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CONTROL SYSTEM DESIGN FOR 100KN DOUBLE COLUMN UNIVERSAL HYDRAULIC MACHINE

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ABSTRACT

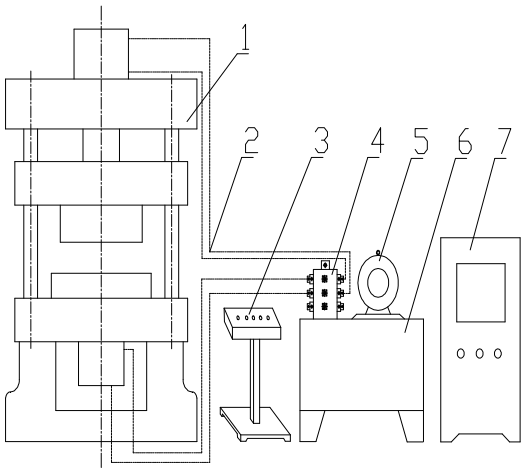
Working process and load need of double column universal hydraulic machine determined hydraulic priciple scheme and selected the entire hydraulic components model. Using a combination style of hydraulic and electrical system control to design PLC (programmable logic controller)-based electric control system. This system had three operating modes- adjustment, manual, automatic, and could realize two forming processes-constant pressure and costant stroke. Thuswe improved the deficiency of traditional relay control. Analyzing the system's hardware and software design, and provide hardware schematics and software programs. All programs were debugged with GX Developer software in this study, and work performance and stability of the hydraulic machine were improved.

Keywords: *Hyaraulic Machine, Programmable Logic Controller, Automatic Control*

1. INTRODUCTION

This design aims at small double column universal hydraulic machine, its maximum working load is 100kN, applied to metal forming, bending, stretching, punching, powder (metal, non-metallic) molding, pressing, extrusion, etc.. Traditional hydraulic machine electrical control system utlizes relay control, which uses hardware logic and fixed wiring, and has poor versatility. In addition, if large-scale system adopted relay contact control, it will need a large number of relays, moreover, in the case of frequent moves, its life is short and system reliability is poor. Programmable logic controller(PLC) has been widely used in automation processes to diminish the production cost and to increase quality and reliability[1-5]. This paper adopted PLC control, which has strong anti-interference ability, high reliability, good adaptability, could improve the lack of a relay controller.

The overall layout of the double column universal hydraulic machine diagram is divided into three parts[6], namely: the host, the hydraulic control system and electrical control system. The main structure of the hydraulic machine shows in Figure 1, all the components of the hydraulic system are centrally installed in the hydraulic tank, which makes hydraulic station layout structure compact, and electrical control element focused on electrical cabinet. The master cylinder is able to make the beam fast descending, slow suppress, maintain pressure, return and suspension stop, the ejection cylinder can complete ejection, return and stop in any position[2]. Work process of the hydraulic machine is shown in Figure 2.



1 – Host; 2- hydraulic tubing; 3 - console;
4- Manifold; 5 - hydraulic pump unit;
6-hydraulic tank; 7 - Electrical Console

