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Design and Manufacture of Heavy Truck Braking Spray Device Based on PLCS7-200

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Abstract: The braking effect is decreased rapidly in heavy truck when the temperature of braking friction plate reaches a certain value. The device measures the temperature of friction plate adopting a thermistor temperature sensor, put the temperature value into the PLC controller, compared with the selected temperature value, and the temperature of friction plate is controlled through controlling the open and close of electromagnetic valve of water supply. It has high stability, strong anti-interference ability and easy maintenance etc.

Keywords: Temperature sensor, Electromagnetic valve, PLC, Control spray.

1. Introduction

The vehicle needs to brake so as to reduce the speed, when it goes downhill. At the same time the heat is generated by the friction between the brake drum and brake shoe. The longer and steeper the slope is, more heat is generated. The vehicle's braking efficiency is affected by the work temperatures of the brake drum and brake shoe. Meanwhile the heat of the brake drum conducts to the rubber tire, making the tire high temperature, high pressure, low strength, which easily causes a tire blowout. So it is important to cooling down brake drums when we break vehicle.

Heavy trucks usually use manual spray cooling device. The driver chooses the moment of opening or closing water value on the basis of experience, it is difficult to determine the optimal water supply time according to the brake drum temperature. In this way, on one hand the cooling water is waste; on the other hand the burden is increased on a driver. Therefore, a kind of vehicle brake spraying device for automatic control is designed and manufactured, lots of devices were used in heavy trucks and have good effects.

2. The Working Principle and Structure Design of the Device

The temperature of braking friction piece are measured by the use of temperature sensors in the vehicle brake spraying devices, and the temperature signal is dialed with and then transmitted to the PLC. When the friction plate temperature value is higher than the set value, PLC controls water supply by pump. At the same time, the corresponding electromagnetic valve which controls this hub switches on and sprays water to the hub until the temperature is below the set vale, and achieves the purpose of precise control.

The spray cooling system of heavy truck consists of water tank, water pipe, water dispenser, sprayer and the PLC control system, the PLC controller is the core parts.

3. The Design of the Device Hardware

The device work procedure is shown in Fig. 1.

This device adopts Siemens PLCS7-200 as the controller, Siemens touch panel as display and parameter setting device, high sensitivity PT100 temperature sensor measuring the brake temperature. PT100 conveys signals to temperature transmitter. Then these signals are transmitted to PCL after amplified by the temperature transmitter. PLC is responsible for calculating temperature parameters, comparing the current temperature of brake drum with set value, and controlling the electromagnetic valve.

