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Design of Alternating Impact Machine with High Temperature and Pressure Resistance

Peng Hu, Dianbin Gao, Kaiyue Li, Tao Yang
School of Mechanical and Electronic Engineering, Tianjin Polytechnic University
Tianjin 300160, China
E-mail:hupeng_1222@163.com

Abstract

The alternating impact machine with high temperature and pressure resistance is a kind of equipment to make the fatigue experiment for rubber pipe in the auto industry. This article mainly introduces the work principle and the design of hydraulic pressure system and temperature control system of the alternating impact machine. This system uses Siemens S7-200 Programmable Logic Controller (PLC) control the temperature, impact of water or oil pulse and the impact control of test-bed. The master machine is monitored by the King View. The combination of PLC with the soft of King View is propitious to design and examine the PLC control system and possesses good practical value.

Keywords: System design, Hydraulic pressure system, Temperature control, PLC, King View

1. Introduction

The alternating impact machine with multi-mediums high temperature and pressure resistance is a kind of machine to add the temperature and pressure to the rubber pipe of auto industry and fulfill the situation of pressure alternating and simulation impact. In fact, this machine performs a kind of fatigue experiment, produces impacts to the interior of the rubber pipe which usually also produces vibration according to the purpose itself through the hydraulic pressure pulse of recurrent changes, finally examine whether the rubber pipe is eligible according to the time of fatigue experiment and the breach of the rubber pipe. This article systematically designs the vibration of the rubber pipe itself, the hydraulic pressure pulse of the interior of the rubber pipe and the interior and exterior temperatures of the rubber pipe, especially designs the hydraulic pressure system, really realizes the pulse change in the interior of the rubber pipe, and solves one of big problems for the examination of the rubber pipe.

2. Structure and work principle of alternating impact machine

The structure of the alternating impact machine with multi-mediums high temperature and pressure resistance mainly includes the test room, vibration part and the hydraulic pressure part. The sketch of the structure is seen in Figure 1.

In the design of the test room, we equip the temperature control and monitor system in the interior to credibly ensure the test temperature range of ±2°C in the test room and fully simulate the actual temperature of the exterior environment for the auto rubber pipe. In order to simulate the vibration of the rubber pipe, we adopt the frequency conversion mode to drive the mechanical vibration part, which can not only adjust the vibration frequency through changing the motor revolution, but can adjust the swing through adjusting the eccentricity of the mandrel of the vibration machine to fulfill the request of the work conditions of the tested rubber pipe, and this is the innovation of this design. To the design of the hydraulic pressure part, we adopt the double mediums of water and oil test system, where the test pressure of oil medium and water medium can be enacted on the master machine according to the needed parameters which can fully adapt the interior environmental change of the auto rubber pipe and simulate the impact to the rubber pipe.

The work principle can be described as follows. Equip the tested rubber pipe on the interface of water or oil according to the request, close the door of the test room after completing the equipment and the test room begins to be heated. Start the system, the vibration motor drive the tested piece to shake according to the input frequency, simultaneously the liquid in the rubber pipe begins to be heated and the heating process is completed in the box filling with liquid. When the heating temperature achieves the appointed value, the heating is stopped and this temperature is require to be maintained. When the heating begins, the hydraulic pressure system begins to work at the same time which produces pulses with a certain pressure and temperature in the rubber pipe. Circulate like this until the rubber pipe is broken, the protective program is started to close the system safely. All this test process is recorded in the master machine in order to analyze the rubber pipe after the test.

3. Design of control system

This control system uses PLC, collects the operation estate and actual data which are displayed on the monitor computer through the pressure and temperature sensors equipped on the machine, at the same time receives the operation orders and test enacted parameters from the monitor computer, controls the motors, heaters and magnetic valve on the machine according to the orders and test parameters to complete the test steps. Simultaneously the monitor computer can perform the save and printout of the test situations. And the master machine uses the configuration soft to complete the live display of the industrial flow and control parameters and realizes such functions as production monitor and management. This monitor system fully utilizes the respective characters of microcomputer and PLC and realizes the complements of their advantages. According to the actual situation of the test equipment, this article designs the computer monitor system which takes the Advantech Industrial Computer and Siemens S7-224CPU transmitter as the hardware core and adopts the King View6.50 as the soft platform, which can fully enhance the automatization level for the control and monitor. The control principle is seen in Figure 2.