Figure 1. Overall Layout Diagram Of The Double Column Hydraulic Press

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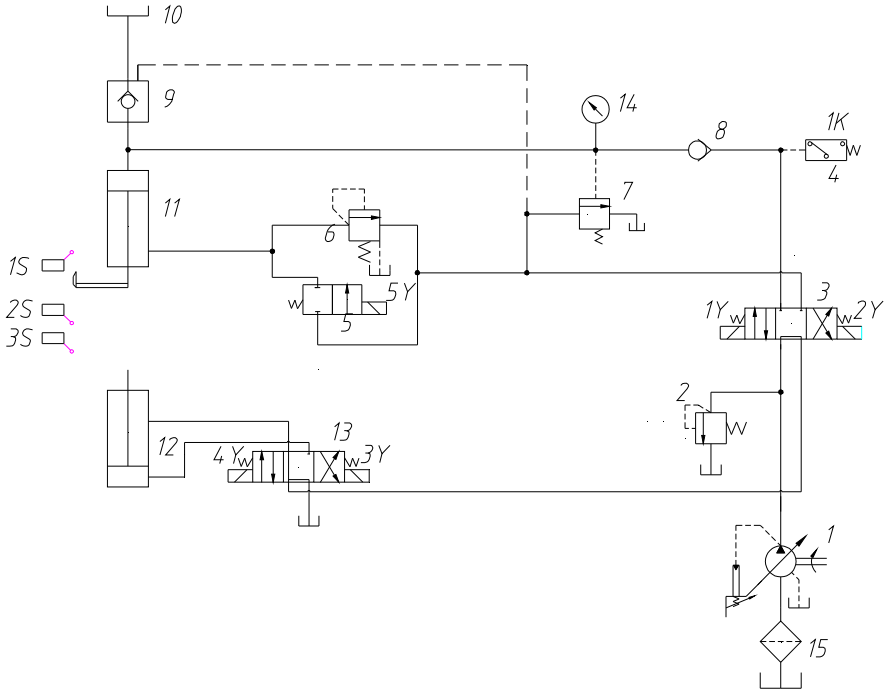

Figure 3. System Schematic Diagram Diagram

Table 1. Selected Hydraulic Components

NO.	Name of components	Model	Flow(L/min)	Pressure(Mpa)
1	Swashplate Axial Piston Pump	25YCY14-1B	37.5	32
2	Relief valve	DBDH10P	40	31.5
3	Three four-way solenoid valve	4WE10D10	100	31.5
4	Pressure relay	HED4OH		35
5	Two two-port valve	22ACO-H10B	40	31.5
6	Back pressure valve	FBF3-D10B	63	1~10
7	Unloading valve	HUR-G03-3-30	100	7~25
8	Check valve	S10P3O	40	31.5
9	Pilot operated check valve	AY-Hb10B	40	32
10	Tank			
11	Master cylinder	SZ-00-01		
12	Ejection cylinder	SZ-00-05		
13	Three four-way solenoid valve	4WE10D10	100	31.5
14	Pressure gauge	Y-60		0~40
15	Oil filter	WU-100×180	100	32

2. HYDRAULIC SYSTEM DESIGN

According to the working cycle, and load requirements, determined system schematic of the hydraulic machine, as shown in Figure 3. Source of oil is the large flow pressure compensated constant power variable pump, the maximum working pressure is set by the relief

valve 2; two main actuator are master cylinder 11 and ejection cylinder 12, the commutation of two hydraulic cylinders are controlled respectively by

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solenoid directional control valve 3 and 13; pilot operated check valve 9 with unloading valve spool acts as filling valve, it opens when the master cylinder 11 rapidly goes down, to make the fuel tank 10 supply oil to the master cylinder; the backpressure valve 6 provides backpressure for slow descending of the hydraulic cylinder; one-way valve 8 is used to maintain pressure of the master cylinder 11; valve 7 is an unloading valve with orifice, used for unloading pump 1 after the end of the master cylinder pressure holding and before commutation; the pressure relay 4 is a sending messege device for starting holding pressure. After checking, the selected hydraulic components as shown in Table 1.

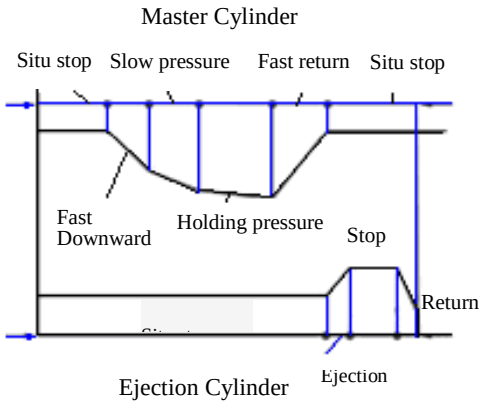

Figure 2. Working Cycle Of The Hydraulic Machine

3. PLC SYSTEM DESIGN

According to working requirements of the double column universal hydraulic machine, its PLC control system includes two ways of working-jog (manual) and automatic operation, and two forming processes -constant pressure and costant stroke, holding pressure and time delay performance[7-10].