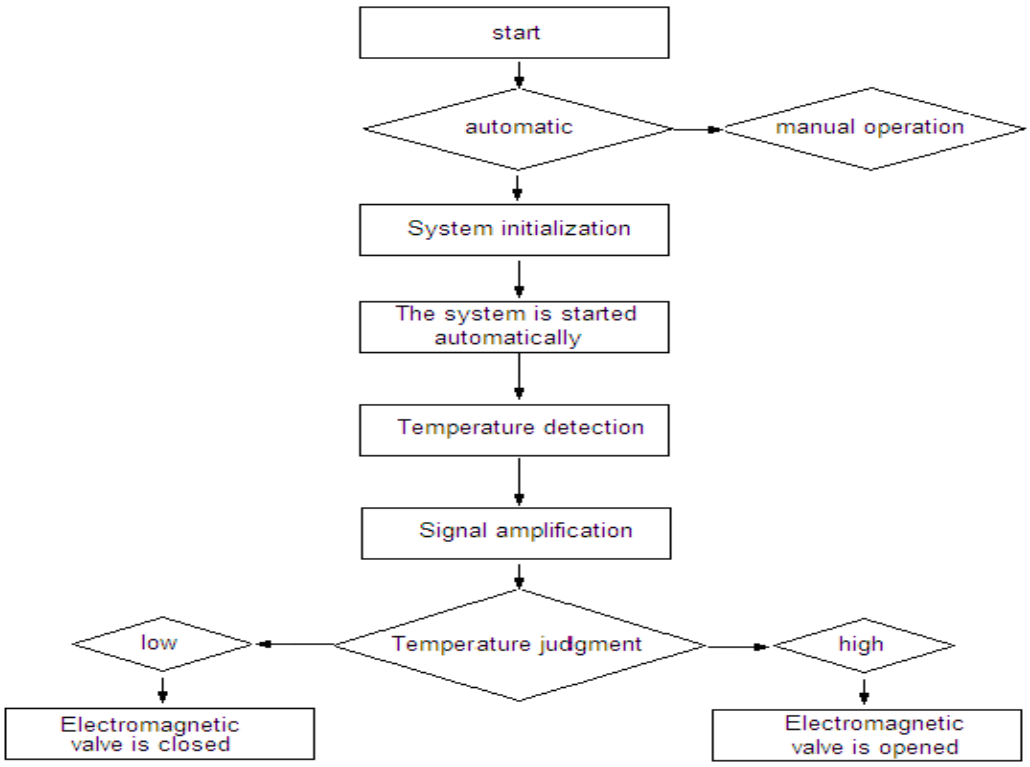

Fig. 1. The system work procedure.

4. The Design of the Device Hardware

4.1. The Determination of the Brake Shoes Cooling Temperature

According to the literature 1, when the heavy truck brakes under heavy load, the temperature of the brake shoes is usually above 300 °C, sometimes up to 600 °C. With the heavy truck speed and road slope angel become higher and larger, the temperature of brake shoes will be higher.

When the heavy truck brakes, the temperature of the contacted friction surface between the brake drum and brake shoes is obviously higher than non-contacted surface. The heavy truck is driven at the speed of 60 km/h in 4 % slope downhill. The temperature curve of the brake shoe on the surface is shown in Fig. 2.

The temperature rises rapidly at the start of braking, and it slows down after 10 seconds.

According to the literature 2, the test of the temperature risen was done for the brake shoes. The temperature of the brake shoe is a function of time, when the brake drum is constantly braking and spraying. At 260 °C, the water was sprayed to the surfaces of the brake drum, and the water amount increased with the temperature. With the extension of time, the heat exchanged from the outside to the inside. The surface temperature on the brake shoe reaches 295 °C, then began to decline. It is shown in Fig. 3.

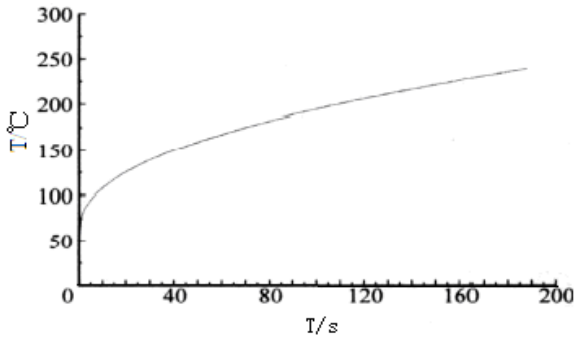

Fig. 2. The temperature curve of the brake shoe on the surface.

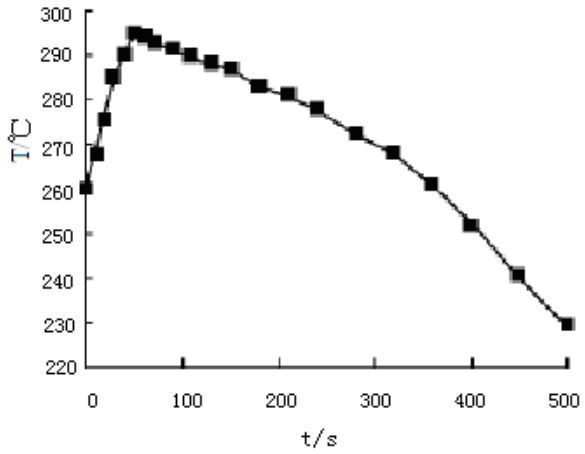

Fig. 3. The cooling temperature curve of brake shoe on the surface.

According to the literature 3, because of the friction, the heat is produced in the brake shoe, the temperature is increasing on the friction pair surface, and the friction factor would be reduced regularly. It is shown in Fig. 4.

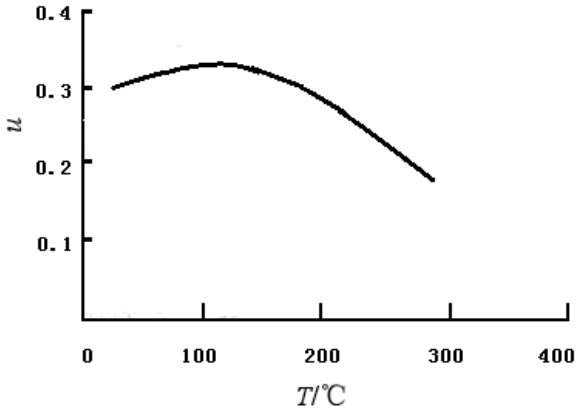

Fig. 4. Relation between the brake shoe friction coefficient and the surface temperature.

