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Siemens PLC Controlled RTP Composite Pipe Winding Part Control System

[1]Zechen Han, [2]Qin Liu and [3]Yixuan Dong,
[1, 2, 3]Mechanical and Electronic Engineering Institute, Shandong University of Science and Technology, Qingdao, China

***Abstract*—**As a new type of pipe, RTP composite pipe consists of an extrusion section, a winding section, and a composite section. The most critical part is the winding part. This article mainly introduces the winding part control system based on Siemens PLC, systematically discusses the composition of this part, explains the development process of the control system, and gives some program ladder diagrams.

Keywords*—PLC; RTP composite pipe; control system; Winding machine*

I. INTRODUCTION

The RTP compound pipe winding part requires high temperature and speed control precision. PLC control can better meet the equipment requirements. In this control system, the controller selects the Siemens SIMATIC S7-1200 series, the CPU selects 1215C DC/DC/DC The Siemens SIMATIC TP1500 Comfort touch screen was selected for the monitoring equipment. In terms of technical configuration of the equipment, it is more advanced in the pipeline production equipment.

The winding part of the RTP pipe is composed of a winding machine, a heater and a clamp. In order to meet the production requirements of the pipeline and the stability and control of the winding process, the winding speed of the winding machine and the heating temperature of the heater need to be adjusted more precisely.

II. COMPOSITION OF RTP PIPE WINDING SECTION

A. *Winding machine*

The winding machine is the core component of the winding part, and is composed of an asynchronous motor, a transmission gear, a winding machine, and a disk. The center of the winding machine is opened in the center of the winding machine. When the RTP inner tube is pulled by the tractor from the center, the winding machine rotates at a constant speed, and the glass fiber ribbon placed on the large shaft is wound onto the inner tube.

B. *Heater*

The heater is divided into two parts, the left and right, each part is equipped with a set of ring heaters and a set of thermocouples. The two parts are respectively mounted on a movable bracket, and the heater can be manually controlled to open and close to achieve heating and heat dissipation effects. Each set of heaters can be heated to a temperature of 800 degrees Celsius and controlled via a PLC temperature module. Heater temperature fluctuations can be maintained at up and down two degrees Celsius.

The function of the heater is to bake the adhesive on the surface of the glass fiber tape so that the glass fiber tape wound on the inner tube is adhered to the inner tube to meet the mechanical requirements of the pipe.

C. *Fixture*

The fixture is installed between the winding machine and the heater, and is divided into a pressing roller and a positioning fixture. The installation position of the pressure roller is close to the big plate, the role is to adjust the winding angle of the glass fiber tape and press the glass fiber tape on the inner tube; the positioning fixture is installed on both sides of the heater, the role is to adjust the position of the fixed inner tube so that the inner tube When entering the heater, keep a proper distance from the inner wall of the heater, so that the heating is even and avoid the inner tube touching the heater and causing fire.

III. DESIGN OF PLC CONTROL SYSTEM FOR RTP PIPE WINDING PART

A. *PLC control system design steps*

First of all, we must understand the production process and control requirements of the RTP production line, and draw the work cycle diagram, flow chart and diagram of the control system. Only by fully grasping the functional requirements of the production line can we achieve the design of the PLC control system.

According to the control requirements of the production line, calculate the number of PLC input and output points, so as to select the PLC and the corresponding expansion module. Drawing work after selection, including electrical schematics, electrical component location maps, electrical installation wiring diagrams, and electrical control cabinet design drawings. In addition, complete the procurement of electrical components list need to complete.

According to the control requirements for the upper computer and lower computer program preparation. When the program is compiled, the definition of the variable is first performed, and then the preparation of the program ladder diagram is performed. The host computer then draws the HMI interface. It should be noted that the correspondence between the upper computer and the lower machine variable address.

B. *System Design*

*1) Control requirements:*The task of the winding part of the RTP pipe production line is to wind and bond the fiberglass belt on the pipe, which requires controlling the traction speed of the tractor, the winding speed of the winding machine, and the heating temperature of the heater. The detailed operation procedure is as follows: firstly, the heater is turned on for preheating, and the extruded part of the extruded pipe is pulled by the tractor to advance at a fixed speed. When the proper position is reached, the winding machine starts to rotate, and the glass fiber ribbon is wound onto the inner tube. After the heater, the inner tube is bonded to the glass fiber ribbon and finally enters the composite portion.

2) Analysis of control system The control of the winding machine is mainly divided into speed control and temperature control, which will be described in detail below.

*a) Speed control:*The speed control is mainly the speed control of the winding machine. In the production process, according to the different pulling speeds of the tractor, the winding speed of the winding machine must be changed accordingly. In order to meet this demand, Siemens SINAMICS G120C frequency converter was selected to drive the asynchronous motor and drive the winding machine to rotate.

