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Automation of Servo Hydraulic Press by Using PLC with Pilz Safety Relay

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ABSTRACT: The force of hydraulic press contains a servo solenoid pressure control valve for maintaining the pressure in cylinder champer. The pressing force of servo hydraulic press is indirectly measured by the pressure sensor which is equipped in champer. Pilz is a safety relay, which is used to monitors a specific function. By connecting them to other relays, one can achieve total monitoring of a machine or plant. Pilz furnished for different automation and safety related function. They are used to detect the defect occur during the pressing operation of hydraulic press. By this press, it is possible to measure the position of the upper plate by using a linear variable displacement transducer, which creates a precondition for the realization of a hybrid force and position control algorithm. The operation of the press is regarding with the PLC ladder program. The PLC will decrease the complexity of the circuit when compared to relay logic. This seems to be an excellent solution for different problems to improve the production.

I. INTRODUCTION

PLC technology is the advanced technology for improving the productivity and performance of the hydraulic press in industry and another concern as the flexibility, which means easily changing the process regarding with the consumer need. The relay logic replaced by the PLC logic for reducing the wiring and size of panel to increasing the reliability. In existing control method rewiring required for any modification in circuit but not in the PLC only the reprogramming is suitable for that. The PLC logic work completion speed faster than the relay logic speed by changing the program in PLC. We can change the circuit connection regarding with user required input and output. The PLC size is very small compared to the relay logic. Hence the use of the PLC, the space occupied by the system installation can be reduced. The use of solid state devices make PLC very reliable as compared to the electromechanical devices used in hardwired control panels. The hybrid force/position controller structure allows independent gains to be used for both the position and the force control task, allowing the different dynamics of each to be adjusted. Hydraulic press control using a programmable logic controller (PLC) as a control device, which could be applied in practice. Presses are one of the most commonly used machine tools in industry for the forming of different materials. In the past, for the pressing tasks in industry, mechanical presses were more frequently used, but now a days hydraulic presses take precedence due to their numerous advantages, such as: - full force through the stroke, - moving parts that operate with good lubrication, - force that can be programmed, - stroke that can be fully adjustable, which contributes to the flexibility of application,- safety features that can be programmed and incorporated into the control algorithms,- can be made for very large force capacities.

II. HYDRAULIC PRESSURE TEST MACHINE PROFILE

A. Machine Profile

The hydraulic press is one of the oldest of the basic machine tools. They present a price and weight benefit over the equivalent electro-mechanical systems needed to generate the same force or torque. Hydraulically actuated systems are used in a wide range of industrial applications, and continue to be a popular and relatively inexpensive power source and modern hydraulic presses offer good performance and reliability. The machine used in this paper is Hydraulic

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Pressure testing machine. It is used to test the disc insulators of different sizes and the machine is capable to generate up to 300bars of pressure. The press has two hydraulic servomechanisms: a hydraulic cylinder, driven by a servo-solenoid flow control valve, to support the punch tool; a hydraulic cylinder, where the chamber pressure is controlled by a servo-solenoid pressure control valve, to support the operations of loading and unloading of the press blank holder.

B. Existing control system

1. Machine is controlled by electrical panel 2. Electrical system controlled by using relay logic
3. Step downing of 415V, 3 phase from main panel to 230V, 1 phase to control panel.

C. Working Principle

The hydraulic press depends on Pascal's principle: the pressure throughout a closed system is same. At one end of the system is a piston with a small cross-sectional area driven by a lever to rise the force. Tiny-diameter tubing leads to the other end of the system. A fluid, such as oil, is displaced when either piston is pushed inward. The tiny piston, for a given distance of movement, displaces a smaller amount of volume than the large piston, which is proportional to the ratio of areas of the heads of the pistons. Therefore, the tiny piston must be moved a large distance to get the large piston to move significantly. The distance the large piston will move is the distance that the tiny piston is moved divided by the ratio of the areas of the heads of the pistons.

