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Programmable Logic Controller for Hydro Pneumatic Press Control

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Abstract

Hydro pneumatic presses are a better choice over hydraulic and conventional mechanical presses. These presses are built to match up to the demands of applications like automotive parts assembly, piercing, embossing, insertion, bending, drawing, etc. The control and the operation of the system is based on a programmable logic unit and a system of sensors. The PLC gets inputs from the sensors in the system. The home limit switch signal defines the 'cycle on' from PLC. The primary parameters measured by the PLC are speed and pressure generated. The signal from the changeover limit switch indicates the transition of the ram from high speed to high pressure generated for the pressing action. A counter is used in the PLC for counting the number of cycles.

Keywords- *Hydro pneumatic, PLC, DVP, SMPS.*

I INTRODUCTION

A system that utilizes air as well as oil in its operation giving higher outlet hydraulic pressure and lower inlet pressure is called as hydro-pneumatic system. This technology combines pneumatics and hydraulics and provides with advantages such as low energy consumption, compact clean design, high stroke frequency, reduced noise levels etc. The main advantage of hydro-pneumatic presses is that they have a compact structure and does not involve the worries of handling oil pumps and tanks like in pure hydraulic presses. These presses are safe efficient and faster to achieve precision work standards.

The programmable controller basically has the function of emulating the functions of electro-mechanical relays.

A unique address is given to discrete inputs. Whether the input state is on or off is tested by the PLC instruction.

In this project, the interface of the press and the PLC is on the basis of a sensory system. The sensors/limit switches, sense the position of the pressing ram and the response is sent as an input to the PLC. The PLC then performs the output function in terms of controlling the next action of the press and accordingly signaling the actuators. The actuators concerned here are relays used for every action of the pressing ram. The ON/OFF action of the relays is controlled by the solenoids in the press. The operating stroke is divided into three stages: air-operated approach stroke, hydro-pneumatic power stroke and air-operated return stroke. Thus the press has a solenoid for each i.e. the solenoid for rapid approach, solenoid for the pressing action and the solenoid for the return action. Each solenoid thus controls the action of the respective relay connected to it. The PLC programming can be done in traditional ladder diagrams, PLC ladder diagrams and using flow chart algorithms. We have used PLC ladder diagram method for programming in this project.

In this project, the interface of Hydro pneumatic press and the embedded system is also done using the microcontroller AT89S52.The embedded system have many advantages over PLC.PLC requires more space than embedded. Embedded have lass mass production than of PLC also embedded requires less space than PLC. That's way embedded system is more conventional than PLC. Operation of system is same as that of PLC.

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II LITERATURE SURVEY

Literature survey is important because it helps to learn important authors and ideas related to the field of interest. This is useful part for the coursework and writing. Knowing key authors also helps to become acquainted with other researchers in the field. It compiles significant research published on a topic by accredited scholars and researchers. The survey examines contrasting perspectives, theoretical approaches, methodologies, findings, results, conclusions. It also reviews critically, analyses, and synthesizes existing research on a topic and performs a thorough "re" view, "overview", or "look again" of past and current works on a subject, issue, or theory.

This project is based on the hydro pneumatic press and its control using PLC and also done using embedded system. This technology combines pneumatics and hydraulics. The controls are very simple and high stroke frequencies are easily achieved with minimum air consumption. The hydro pneumatic press technology has three stages: air-operated approach stroke, hydro pneumatic power stroke and air-operated return stroke. These strokes are controlled using a PLC.

*PLC - Delta DVP-14SS2***:** PLC used in this project. Features are as given below:

- economic and compact
- built in RS-232 and RS-485 ports
- program capacity: 8k steps, data registers: 5k words.

Reference Paper**:**

Meftah Mahmoud Mohamed and Jason Gu. "PLC Controller for Hydraulic Pressing Machine". [1]

[In this system control using plc is actual implementation, Simulation is carried out for evaluation and identification of its normal operation and performance, Hydraulic and Electromechanical parts to ensure the safety and functionality of the system.]
Feng Jinbing, "Design of control system automatic riveting machine based on PLC."[2]

[The machine is static automatic riveting machine, energy, no pollution, to compressed air as a driving force, low energy consumption. The system improves the product productivity and activity while reducing worker level intensity and improving the working environment.]
Lili Liu and Jin Wan, "The design and implementation of embedded computer control system in hot pressing machine."[3]
[This system gives us a better reliable, stable and good quality output in controlling, improve in working efficiency and quality of electric machine.]

III HYDRO-PNEUMATIC PRESS

1: *Hydro-pneumatic press machine*: Hydro- pneumatic system contain two component hydro-pneumatic pump and cylinder. Main component of hydro-pneumatic pump are gear box, cranky Air motor and oil reservoir Pump is connected to the pneumatic compressor.
2: *Hydro-pneumatic tank control system*: A hydro-pneumatic tank contains pressurized air and water.
3: *Hydro-pneumatic clutch actuation system*: hydro pneumatic clutch actuation system is complex system where pneumatic, mechanical, hydraulic and if required electric component are coupled.