*b) temperature control:*Temperature control is mainly heater temperature control. During production, it is necessary to maintain the temperature at a certain set value. In order to meet the control requirements, the Siemens SM 1231 AI 8*16 TC temperature module was used to control the temperature of the heater. It satisfies the required requirements and is adjusted so that the temperature fluctuations can be maintained at up to 2 degrees Celsius.

3) Control System Hardware Design

a) Statistics of PLC input and output points: There are two winding machines in the winding machine, and there are two inverters that need to be controlled. Each inverter corresponding to the PLC needs to have an alarm input and a start/stop output (the speed control is directly controlled by the Profaned communication line). Two total two input points, two output points. Heater part of each heater is divided into two heating areas and two temperature measurement positions, and then the PLC requires two start and stop output, two temperature input. A total of two heaters require a total of four outputs and four inputs. In addition to this, an alarm light output is required, an emergency stop input. Finally, the statistics require a total of seven digital output points, three digital input points, and four analog input points.

*b) PLC selection:*Select Siemens SIMATIC S7-1215C/DC/DC/DC as the PLC, this model has 16 digital input points and 10 digital output points. In addition, SM 1231 AI 8*16 TC expansion module is selected as the temperature measurement module, which has 8 temperature analog input points, which can meet the control requirements.

*c) Other control components selection:*Other components include a Siemens SIMATIC TP1500 Comfort touch screen, two Siemens SINAMICS G120C inverters, four temperature sensors and circuit breakers, emergency stop switches, alarm lights, relays, contactors and so on.

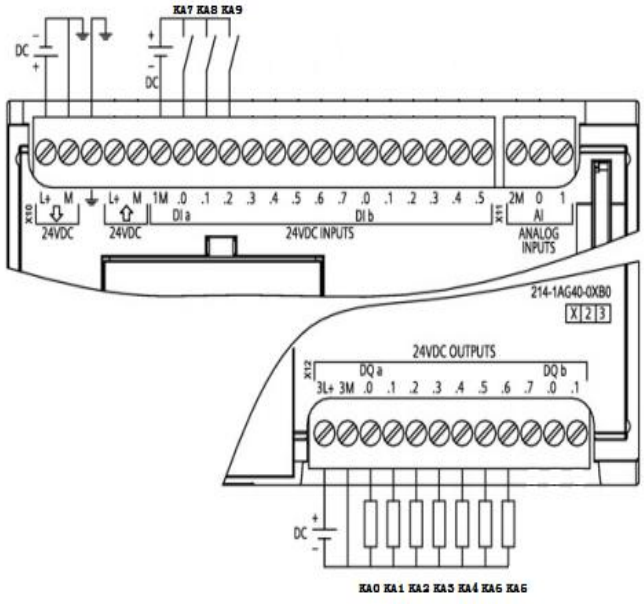


Fig. 1. PLC input / output wiring diagram

4) Drawing of electrical schematics

According to the requirements of the control system and the wiring instructions of each device, draw the corresponding electrical schematics. PLC input / output wiring diagram is shown in Figure 1. The SM 1231 AI 8*16 TC thermocouple module is shown in Figure 2.

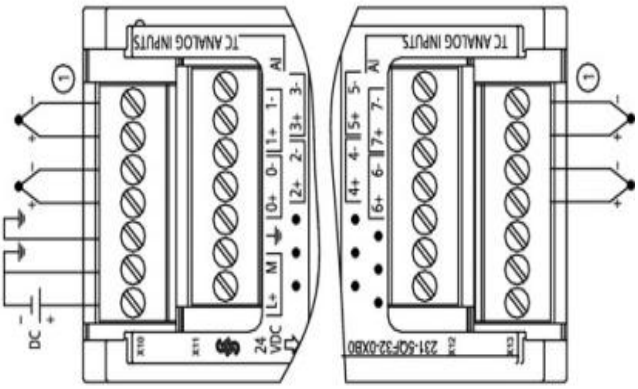


Fig. 2. SM 1231 AI 8*16 TC thermocouple module

5) Writing control programs

The control program was written using Siemens TIA Protal V14 software. TIA Protal is a brand new fully integrated automation software released by Siemens Industry Automation Group. It is the industry's first automation software that uses a unified engineering and software project environment. It is suitable for all automation tasks. TIA Protal uses a new, unified software framework to configure all of Siemens' programmable controllers, human-machine interfaces and drives in the same development environment. Sharing tasks when establishing communications between controllers, drives, and human-machine interfaces can significantly reduce connection and configuration costs.