III. SWITCHGEAR ELEMENTS

A. Relays

The relays are devices that keep an eye on various parameters in various ways. The relays can be broadly classified into two types such as electromechanical relays and static relays (analog and digital). The electromechanical relays have been directing the electrical protection field until the use of silicon semiconductor devices became more common. Because a relay is able to regulate an output circuit of higher power than the input circuit, it can be considered, in a broad sense, to be a form of an electrical amplifier.

Operating Principle:

When a current flows through the coil, the resulting magnetic field attracts an armature that is mechanically linked to a moving contact. The movement either makes or breaks a connection with a fixed contact. When the current to the coil is switched off, the armature is returned by a force approximately half as strong as the magnetic force to its relaxed position. Usually this is a spring, but gravity is also used commonly in industrial motor starters .Most relays are manufactured to operate quickly. In a low voltage application, this is to reduce noise. In a high voltage or high current application, this is to reduce arcing.

B. Pilz safety relay

PILZ to rattle away electrical relay of the electric current with light current control in safety relay, it has a small and exquisite complete control system and the control system, so easy and simple to handle, flexible in usage and guaranteeing security automatic regulation, safe protection, chance-over circuit, etc. function.

Principle of PILZ safety relay

PILZ safety relay is when energization, both ends of the coil have certain voltage, then have electric current that flow through the coil, thus produce electromagnetic induction under the function of electromagnetic force the armature will be sucked to the core, drive the attracting of normally-open contact, normally closed off-contact. On the contrary, after the deenergization of the coil, the electromagnetic suction disappears, then return to the original position in the reacting force armature of the spring, enable normally closed closing of contact, normally open off-contact, thus reach safe protection.

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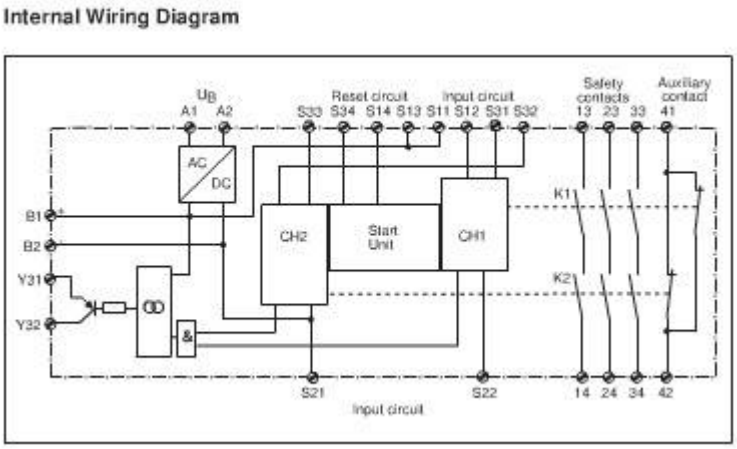
Schematic diagram of PILZ safety relay



A key benefit of safety relays is their ability to specialize. They have a clear, self-contained task to fulfill, so specific customer requirements have led to a wide range of safety relays with particular functions and features: these include devices with muting function, with safe monitoring of speed, standstill and monitored disconnection, as well as safety relays with special properties for the Ex area.

C. Contactor

A contactor is an electrical device. Which is used to switching a power circuit. A contactor is activated by a control input which is a lower voltage / current than that which the contactor is switching. Contactors come in many forms with differing capacities and features. Unlike a circuit breaker a contactor is not intended to interrupt a short circuit current.

Operating Principle:

A magnetic field is produced when current passes through the electromagnet, which attracts ferrous objects, in this case the moving core of the contactor is attracted to the stationary core. Since there is an air gap initially, the electromagnet coil draws more current initially until the cores meet and decrease the gap, increasing the inductive impedance of the circuit. Alternating current used for contactors energized with, a small part of the core is surrounded with a shading coil, which slightly delays the magnetic flux in the core. The effect is to average out the varying pull of the magnetic field and so prevent the core from buzzing at twice line frequency.