Given the function relation among the delay characteristics of the cooling temperature of the brake shoes, the friction coefficient and surface temperature of the brake shoe, it is preliminarily decided that the cooling temperature of the brake shoe is 240 °C. If the temperature is not suitable, it can be adjusted according to the braking effect.

4.2 The Selection of Temperature Sensor

The temperature sensor is one of the most important components of PLC control system, according to the working conditions appropriate temperature sensor is chosen.

Choosing the range of the measured object according to the temperature, the temperature range of brake shoe is -50~600 °C.

According to the sensor use, it is divided into direct contact and non-contact temperature measurement method. Given the temperature measurement range and economy, the sensor of thermal resistor type is more suitable for the system, the main technical parameters are as follows:

Temperature range: -100~600 °C;

Service voltage: 24 V;

Output voltage: 0~5 V.

According to the internal structure of brake drum, the probe of the temperature sensor is embedded under the friction surface about 1~2 mm, it is fixed with binder on the surface to be measured, the wire is fixed with mechanical connection way on the brake shoe, it is crossed from the installation hole in the brake plate.

4.3. The Selection of PLC Controller

The system uses Siemens PLCS7-200 as the controller, and uses EM231 as analog extension module. The central processing unit is CPU224, with 14 input /10 output I/O points. It has large capacity in program and data storage. It can extend up to seven external function modules, and built-in clock. It has become the most popular application in S7-200 series products.

4.4. The Design of the Device Circuit

The device circuit diagram is shown in Fig. 5.

Thermometric element includes temperature sensor 1, temperature transmitter 2. The input terminal of temperature transmitter 2 is connected to temperature sensor 1, the output terminal is connected to the input terminal of the touch panel 3 and the analog input of PLC 8. The output of the touch panel is connected to terminal PROT1 of PLC 8.

The water pump 7 is connected to the output terminal Q0.0 of PLC 8 and negative pole. Output terminal from Q0.1 to Q1.1 are connected to negative pole via electromagnetic valve 6. The common input terminal 1M and 2M are connected to negative pole of power 5. The common output terminal 1L, 2L and 3L are connected to positive pole of power 5. Input terminal from I0.0 to I1.5 are connected to positive pole of power 5 via brake signal switch [5, 6].

Device circuit variables are shown in Table 1.

4.5. Working Process of the Device

Working condition of the touch panel is shown in Fig. 6.

When brake drum works, brake signal switch 4 is on. The corresponding hub showed in the touch panel flickers. A lot of heat is generated due to the friction between the hub and brake drum, temperature

sensor 1 detects temperature change, then it conveys temperature signal to temperature transmitter 2 and touch panel 3. Current temperature is shown on touch panel 3. Signal is conveyed to analog terminal after amplified or reduced by temperature transmitter. PLC 8 calculates the temperature parameters, compares the current temperature of hub with the set value. When the current temperature is higher than the set value, PLC 8 controls water supply by pump 7. At the same time, the corresponding electromagnetic valve 6 which controls this hub switches on and sprays water to the hub until the temperature is below the set vale.

The shape of 6 axles in heavy truck and the temperature of the brake drums are displayed on the touch panel. The parameter of axle is selected between 1~6. "Parameter setting" is touched; you can set up the parameter of axle and the temperature of the hub. The temperature is flickered with red on the touch panel when the heavy truck is braked.

An indicating lamp installed in the cab indicates the system is working or not.

