PID control realization of drying system of the finishing line based on MCGS and PLC

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Abstract, In order to achieve the temperature control accuracy of the finishing line drying system, a PID control system based on MCGS and PLC is proposed. Using MCGS configuration software to edit the touch screen picture, Siemens PLC hardware configuration and programming, PID control algorithm to realize the conversion of analog and digital quantity, as well as the communication design between the upper computer (PC) and PLC and touch screen. Through the practical verification of assembly and debugging, the control of the given value ±5 ºC of the drying system temperature of the finish line is realized.

1. Introduction
According to incomplete statistics, about 80% of the industrial departments in metallurgy, iron and steel, petrochemical, cement, glass, medicine and other industries should consider the temperature factor. Temperature has become an important controlled parameter in industrial objects, it is also one of the common process parameters in industrial production, any physical change and chemical reaction process are closely related to temperature, so temperature control is an important task of production automation in various industries. The traditional temperature acquisition method of automobile body surface after spraying is time-consuming and laborious, and its accuracy is poor. The control method can not meet the requirements of high-precision and high-speed control. For example, the temperature contactor control system of temperature control mainly changes the heating power by controlling the on-off time ratio of the contactor. The on-off frequency is limited by the instrument error and the service life of AC contactor the main disadvantage is that the temperature fluctuation range is large and the precision of temperature control is low. With the continuous development of human-machine interface (touch screen) and PLC, the temperature contactor control system is improved by using PLC control system. The PID control realization of the drying system of body topcoat line based on MCGS and PLC is proposed, which overcomes the shortcomings of large temperature fluctuation range and low temperature control accuracy. The closed-loop control system will realize real-time response to temperature changes and realize the drying of body topcoat line System temperature control requirements.

2. MCGS embedded configuration software
MCGS embedded configuration software and TPC series (tpc7062k) touch screen are widely used in mainstream industrial control hardware enterprises. MCGS embedded configuration software is based on RTOS (real time operating) the configuration software of real-time system is specially used in
embedded operating system. It mainly completes field data acquisition, front-end data processing and control, and can freely and flexibly configure various intelligent instruments, button switches, output load, etc. The user application system generated by MCGS embedded configuration software consists of main control window, device window, user window, real-time database and operation strategy. The configuration environment and simulated running environment of MCGS embedded configuration software are equivalent to a complete set of tool software, which can run on PC (computer).

The running environment of Embedded Configuration software is an independent operating system. It processes all kinds of processing according to the way specified by users in configuration engineering, and completes the goal and function of user configuration design. If the project is downloaded to the TPC touch screen through USB port, the touch screen control system can be realized.

3. Siemens s7-1200 series PLC

S7-1200 plc is a small controller for discrete automation system and independent automation system launched by Siemens company. It combines microprocessor, integrated power supply, input and output circuit into a compact shell, integrates Ethernet interface and strong process function, and is suitable for various application fields.

Totally integrated automation (TIA) is the latest fully integrated automation software platform of Siemens. It integrates PLC programming software, motion control software and visual configuration software to form a powerful automation software.

TIA V15 provides users with two views, portal view and project view. In the portal view, select create new project and configure device. The project view is similar to the windows interface. On the left is the project tree. Select "add new equipment", click "controller" button, select CPU, model: 6es7214-1bg40-0xb0. First, configure the hardware of Siemens PLC, download it to PLC for hardware matching, find ob1 main program block in the project tree, and then program the PLC.

4. PID control principle

The composition of analog closed-loop control system is shown in Figure 1, and the dotted line part is in PLC. In the closed-loop control system of analog quantity, the temperature of controlled quantity C (T) is the analog quantity of continuous change, while the actuator heater requires PLC to output analog signal M (T), while the CPU of PLC can only process digital value. C (T) is first converted into standard range DC current or DC voltage signal PV (T) by detecting element (sensor) and transmitter. Analog input module of PLC converts them into digital PV (n) by A-D converter. PLC collects the feedback according to a certain time interval and calculates the regulation control. Sp (n), PV (n), e (n) and m (n) in the graph are all digital quantities at the nth sampling time, and PV (T), m (T) and C (T) are analog quantities with continuous changes. In Figure 1, SP (n) is the given quantity, PV (n) is the feedback quantity after A-D conversion, and the error E (n) = sp (n) - PV (n). The D-A converter converts the digital quantity m (n) of PID control output into analog m (T), and then controls the heater to control the average temperature of the heater to realize the closed-loop control of the temperature.
In the above-mentioned system, there is steady-state error, that is, introducing PID adjustment function, P (proportional gain link), and amplifying the value of deviation signal according to proportion (amplifying KP times). In this way, although the value of deviation signal is very small, it is more accurate and rapid to adjust the temperature after amplification. After amplification, the value of the deviation signal is greatly increased, and the proportion of static error in the deviation signal is relatively reduced, so that the sensitivity of the control is increased and the error is reduced, as shown in Fig. 2 (a). If the p value is set too large, the value of deviation will also become very large, because of the inertia of the system, it is easy to cause overshoot.