When writing a control program, first add the required PLCs, HMIs and frequency converters in the software and configure them. After the configuration is completed, the PLC and HMI programs are written separately. When writing a program, you first need to define the variables. After the definition is completed, the ladder diagram of the PLC program is written according to the production process and control requirements. Finally, the HMI human-machine interface is created. After all is completed, the entire system can be compiled and simulated to modify the program in time.

a) Defining variables: Variable definitions need to consider the data type and address of each variable. In addition, the correspondence between the variables in the HMI and the variables in the PLC needs to be considered. Next, a definition table of some corresponding variables is given.The connection of all are PLC_1.

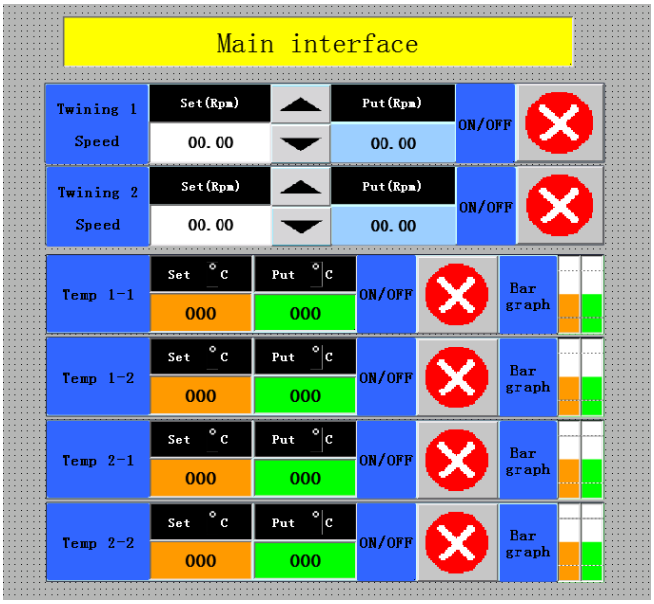
Table 1: Variable parameter table

Name	PLC tag	Data Type	Address
TEMP_ SV_1-1	TEMP_SV_1-1	Real	%MD1300
TEMP_ SV_1-2	TEMP_SV_1-2	Real	%MD1304
TEMP_ SV_2-1	TEMP_SV_2-1	Real	%MD1308
TEMP_ SV_2-2	TEMP_SV_2-2	Real	%MD1312

TEMP_PV_1-1	TEMP_PV_1-1	PID_Temp_1.ScaledInput	
TEMP_PV_1-2	TEMP_PV_1-2	PID_Temp_2.ScaledInput	
TEMP_PV_2-1	TEMP_PV_2-1	PID_Temp_3.ScaledInput	
TEMP_PV_2-2	TEMP_PV_2-2	PID_Temp_4.ScaledInput	
TEMP_ON_OFF_1	TEMP_ON_OFF_1	Bool	%M54.4
TEMP_ON_OFF_2	TEMP_ON_OFF_2	Bool	%M54.5
SPEED_SV_1	SPEED_SV_1	Real	%MD146
SPEED_SV_2	SPEED_SV_2	Real	%MD246
SPEED_PV_1	SPEED_PV_1	Real	%MD142
SPEED_PV_2	SPEED_PV_2	Real	%MD242
SPEED_ON_OFF_1	SPEED_ON_OFF_1	Bool	%M100.0
SPEED_ON_OFF_2	SPEED_ON_OFF_2	Bool	%M200.0
ALARM	ALARM	Bool	%M4.0
RESET	RESET	Bool	%M20.1

*b) Defining variables:*Variable definitions need to consider the data type and address of each variable. In addition, the correspondence between the variables in the HMI and the variables in the PLC needs to be considered. Next, a definition table of some corresponding variables is given.

c) Create HMI: When creating HMI, you should first define the variable. After the variable definition is completed, create a template screen according to the requirements (you can also use the template screen), then add one or several screens according to the control requirements, and add the required ones to each screen. Siemens TIA Protal supports dragging components directly from the toolbox to the screen. The operation is simple and convenient. The main interface of the control system is shown in Figure 3.



CONCLUSION

As a new type of pipe, RTP composite pipe has higher temperature resistance, pressure resistance and corrosion resistance than ordinary pipes. Its production and use have great significance for oil and gas transportation, and the prospect is very broad. The RTP composite pipe production equipment compared with the traditional polyethylene pipe production equipment, the core is also the most difficult part of the winding part. This set of control system uses a more advanced Siemens S7-1200 series PLC as a controller, better completed the control requirements. After production inspection, the control system runs well and the entire equipment can be operated safely, stably and reliably.

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