D. Circuit Breaker

A circuit breaker is an automatically-operated electrical switch. Which designed to protect an electrical circuit from damage caused by overload or short circuit. Unlike a fuse, which operates once and then has to be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation. Circuit breakers are made in differing sizes, from small devices that protect an individual household appliance up to large switchgear designed to protect high voltage circuits feeding an entire city.

Operating Principle:

Magnetic circuit breakers are implemented using a solenoid (electromagnet) that's pulling force rises with the current. The circuit breaker's contacts are held closed by a latch and, as the current in the solenoid rises beyond the rating of the circuit breaker, the solenoid's pull releases the latch which then permits the contacts to open by spring action. When an overload occur, the solenoid pulls the core through the fluid to close the magnetic, which then provides sufficient force to release the latch. The delay permits brief current surges beyond normal running current for motor starting, energizing equipment, etc. Short circuit currents provide adequate solenoid force to release the latch regardless of core position thus bypassing the delay feature. Atmospheric temperature affects the time delay but does not affect the current rating of a magnetic breaker.

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E. LVDT

LVDT is an acronym for Linear Variable Differential Transducer. It is a common type of electromechanical transducer that can transforms the rectilinear motion of an object to which it is coupled mechanically into a corresponding electrical signal. LVDT linear position sensors are readily available that can measure movements as small as a few millionths of an inch up to several inches, but are also capable of evaluate positions up to ±30 inches (±0.762 meter). The transformer's internal structure contains a primary winding centered between a pair of identically wound secondary windings, symmetrically spaced about the primary. The coils are wound on a one-piece hollow form of thermally stable glass reinforced polymer, encapsulated against moisture and wrapped in a high permeability magnetic shield, and then secured in a cylindrical stainless steel housing. This coil assembly is usually the stationary component of the position sensor. * LVDT gives High sensitivity* Very good linearity* Ruggedness* LVDT Provides Less friction* Low hysteresis* LVDT gives Low power consumption.

Principle of LVDT

LVDT works based on the principle of mutual induction, and the displacement which is a non-electrical energy is transformed into an electrical energy.

IV. PROGRAMMABLE LOGIC CONTROLLER (PLC)

A. Introduction

A Programmable Logic Controller (PLC) preferred in this paper is of the SIEMENS Company's S71500 and it is microprocessor-based control system that can be programmed to sense, activate and control industrial equipment and therefore incorporates a number of input/output terminals for interfacing to an industrial process. A control program stored in the PLC memory determines the interrelation between the inputs and outputs of the PLC.

B. History

In 1960's PLC were first developed to swap places relays and relay control system. Relays, while very useful in some applications, also have some troubles. The main troubles are the fact that they are mechanically. Which means that they wear down and have to be replaced every so often. These along with other considerations led to the advancement of PLC's. More advancement of PLC's occurred in the 70's. In 1973 the capacity to communicate between PLC's was added. This also made it possible to have the regulating circuit quite a ways away from the machines it was controlling. However at this time the lack of standardization in PLC's created other troubles. This was improved in 1980's. The size of PLC's was also reduced then, thus using space even more efficiently. The 90's increased the collection of ways in which a PLC could be programmed.

C. Block Diagram

The block diagram of the PLC is as shown in the fig. 4. The processor is a solid state device designed to replace relay logic, timers, counters etc. The essential voltage and current requirements for the internal working of the PLC is generated by the power supply. The field elements dare interfaced to the input or the output portion. Typical input components are push buttons, limit switches, proximity switches, relay contacts, selector switches, thumbwheels etc. Typical output elements are solenoid valves, relay coils, indicator lights, LED display etc. These field components are selected by the end user.