a. Manual mode of operation: control every work process of the hydraulic machine with button operation. For example, press pressing buttons, sliders downlink; press return button, slider backhaul.

b.Automatic mode of operation: as single-cycle mode, each time you press the start button, complete a work cycle. In the work process, press the stop button to stop the operation of the hydraulic press.

PLC requires 17 input points and 6 output points, so Mitsubishi FX2N-48MR type PLC was chosen. Its host input / output points is 24/24, which can meet the control requirements, and spares input and output points to meet future expansion needs.

According to the design requirements, the exterior wiring diagram of the PLC control system was shown in Figure 4.

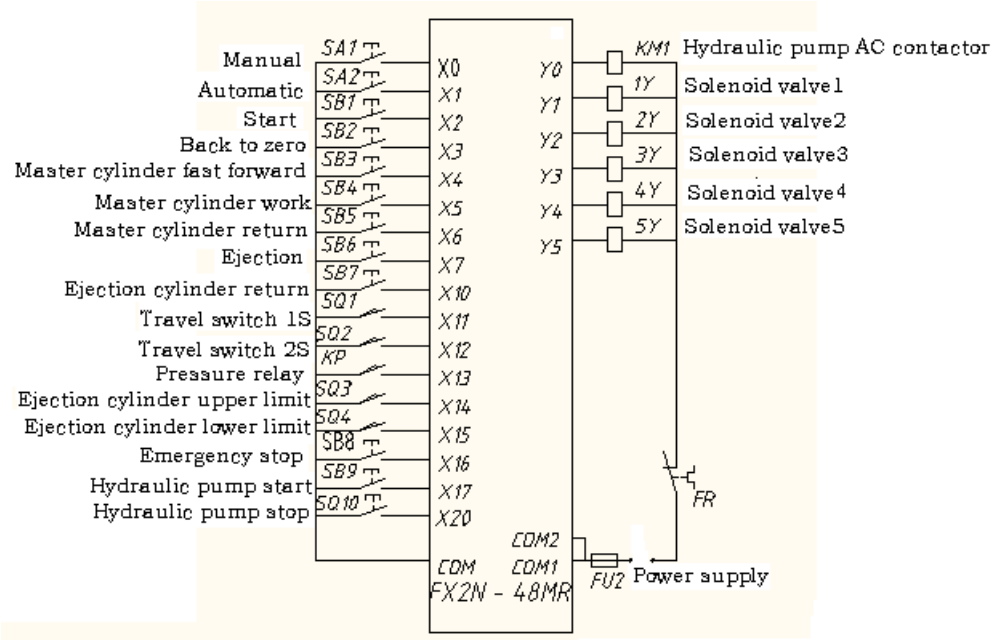

Figure 4. Wiring Diagram Of The Input And Output Terminals

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The program consists of a main program that is the public program and three subroutines, including manual subroutine, back to zero subroutine and automatically subroutine. The program was compiled and debugged with Mitsubishi programming software GX developer.

a. Public program

Figure 5 is a control program of the public program PLC, used for switching between the various operating modes. In the automatic state, if encounter a problem or emergency situation, you can press the emergency stop button to make the hydraulic pump in the unloading state.

b. Manual subroutine

In the manual operation mode, X4 ~ X10, as Figure 4 shows, respectively corresponding to the master cylinder's fast forward, work, return and the ejection cylinder's ejection and return. In the program design, when press the action button, the corresponding action state is transitted.

c. Back to zero subroutine

As shown in Figure 6, pressing the "back to zero"button (X3), right positions of switching valve 3 and 5 aresimultaneously electrified (Y2 and Y5 coils are turned on), the master cylinder returns to the initial position and press the limit switch 1S, corresponding to X11, 13 left position is electrified (Y4 coil is turned on) to make the buffer cylinder back to the initial position.

d. Automatic subroutine

As shown in Figure 7, press the "start" button (X1), followed by automatic fast downlink, slow close to the workpiece, increasing pressure, holding pressure, pressure relief, quick return, stop of master cylinder, ejection, return of ejection cylinder to achieve a work cycle. T0 is a timer to realize 10 seconds holding pressure.

