Design of Ring Furnace Temperature Control System Based on PLC

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Abstract. This paper gives a general overview of the ring heating furnace and introduces the process, characteristics and control requirements of the automatic control system of the heating furnace. On the basis of this, the control of furnace temperature is controlled by cascade double cross limit control. Siemens S7-200 PLC as the core, completed the overall design of the annular furnace control system and the system hardware configuration, and the selection of main equipment, in order to achieve the control function of different provides hardware support.

Introduction

In rolling production of seamless steel tube, ring heating furnace is the key facility and main energy dissipation facility. The quality of steel tube is directly affected by the heating quality of the ring furnace. The output of steel tube is directly affected by its equipment and operating level. The energy consumption and sintering of the ring furnace also determine the cost of steel pipe production. Therefore, it is a key point to ensure the high quality of the ring heating furnace to complete the heating task of the blank material and become the focus of seamless steel pipe production. Therefore, it is the key to the seamless steel tube production that the ring heating furnace can complete the heating task of the blank.

As shown in Fig.1, the overall is circular, the circular furnace is mainly composed of fixed and rotation, the fixed part is the roof and composed of external ring tunnel, rotating part is the furnace bottom. When working in a ring furnace, the blastula is placed on the bottom of the furnace, and the bottom of the furnace turns and carries the germ material from the feeding mouth to the outlet. During the rotation of the furnace, the burner on the wall of the furnace heats the material. The ring heating furnace is divided into several heating sections, which can control the temperature by configuring burner heating strength and adjusting the intensity of the heating, so that the temperature can be adjusted independently.

Figure 1. Ring furnace top view

The control function of the system mainly include: automatic control of furnace pressure, seven areas in furnace temperature automatic control, automatic protection of preheater, the regulation of air-fuel ratio and the fuel consumption and furnace temperature records, etc.

The Overall Design of the Control System

The Overall Structure of the Control System

Figure2. Thermal control general structure diagram

As shown in Fig. 2, the system mainly consists of the industrial control machine part, the PLC system, the signal detection part and the actuator, where the industrial control machine and the PLC communicate through profibus. The industrial control machine is responsible for real-time monitoring, recording and displaying data. And PLC is responsible for receiving the detection part signals and sent to PC, then according to the upper machine control command driven actuators burning medium flow to achieve the ultimate goal of controlling temperature.

Cascade Double Cross Limit Control. The design adopts double cross limit cascade combustion control. Namely: when the furnace temperature rise and fall, the change of the air flow and gas flow always alternate to monitor the changes of the other side of the flow rate value, makes the air-fuel ratio always stay in advance experience within the permitted set of air-fuel ratio. That is, air traffic is limited by the limits of fuel overflows, and the gas flow is limited by the limits of air surplus. The purpose of this is to quickly adjust the air combustion ratio, ensuring that the fuel is burned as completely as possible during the process of combustion. Finally realize the following ideal goal: reach the goal of temperature adjustment in the furnace, reduce combustion loss, save fuel energy, and reduce air pollution.

There are four operating units: Positive bias, negative bias, high value selector and low value selector. The principle is shown in Fig.3.

Figure3 . Double cross limit combustion control schematic diagram

PID Temperature Controller. The control of furnace temperature has a great lag. In this paper, the second order inertia model with pure lag is selected as the research object. Its transfer function is:

$$G(s) = \frac{Ke^{-\tau s}}{(T_1s + 1)(T_2s + 1)}$$

In the formula: K is the amplification factor; T1 and T2 are time constants; τ is pure delay. The simulation model is shown in Fig.4:

Figure4. The temperature control model of PID algorithm

In the simulation model, the change of the furnace temperature under the control of PID algorithm can be observed by oscilloscope. In the second-order inertia model with $\tau = 1$, $K_p = 1.6$, $K_i = 0.1$, $K_d = 0.05$, its control effect is more ideal:

Figure5. temperature curve with $\tau=1, K_p=1.6, K_i=0.1, K_d=0.05$.

The Realization of Heating Furnace Control System

Hardware Design of Control System. The whole control system of ring heating furnace is designed for two functions: primary and secondary systems. The primary system includes the field device and the detection instrument, etc. The secondary system includes the electrical and instrument control system used by the ring heating furnace, and the configuration of the control system is shown in Fig.6:

Figure6. Hardware configuration diagram

The hardware system of this design selects the CPU 224 in Siemens s7-200 PLC, the thermocouple input module EM231, the analog output module EM232, and the flow acquisition module EM235, whose hardware wiring diagram is shown in Fig.7.

Figure7. PLC Hardware wiring diagram

PLC Control Program Flow. The main program flow diagram is shown in Fig.8:

Figure8. Master program flow diagram

Conclusion

The system combines mature control theory with advanced automation products. The system basically meets the technological requirements of high yield, low consumption of heating process, low emission and automation of production process. The heating furnace temperature control system adopts the mature PLC technology, and the automatic control of the ring heating furnace control system is successfully completed.

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