Since the control system is regulated in the opposite direction, it is easy to make the actual value of the system oscillate back and forth near the given value. I (integral link) is introduced to integrate the deviation signal and output, so as to prolong the acceleration and deceleration time, so as to alleviate the overshoot caused by the excessive setting of P function. See Figure 2 (b). The introduction of PI (proportional integral) link avoids static error and system oscillation, but also prolongs the time for temperature to return to the given value. In order to overcome the above defects, D (differential link) is introduced to take differential for the deviation signal and then output. That is, when the system temperature begins to drop, the variation rate of deviation signal is the largest, and the output of D is the largest. When the temperature of the system gradually returns to the average value, the D output will gradually weaken. Therefore, after PID adjustment, the system not only ensures the dynamic response speed of the system, but also avoids the oscillation in the regulation process.
The oven temperature can be selected by button and selector switch in the control system of body topcoat drying. The furnace box temperature can be selected as low 40 °C, medium 60 °C, high 90 °C, and the heating element is heater. When the temperature of furnace and box is higher than the set value of 5 °C, the heater stops heating; when the temperature is lower than 5 °C, the heater starts heating automatically. If the whole system gives a stop signal, that is, the whole system stops heating. The furnace temperature is detected by the temperature sensor. The output signal of the temperature sensor is 0-10V, and the corresponding furnace temperature is 0-100 °C. The following is the conversion calculation between analog quantity and digital quantity, and the relationship curve between analog quantity and conversion value is shown in Fig. 3.

The output signal of the temperature sensor is 0-10V. The analog input module converts the voltage signal of 0-10V into 0-27648. According to the 0-10V corresponding to 0-100 °C, the temperature is...
set as T and the number is n, then the relationship is obtained, \( \frac{t}{N} = \frac{100}{27648} \). Then \( n = \frac{27648 \times T}{100} \) (1) is obtained, and the numerical value of 5 °C can be calculated as 1382.

5. Realization of PLC control system

5.1. Realization of PLC control

Firstly, the hardware schematic diagram of PLC control system is determined according to the control requirements of topcoat drying system and I/O distribution table. Then create an engineering project with botu software, open botu programming software, select "create new project" in portal view, and enter the project name "Q"_Honggan ", select the project saving path, and then click the" create "button to create the project, complete the hardware configuration of the project, configure the hardware of the PLC (select CPU, see 2. Above) and sm1234 (analog channel 0 is voltage input 0-10V), the hardware configuration is loaded to PLC, click PLC variable in the project tree bar, edit variable table and write program [5]. The program mainly includes (1) cycle interrupt ob30: the temperature signal is collected once every 500ms, so the cycle interrupt is adopted. Main program ob1: it is the main program of the topcoat line drying system, as shown in Figure 4.
5.2. Realization of communication control between MCGS, PC and PLC

Siemens s7-1200plc is integrated with a PROFINET interface, which can be used as programming download interface or Ethernet communication interface. The interface has two network connection methods, direct connection and network connection. This paper adopts direct connection, direct connection does not need to use switch, and can be directly connected to two equipment with network cable. In this project, two network cables are needed to realize the connection of three equipment. The IP address of the touch screen (model: tpc7062k) in this project is set to 192.168.0.10, the IP address of PC is 192.168.0.3, and the IP address of Siemens PLC is 192.168.0.1 [6].

6. Debugging procedure

Download the edited user program and equipment configuration to the CPU, and connect the hardware circuit. Turn the change-over switch SA to low, medium and high gear respectively. After pressing the start button SB1, the output terminal q0.0 of PLC will give a signal, and the heater will act according to the given temperature value. When the temperature is less than 5 ℃ of the set value, the heater will automatically heat up in response to the deviation signal. When the temperature is higher than the set value of 5 ℃, the heater will automatically stop heating in response to the deviation signal, so that the temperature of the system can be controlled constantly within the range of ± 5 ℃, press the stop button SB2, the heater will stop immediately.

7. Conclusions

PLC control system realizes the automation of the system and eliminates the disadvantages of traditional system, such as low on-off frequency, multiple contacts of temperature AC contactor system, difficult troubleshooting and maintenance. The PID control of the system eliminates the steady-state error of the system [7], responds quickly to the change of temperature sensor signal, and the temperature range control is accurate. At the same time, the touch screen of MCGS configuration
is vivid. It is easy to display the temperature range value of the control system and the shutdown control of the heater in real time; the real-time temperature value can be directly displayed on the screen to meet the temperature control requirements of the whole topcoat drying system.

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