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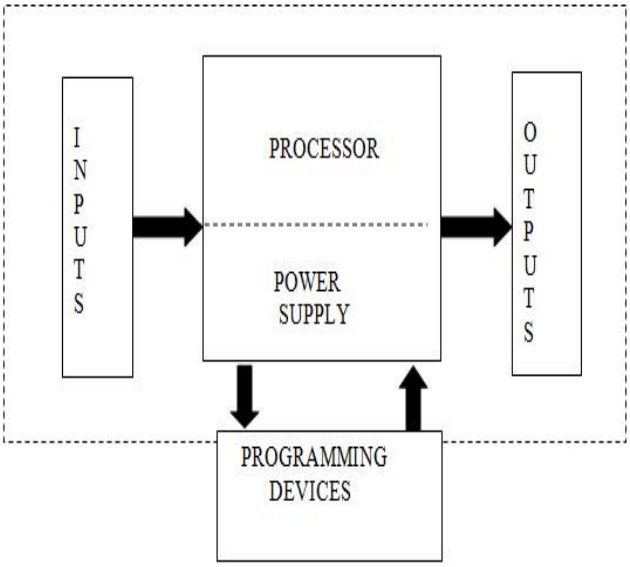

Block diagram of Programmable Logic Controller

The PLC power supply is designed and rated only to operate the internal structure and dot the field components. The processor is programmed in a similar way as the hardwired control panels, known as ladder logic diagrams. The programming device is the device where, by the programmer or operator can enter or edit program instructions or data based on their requirements. The programmer can be handheld unit that is a personal computer, or an industrial computer-programming terminal. Hydraulic press control using a programmable logic controller (PLC) as a control device, which could be applied for industrial automation.

V. LADDER LOGIC DIAGRAM (LLD)

A. Ladder Logic

The main modeling language of the PLC is based on the ladder logic so-called Ladder Logic Diagram (LLD). This graphical symbolic language is widely used in the design of PLC for industrial regulation. LLD models the actual combination of relay contacts. The term "ladder" derives from the appearance of the diagram [3]. The ladder diagram is to be read left to right, then top to bottom execution. A relay contact or a step in LLD is either (a) normally closed (NC), represented symbol by -| / |- or (b) normally open (NO), denoted by the symbol -| |-. They are controlled by logical inputs and state variables which are denoted by the labels (e.g. alarm, stop). When an input triggers the step, the corresponding relay state changes to the opposite state, which means, the NC step is turned ON while the NO step is turned OFF. A PLC ladder logic consists of N/O contacts are and N/C. The relays coils are denoted by the symbol - **( )**- [5]. These symbols are associated with the determined OP (operation) codes which instruct the CPU to take specific action while executing the ladder logic. The ladder is the combination of the above symbols interconnected with each other in a sequence and in a predestined syntax. One branch of such a ladder is known as a "RUNG" in LLD.

B. Ladder Structure

The ladder logic program is arranged in a set of ladder rungs. The structure of each ladder rung allows to program.
Maximum 9 contacts and one output coil in series connection (columns) Maximum 6 contacts / coils in parallel connection (rows)The rungs are numbered serially by the programming devices and are executed sequentially. Each rung is recognized by a unique number from 000 to 999. Insertion / deletion of rungs results in renumbering of all the succeeding rungs i.e. if rung number 0,1,2,3 are existing in the ladder logic and if rung number 1 is deleted then rung number 2 will become rung number 1, rung number 3 will become rung number 2 whereas rung number 0 will remain

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as it is. Similarly if a new rung is inserted in between two rungs then the addresses of the succeeding rungs to the new rung is shifted by 1.

C. Ladder Execution

The PLC performs its task in a definite cycle. This is called as the PLC Scan the definite cycle of PLC scan is as shown in below fig. 5. PLC Scan means that contribute the input processing, program processing and output processing together.