Survey on Hydraulics:
A hydraulic system spread the equal fluid constantly from a certain stock that is part of the primary mover, The liquid is almost non-compressible fluid, so the actuator it drives can be controlled to very correct speed, force and position. A dedicated power unit is present foe every machine in hydraulic systems.

Survey on pneumatic:
The pneumatic circuits run at a lower power than pure hydraulic systems. Two main benefits of air-operated circuits are their design simplicity and low initial cost. Because air systems operate at the building block, somewhat low pressure and can be made of relatively inexpensive material.

IV BLOCK DIAGRAM

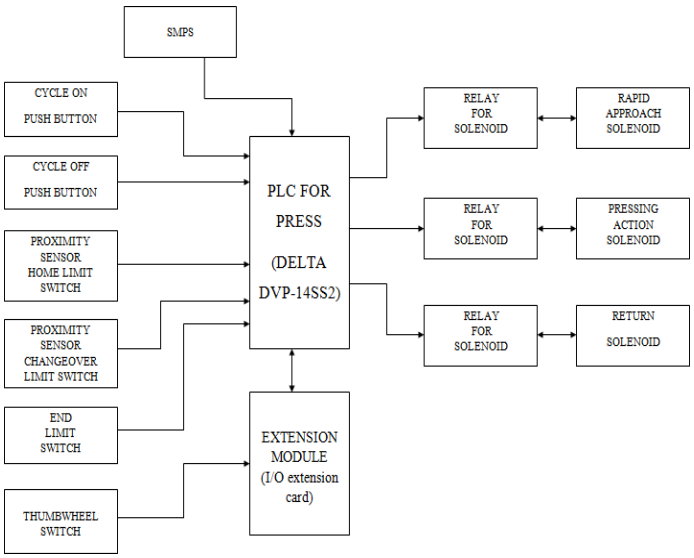

Fig. 1.Block diagram of System

Block diagram description:
PLC for press: The Delta PLC DVP-14SS2 is used. It gets inputs either manually from the controls on the control panel or from the sensors in the system. The PLC controls the relays for the solenoid valves at the output.
Extension Module: The main PLC originally has 8/6 I/O. If more number of inputs is required, an additional I/O extension card can be connected to the PLC for that provision.
SMPS: SMPS is supplies to supply mains and PLC.
Cycle on PB: This push button is provided on the control panel. This is used to start the mechanical cycle of the press. Its signal is given as input to the PLC which then controls the actuator.
Emergency off PB: This push button is provided on the control panel. This manual control is used if in case any untoward
incident takes place. Its signal is given as input to the PLC which then controls the actuator.
Home Limit Switch: This is basically a proximity sensor. It senses whether the ram is in its home position or not. When the ram comes to the home position, its signal is given as input to PLC.
Changeover Limit Switch: This is another proximity sensor used to detect the changeover of the ram from high speed to high pressure. The signal is given to PLC which accordingly activates the lower ram for high pressure pressing action.
Thumbwheel Switch: It enables us to set a specific count which is calibrated to time in PLC. This is used to set the dwell time of the ram after pressing.
Relay for solenoid: The relay for every solenoid is connected to output of PLC. Every solenoid has individual relay connection

Rapid approach: This solenoid activates the ram for rapid approach before conversion to high pressure.
Pressing action: This solenoid activates the ram for high pressure pressing action. The rapid approach cycle changes over to high pressure.
Return: This solenoid enables the ram to return to the initial/home position after completion of the pressing action.