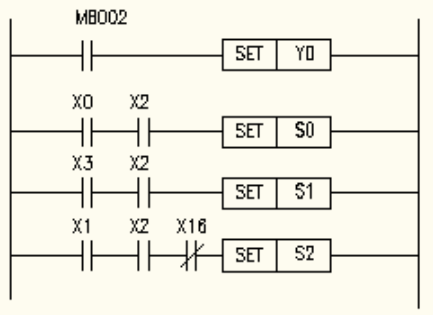

Figure 5.Public Program

The software for the control system was developed in the GX developer of MELSOFT series. Programmers can select the programming mode: ladder diagram logical or SFC. The project structure is used to store and arrange all the data and programs in order.

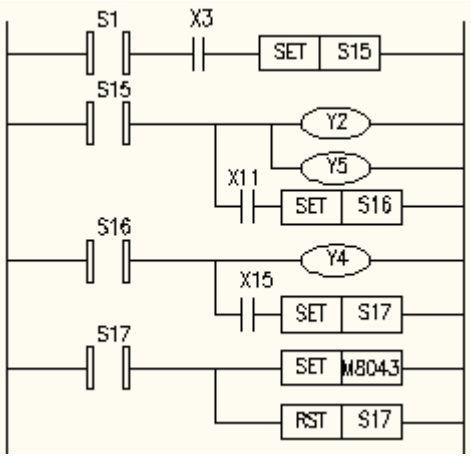

Figure 6. Back To Zero Subroutine

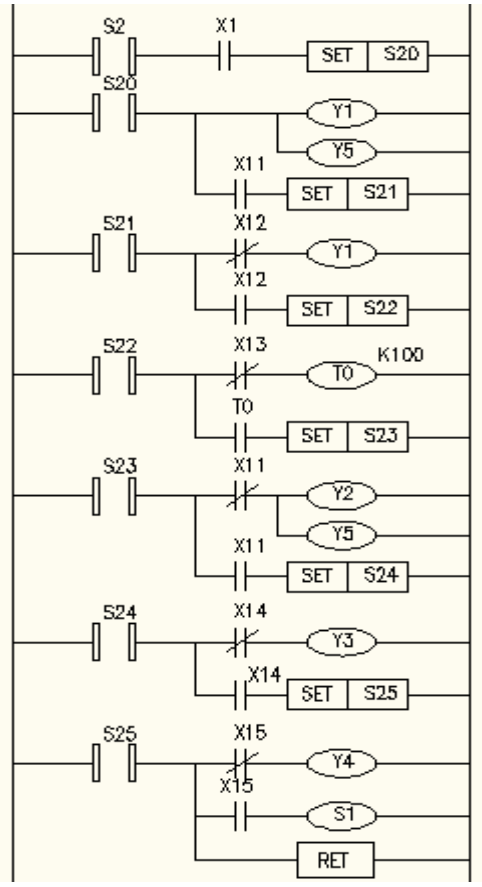

Figure 7. Automatic Subroutine

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The system software was completed in four steps. Step 1 is to edit the ladder diagram. Step 2 is to input SFC control instructions. Step 3 is to convert the program. Step 4 is to transfers the program to the CPU. Finally, the software is tested for input status, program execution, and output status. Figure 7 is the program debug interface in GX developer.