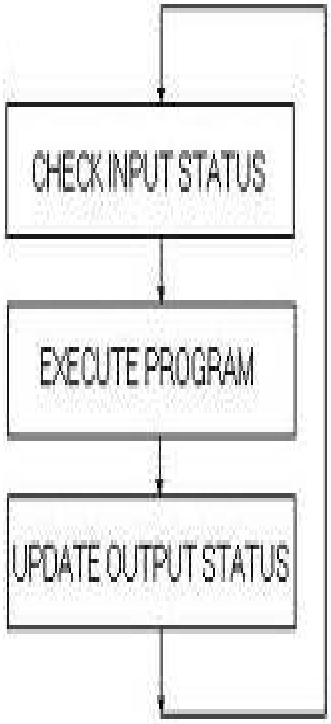

Fig.5. PLC scan process

When the PLC is performing these scan it is said to be in the RUN mode, else it is said to be in STOP mode. The PLC reads the status of all the inputs and updates their images in the memory. This is called as input scan process. Based on the status of inputs read in input scan the PLC solves the logic written by the user in User Memory Cassette (UMC). This is called as logic scan. The status of the outputs generated in the logic scan is transferred on to the output module in the output scan. One input scan followed by one logic scan followed by one output scan together contributes to one PLC scan. As soon as PLC processor finish a scan it immediately starts another scan forming continuous loops. In the logic scan the rungs programmed in UMC are executed in the sequence in which order they are entered. It is important to note that the execution of complex ladder rung having multiple coils will follow the thumb rules as given below.

The PLC will evaluate the status of all the coils in a rung sequentially from top to bottom. This will be done considering all the different paths controlling that coil. Each path will be traversed from left to right only. No contact or link will conduct from right to left.

The status of those node points need to evaluate the status of the first coil considering all its paths are decided. The node points are those points where one or more parallel paths being or end. Using this status of node points the status of the first coil is analysed. In evaluating the status of subsequent coils and nodes within that rung, the status of previously evaluated coils and nodes are used again, without reevaluating of that.

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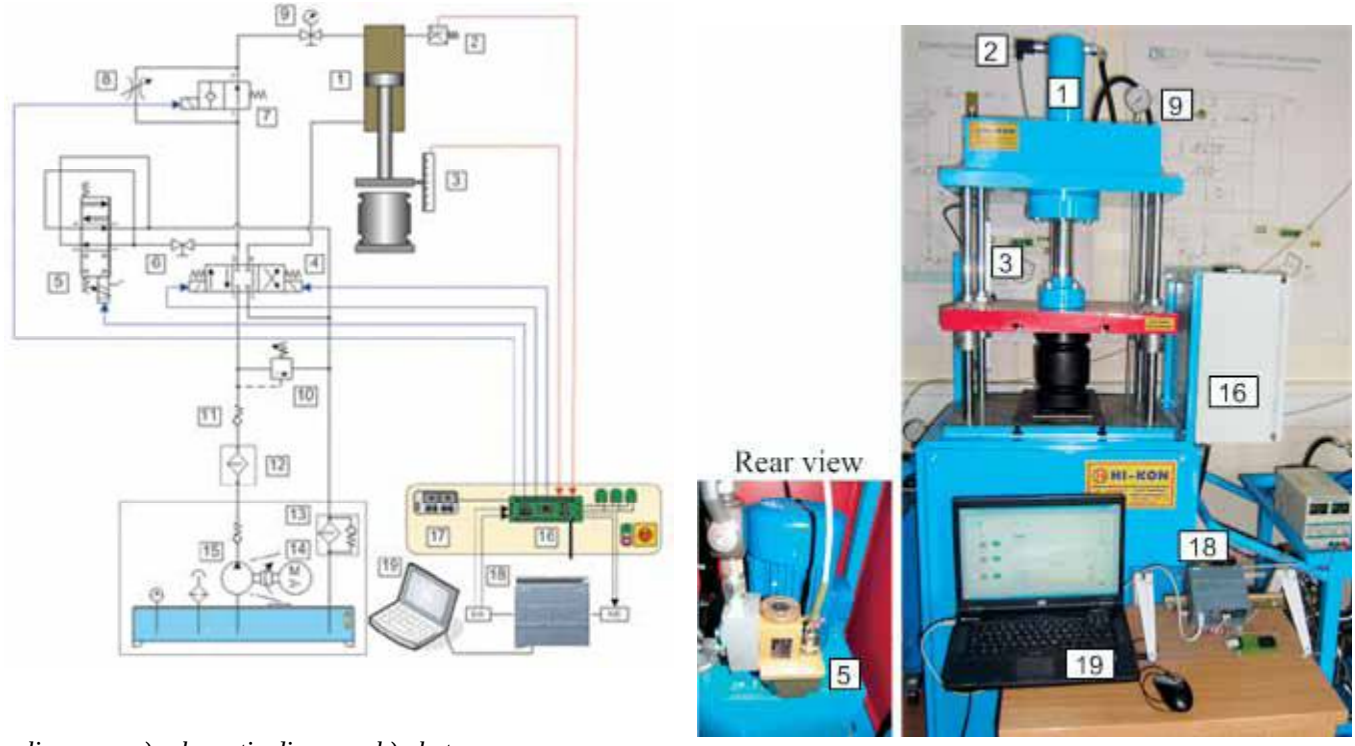
VI. EXPERIMENTAL SETUP



