS, as shown in Figure 2.

(2) Electromagnetic flowmeter selection: Siemens electromagnetic flowmeter MAG5100W, range 0 ~ 9m/s; supply voltage: DC 220V; analogue signal 4~20mA current, accuracy of 0.2% FS, as shown in Figure 3.

(3) Level sensor selection: choose ultrasonic level meter MIK-MP, range 0~5m; power supply voltage: DC 24V; analogue signal: 4~20mA current, accuracy of 0.3% FS, as shown in Figure 4.

(4) Flow control valve actuator: choose and VXF47 water valve with the use of SBX61 actuator, actuator drive stroke of 40mm; power supply voltage: AC 24V; analogue signal: 0~10VDC, as shown in Figure 5.

Figure 2. Pressure sensors

Figure 3. Electromagnetic flowmeter

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Figure 4. Liquid level sensor

Figure 5. Control valve actuator

4.4 PLC main module selection description

Combined with the PLC control requirements of the polymer dispensing system and the I/O allocation table, the CPU and module selection is carried out.

(1) CPU selection for Siemens S7-1500 series CPU: SIMATIC S7-1500, CPU 1516-3PN/DP; central processor, can store 1MB of code and 5MB of data; the first interface, PROFINET IRT with dual-port switch; the second interface, industrial Ethernet; the third interface, PROFIBUS DP master.

(2) IO interface module selection: SIMATIC ET 200SP, PROFINET, integrated double-ended interface, IM 155-6 PN HF performance; 64 I/O modules (including F module).

(3) AI module selection: SIMATIC ET 200SP, analogue input terminal module, AI 4XRTD/TC 2-3-4-WIRE high-performance type for BU types.

(4) Selection of AQ module: SIMATIC ET 200SP, analogue output module, AQ 4XU/I standard type, suitable for A0 type base units.

(5) DI module selection: SIMATIC ET 200SP, digital input module, DI 8X24VDC high performance type, suitable for BU type.

(6) DQ module selection: SIMATIC ET 200SP, digital output module, DQ 4X24VDC/2A standard type, suitable for A0 type base unit.

7) Module base selection: First, SIMATIC ET 200SP, base unit BU15-P16+A0+2D, type A0 base unit, straight plug-in terminals (with power supply); second, spare parts SIMATIC ET 200SP, s double base unit 2BU15-P16+A0+2B, straight plug-in terminals (without power supply).

4.5 I/O distribution table for polymer dispensing systems

Based on the PLC control requirements of the polymer dispensing system and the input and output devices of the system, determine the I/O allocation table for the system, as shown in Figure 6.

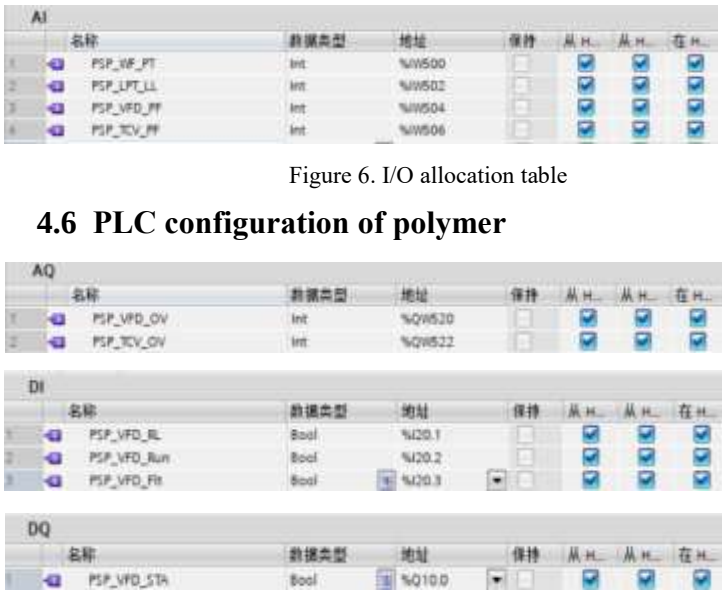

Figure 6. I/O allocation table

4.6 PLC configuration of polymer dispensing system

The hardware configuration of the PLC control system is configured as shown in Figure 7 [7].