The characteristic of this article rests with the hydraulic pressure and temperature control system, so we make the detailed research on these two aspects.

3.1 Hydraulic pressure part

The hydraulic pressure system of this machine is very important, and it is the key of this design, so we explain it detailed in this article. According to the actual situation of the auto rubber pipe, there are strict requests on the aspect of the choice of hydraulic pressure test equipment. All hydraulic pressure components providing for the pressure test system adopt the oil hydraulic pressure components which are refitted by temperature resistance and can work on the 150°C. And the overflow valve adjusting the pressure adopts the overflow valve with low noise which can ensure the noise is smaller than 60 dB in the process of the continuous test.

The main function of this system is realized by the switches of two magnetic valves to complete the simulation of the alternating pressure in the rubber pipe. After the test begins, the entrance valve is opened and the exit valve is closed, so the pipe interior is in the stage of pressure ascending, when the ascending pressure achieves the enacted value, two valves are closed at the same time, and the pipe interior is in the stage keeping pressure, finally, the entrance valve is closed and the exit valve is opened, and the pipe interior is in the stage releasing pressure.

The hydraulic pressure system control unit is composed by the motor controller and magnetic valve controller. The intermediate relay and AC contactor make up of the motor controller. The start or open orders of the motor made by PLC switches on or cuts the control turn of the AC contactor, control the connection or disconnection of the motor main loop power, and control the operation of the motor. The control part of the magnetic valve is composed by the rapid solid estate relays, and it can switch on or cut the control circuit of the magnetic valve according to the opening and shutting orders of the magnetic valve made by PLC in 5ms, and realize the rapid control of the magnetic valve.

The oil box and water box of the test system equip the sensors of heating and temperature control which can control the temperature of the liquid changes in the range of the test request. In the loop of the test system, there are sensors on the entrances of oil, water and unload, and the whole alternating process of the pressure ascending and unloading tests can be displayed on the computer, and the pulses can be clearly expressed in the Figure 3 of the wave ladder diagram. When the rubber pipe breaches, the low pressure time is very long, so the program design can ensure the safe stop.

3.2 Temperature control

This article adopts S7-200 PLC to design the temperature control system, and the advantages are: this PLC can compose proportion control, integral control and differential coefficient control according to different requests, the parameters can be adjusted conveniently, the program design is simple and easy to realize fussy mathematics operation, and the math model of the controlled objects is not needed. The composed PID adjustor bases on the continuous and systematic PID control laws, then digitizes and gets the control equation with the form of function. The principle of PID temperature control is seen in Figure 4.

Except for the restorations of all PID values in the initialization part we definite the control cycle T_c of PID controller. For the numerical value problems appeared in the process of computing PID and calculation of T_c, we complete them through replacement method and don’t transfer the special division subprograms because of the limitation of scan time. To the calculation of differential coefficient and integral, we adopt the following formulas (the feedback input variables are from simulation in the processing process).

Differential coefficient operation = (old difference value $E_{(n-1)}$ + new difference value $E_{(n)}$) ÷ T_c

Integral operation = (old difference value $E_{(n-1)}$ + new difference value $E_{(n)}$) ÷ 2 ×T_c

The S7-200 PLC has the thermocouple modules, the input points of simulation are A+ and A-, the input voltage is 0-24V DC which is transformed as numerical values 0-1023 through A/D and the maximal error ? 0.2%. There is each amplifier in the interior of the input points. The output can be 220V AC or 24V DC. We adopt the magnetic valve with

24V DC, which has special cold junction compensation circuit, and the thermocouple and the thermocouple modular are connected. This circuit measures the temperatures of oil and water on the modular junction, and makes necessary correct to the measure values to compensate the temperature differences between benchmark temperature and modular temperature, which basically realizes the control without error and overcomes such disadvantages as temperature excursion, big error, bad quality of axes and so on.

3.3 Design of King View

The communication between the industrial computer and PLC can be performed by the PC/PPI cable which connects the program junction of S7-200 with RS232 junction of computer, and it is completed in the equipment window of program environment and view soft in the slave computer. The communication between the industrial computer and digital display instrument adopts the universal RS232/RS485 transmitter, and it is completed in the equipment window of instrument and view soft.