Hydraulic press, a) schematic diagram, b) photo;
1–Cylinder, 2–Pressure sensor, 3–LVDT
4–Solenoid 4/3 valve, 5–Servo valve, 6–Shut-off valve, 7–Solenoid 2/2 valve, 8–Throttling valve, 9–Manometer,10–System pressure relief valve, 11–Ball check valve, 12–Pressure filter, 13–Return flow filter, 14–Three-phase electric motor, 15–Hydraulic pump, 16–Electronic interface, 17–Electric rectifier, 18–PLC SIMATIC S7-1500, 19–Control computer

The hydraulic press for control of the force and position are shown in Figure 2. The hydraulic cylinder (1) it is used to actuate the press is a double-acting 300-mm-stroke cylinder with an 80-mm bore and a 60-mm diameter rod. The limitation of the press force is accomplished using an electro-hydraulic servo valve (5) designed for bypass operation, manufactured by Schneider, model HVM 025-005-1200-0, with a box-chopper amplifier and ±10-V analogue input signal. The maximum pressure in the system is controlled by a pressure relief valve (10) and the servo valve actually reduces the pressure in the system pressure line and the cylinder chamber. The servo valve is installed in a bypass line, and with respect to the control signal enables the oil flow to the tank, for keeping the pressure in the cylinder chamber at a desired value. The hydraulic force applied to a rubber bumper is indirectly calculated by a pressure transducer, with a measuring range of 0 to 250 bar and an output signal of 0 to 10 V, which is installed in the cylinder chamber. In this system it is also possible to measure the displacement of the press by using a linear variable displacement transducer P-S32, with an output voltage of 0 to 10 V and a resolution of ±2um with the installation of The displacement sensor in the system, the preconditions for the realization of hybrid force/position-control algorithms are obtained. If the shutoff valve (6) is closed then the servo valve is turned off, and then it can be shown the action of a press whose motion is limited by using a classical solenoid 4/3 valve (4). Also, if the solenoid 2/2 valve (7) is closed, the oil flow is directed to a throttling valve (8) and this changes the speed of cylinder. Since the servo valve is equipped in the system, particular attention should be given to ensure the cleanliness of the oil, so a high pressure filter (12) and a return flow

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filter (13) are set in the hydraulic circuit. The hydraulic power is provided by a hydraulic gear pump (15), model KV-1P from ViVoil, with a volumetric displacement of the pump of 2.6 cm3/rev and a maximum nominal pressure of 25 MPa. The oil pump is driven by a three-phase electrical motor (14), 2.2 kW at 980 rpm. An industrial solution of the hydraulic press control is realized by using a programmable logic controller SIMATIC S7-1200, manufactured by Siemens (18). The control program was built using SIMATIC WinCC flexible software for programming the controller and configuring the HMI panel.

VII. CONCLUSION

Replacing the relay control system with PLC makes more efficient and effective control system. The very nature of PLC design as well as its application, offers numerous benefits to industrial users to control and troubleshoot the faults. Operation of servo hydraulic press under certain pressure using PLC logic is possible, which decreases the complexity in operation compared to relay logic. So, PLC appears to be an excellent solution for many different problems which improves the status of production.

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