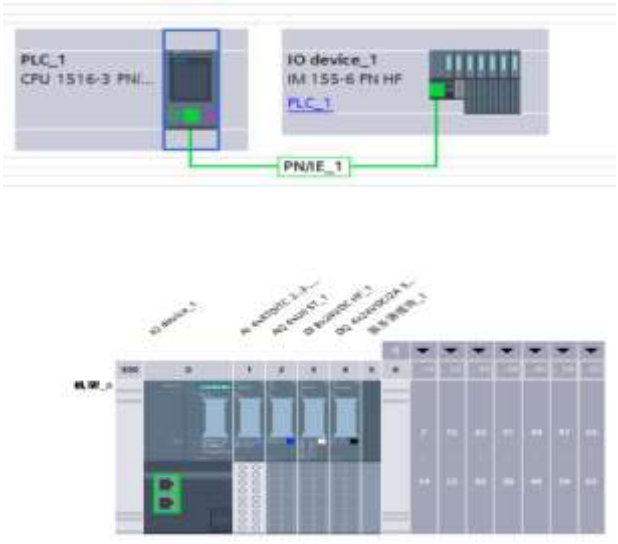

Figure 7. PLC hardware configuration

4.7 PLC programming of polymer dispensing systems

PLC programming of the polymer dispensing system, combined with the above working principle of the polymer dispensing system, to achieve the control of the PLC, it is

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necessary to design the analogue input processor, and analogue output processor in OB1 as shown in Figure 8[8], as well as the manual/automatic non-disturbance switching instructions as shown in Figure 9 [9], and the valve opening instructions as shown in Figure 10.

Figure 8. Analogue input and output handlers

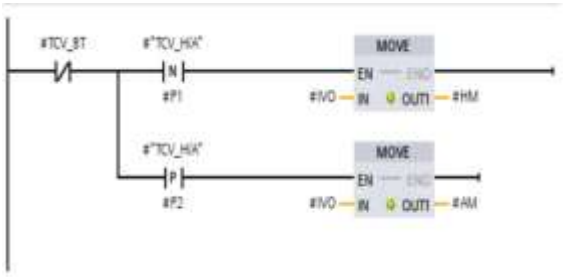

Figure9. Manual/automatic switching programme

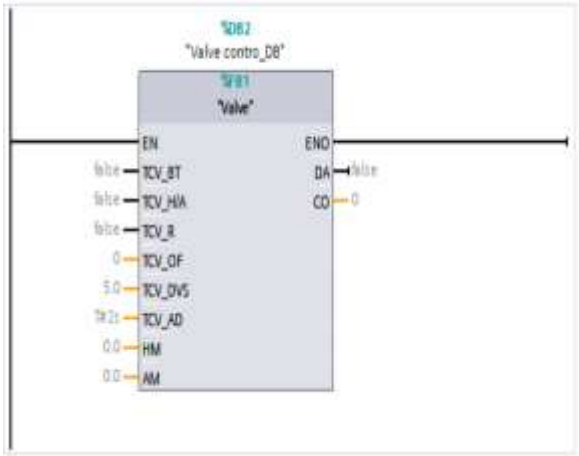

Figure 10. Valve control programme

5. REACH A VERDICT

This system designs a polymer liquid dispensing system for offshore platforms by adding some new control devices, using PLC programmable controller and combining PID closed-loop control technology. It can automatically control the frequency of the inverter motor and the valve opening according to the actual situation of the liquid level change. When the liquid level of the dispensing tank is higher than the target level, the inverter should gradually reduce the output frequency to lower the amount of polymer delivery, and at the same time, the valve opening is reduced to decrease the water flow rate; when the liquid level of the dispensing tank is lower than the target level, the inverter should gradually increase the output frequency, and the valve opening is enlarged. Through the frequency converter multi-step speed design, as well as the valve opening adjustment, the range control liquid level of the liquid distribution tank. The polymer liquid dispensing system is simple to operate, with superior performance and high degree of automation, which meets the requirements of offshore platforms for liquid dispensing systems.

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