This operation system mainly designs three interfaces which include data monitor interface, oil pipe data display interface, water pipe data display interface and relative warning interfaces. The data monitor interface (see in Figure 5) lively displays the whole work estate of the machine. Various indexes including the figuration of the machine, the position of each data sampling point, valve and motor, the present value, the present running estate and the flowing direction of the liquid. The system exactly reflects all data of the present machine and test process. And in this interface, we can observe and adjust the test conditions in real time.

4. Conclusions

The practice proves that the control system has perfect function, reliable performance, convenient servicing and realizes the automatic control of the vibration control. The adoption of the hydraulic pressure system and PID temperature control ensures the test conditions and test process. The configuration control of the master computer enhances the automatization level of the vibration system, decreases the labor intensity and avoids the accidents produced by the artificial operation. Therefore, this design possesses comparative advancements.

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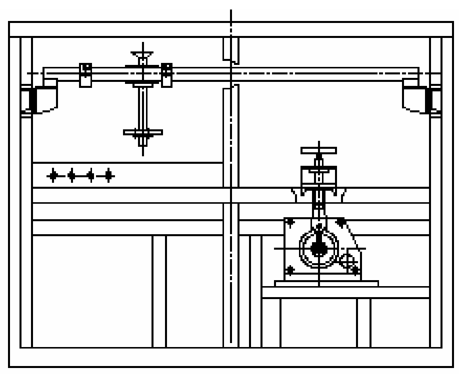