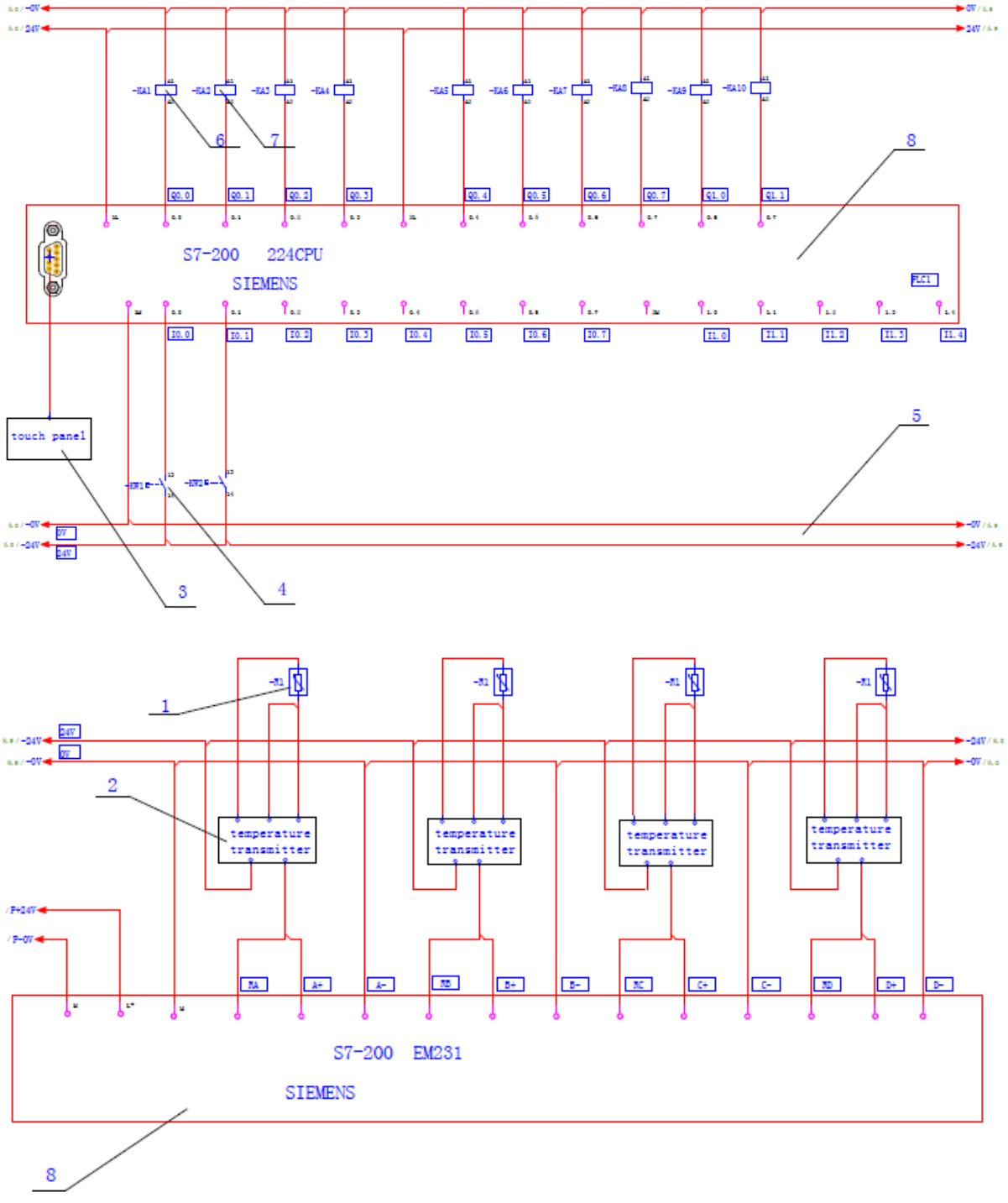

Fig. 5. Device circuit diagram.