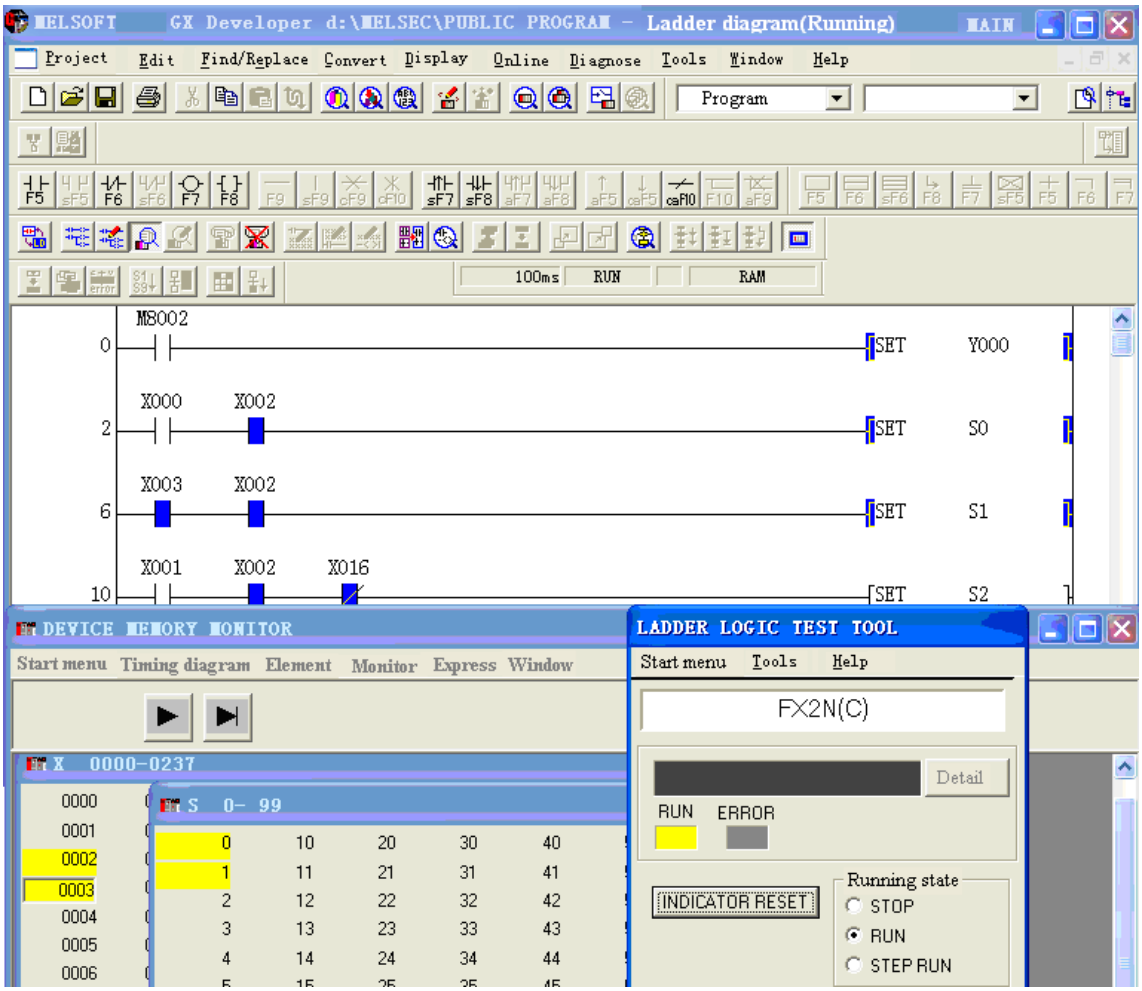

Figure 8. Program Debug Interface In GX Developer

4. CONCLUSION

This design adopted PLC control in the overall process of the double column universal hydraulic machine, used Mitsubishi programming software GX Developer for programming, debugged all the programs, and realized the function of automatic control system. Both the automatic operation and manual operation were achieved, which further improved the work performance and stability of the hydraulic machine, and provided a reference to the double column universal hydraulic machine control system applied in practical applications.

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