Figure 1. Sketch of Structure

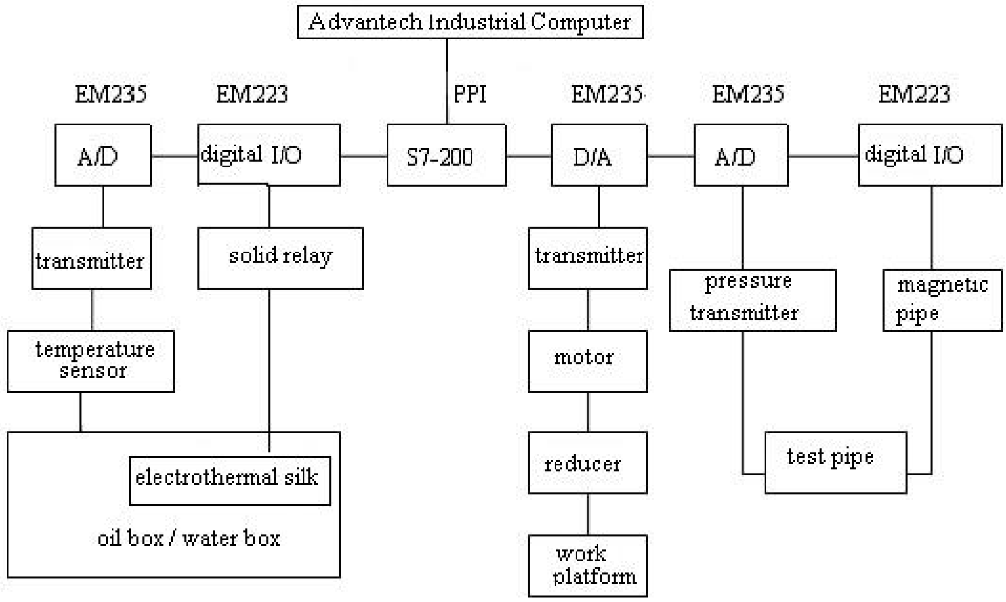

Figure 2. Control Principle of the System

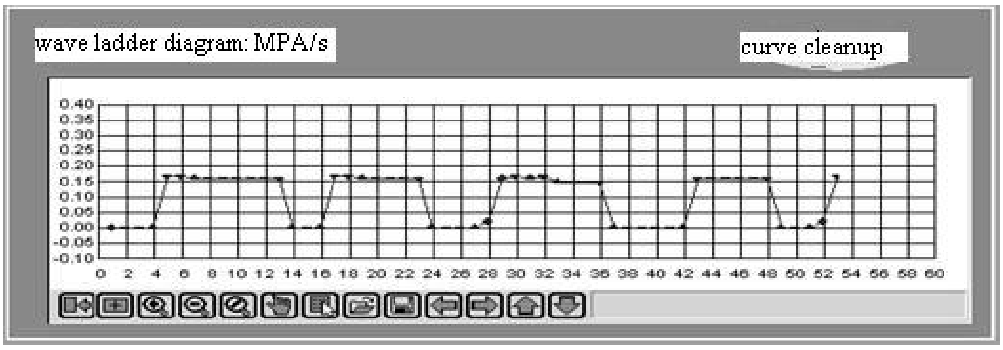

Figure 3. Pulse Curve

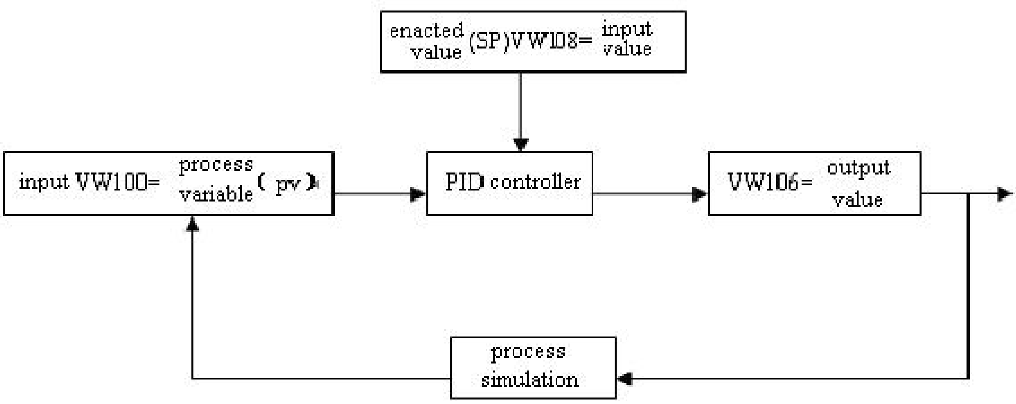

Figure 4. Control Principle of PID

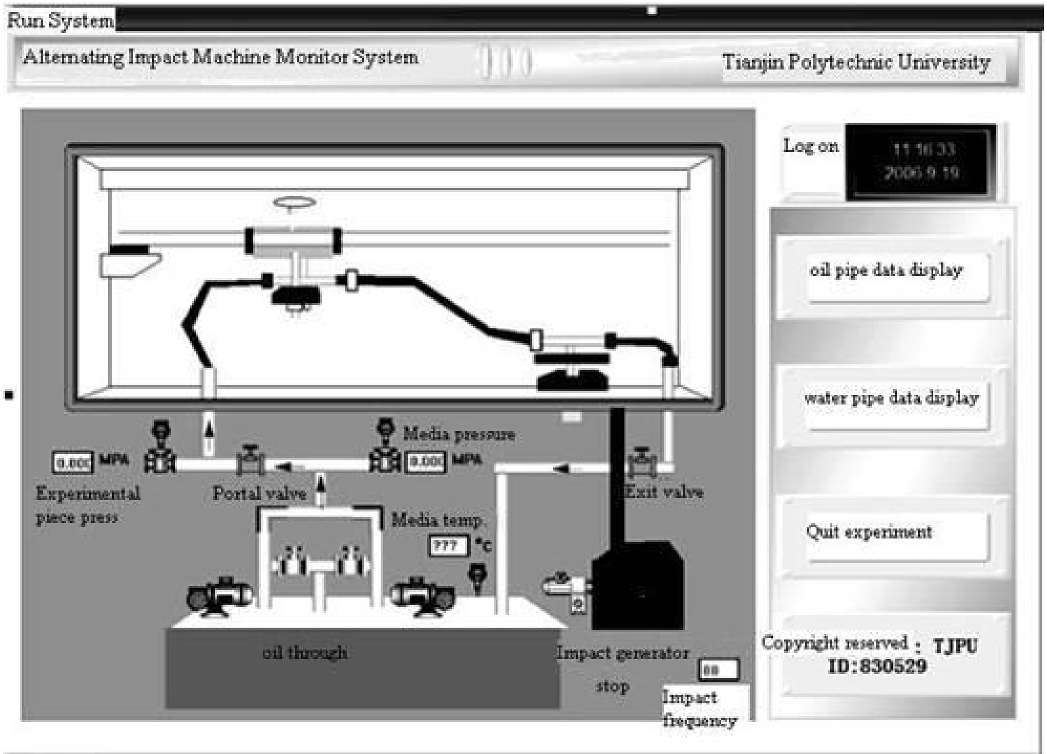

Figure 5. Data Monitor Interface