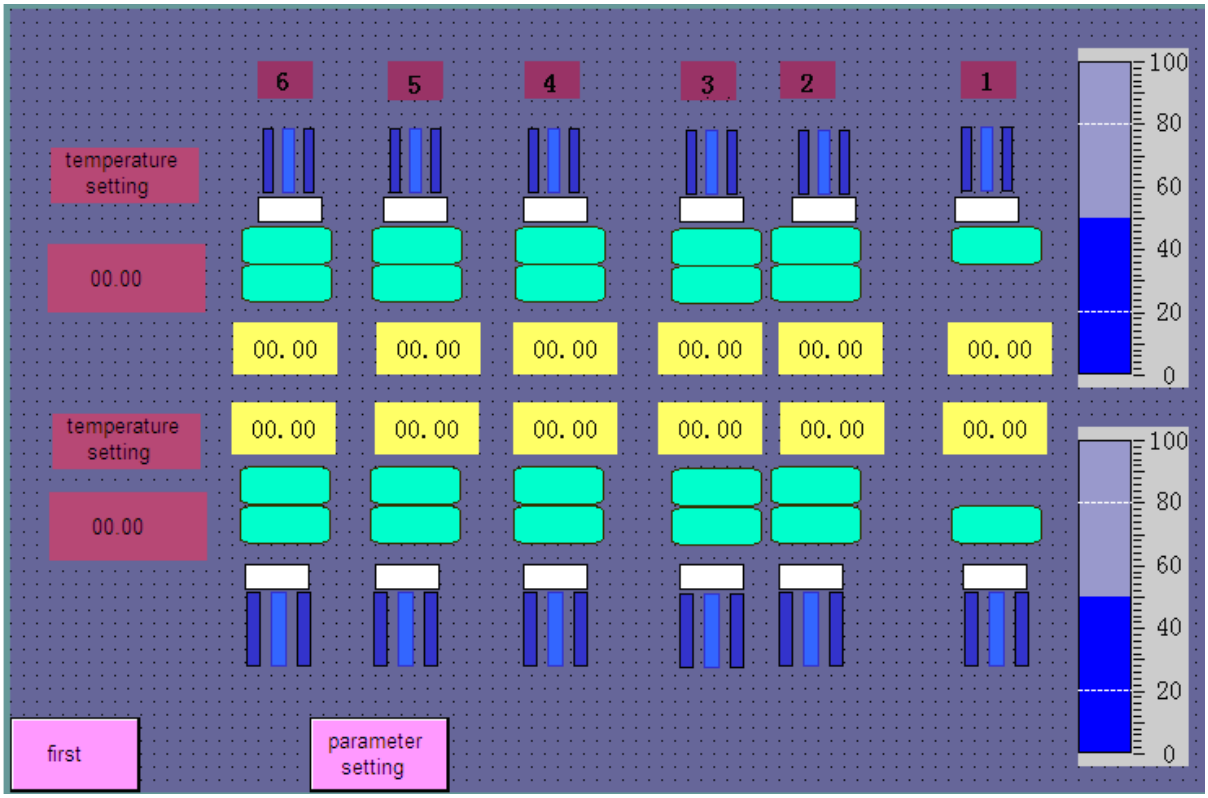

Fig. 6. Work condition of the touch panel.

Table 1. Circuit variables instruction of the device.

Variable address	Variable name	External device
variable-41	VW10	Control shaft position
variable-42	VD500	Temperature scale
variable-1	VD150	Temperature setting A
variable-7	VD160	Temperature setting B
variable-8	VD380	Temperature display value /A
variable-9	VD480	Temperature display value /B
variable-29	M12.5	Spraying instructions A
variable-28	M12.4	Spraying instructions A
variable-27	M12.3	Spraying instructions A
variable-26	M12.2	Spraying instructions A
variable-25	M12.1	Spraying instructions A
variable-24	M12.0	Spraying instructions A
variable-35	M13.5	Spraying instructions B
variable-34	M13.4	Spraying instructions B
variable-33	M13.3	Spraying instructions B
variable-32	M13.2	Spraying instructions B
variable-31	M13.1	Spraying instructions B
variable-30	M13.0	Spraying instructions B
variable-15	M10.5	Tire water instructions A
variable-14	M10.4	Tire water instructions A
variable-13	M10.3	Tire water instructions A
variable-12	M10.2	Tire water instructions A
variable-11	M10.1	Tire water instructions A
variable-10	M10.0	Tire water instructions A
variable-22	M11.5	Tire water instructions B
variable-21	M11.4	Tire water instructions B
variable-20	M11.3	Tire water instructions B
variable-19	M11.2	Tire water instructions B
variable-18	M11.1	Tire water instructions B
variable-17	M11.0	Tire water instructions B

5. Test Results

Simulation test. The brake signal switch is connected, the temperature sensor is heated with a hair dryer, the temperature changes on the display are checked.

Experiment test. The rear brake drum (Φ 410x180) is used in the EQ1208, do the risen temperature test. The same working conditions are simulated. The surrounding temperature in test condition is 10 °C, the surface temperature of the rotary brake drum is measured by infrared thermometer, and the result of the test is obtained. In the beginning of the curve (lower than 100 °C), the change is linear. When temperature is higher than 100 °C, the temperature change is nonlinear; the rising trend becomes slower [7]. The temperature tends to be stable when it reach 400 °C, and meet the design requirements.

6. Conclusions

Vehicle brake spray device applies thermistor temperature sensor, and PLCS7-200 does the controller. The device has the characteristics such as fast response, high precision, high reliability, strong anti-interference ability etc. It can monitor the running state in time and has good water-saving effect.

Automatic control heavy truck braking spray system has advantages such as responsive, high precision, high stability, it can real-time monitor the running state and has good water-saving effect.

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