V SYSTEM OPERATION

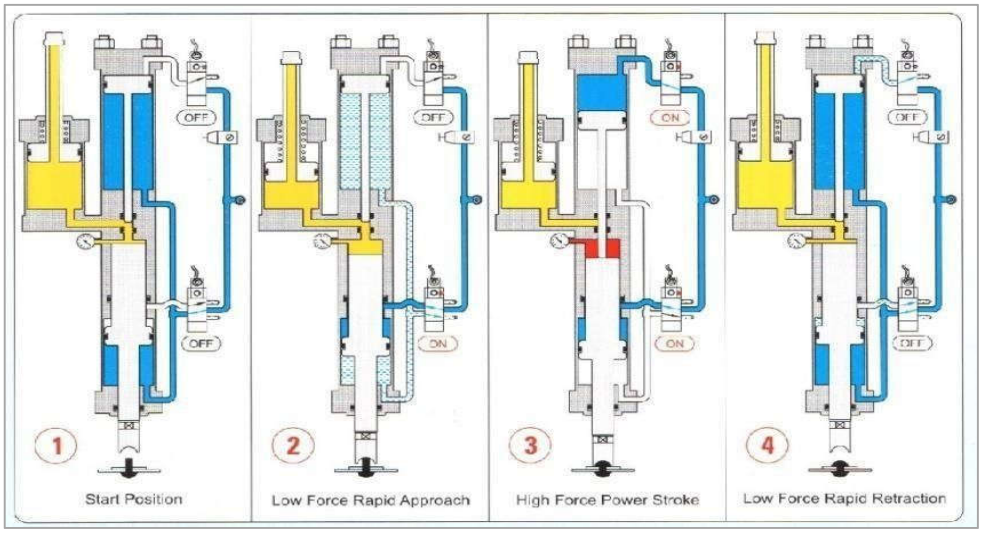

Fig. 2.Operation of System

The PLC gets supply from the SMPS which is the driven by the mains power supply. The cycle starts ON by pressing the cycle ON push button. In this case, a two hand push button has been used. The main reason to do this is to keep both the hands of the operator engaged while the operation starts so as to avoid any untoward incident. The hydro pneumatic press operates in three main steps: rapid approach stroke, pressing action and return stroke. 1. Initially, both the rams are at their home position and both the solenoids actuating each ram are off. This is the start position of the system. The home position of the rams is sensed by the proximity switches. The proximity sensor used as the home limit switch senses whether the upper ram is in its initial position or not. 2. In the next step, the lower solenoid, say Solenoid 1, turns ON. This actuates the lower ram as air pressure keeping the ram pressed upward is released. Thus the ram moves downward. Due to the ram moving downward, a cavity is created above it and oil from the oil tank enters this cavity. 3. The solenoid controlling the upper ram, say Solenoid 2, then turns ON. This activates the motion of the upper ram which moves down with high speed. This is the rapid approach stroke of the ram. Once the upper ram approaches the lower ram, the changeover limit switch then actuates the changeover motion from high speed to high pressure. This happens as oil exists between both the rams. Since, like air, oil cannot be compressed, the only way the rams can continue moving downward is with extreme pressure. This pressure generated is translated to the lower ram which in turn begins its pressing action on the job. 4. After the pressing action, the ram remains its position for the dwell time set by the thumbwheel switch. The Count in the thumbwheel switch is calibrated to time for the ram. The end position of the ram is thus sensed by the lower/end limit switch. This then turns Solenoid 2 OFF due to which the air above the ram acting downward pressure on it is released resulting in the ram moving upward. This is the return stroke of the ram. 5. After Solenoid 2, Solenoid 1 is turned OFF due to which the air above the lower ram is released and air enters below the ram which forces it

upward. Thus both rams return to their initial position. This position is again sensed by the home limit switch and the entire cycle starts again. Hence, the press operates using oil as well as air pressure following the principle of hydro-pneumatics. The actuating solenoids are controlled by the relay operations through the PLC.

VII EXPERIMENTAL RESULTS

In this project, the PLC DVP 14SS2 has been programmed using the software WPLSoft. The programming is done using ladder diagram technique. The ladder diagram is a method of programming a PLC using a combination of N/O N/C contacts i.e. 'normally open' or 'normally closed' relay contacts. The PLC program can also be simulated in the software with or without physically connecting the PLC. However, in case of simulation without connecting the hardware, the input signals from the sensors need to be given manually which otherwise would have been received automatically in the course of action of the entire program cycle. Given below is the best case scenario of the PLC program for this project.

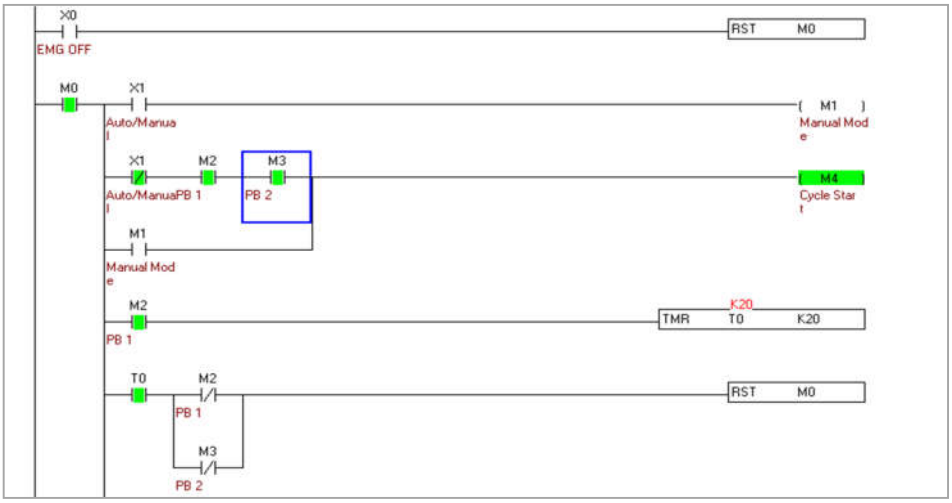

Fig. 3.PLC ladder diagram

The figure above shows the inputs X0, M0, X1, M2 and M3 and the outputs M1, M4 and T0. The inputs and outputs denote the following:
X0: Emergency Off
M0: Supply Auxiliary Relay
X1: Auto/Manual Selector Switch
M2: Cycle 1 ON Push Button
M3: Cycle 2 ON Push Button
M1: Manual Mode
M4: Cycle Start
T0: Timer

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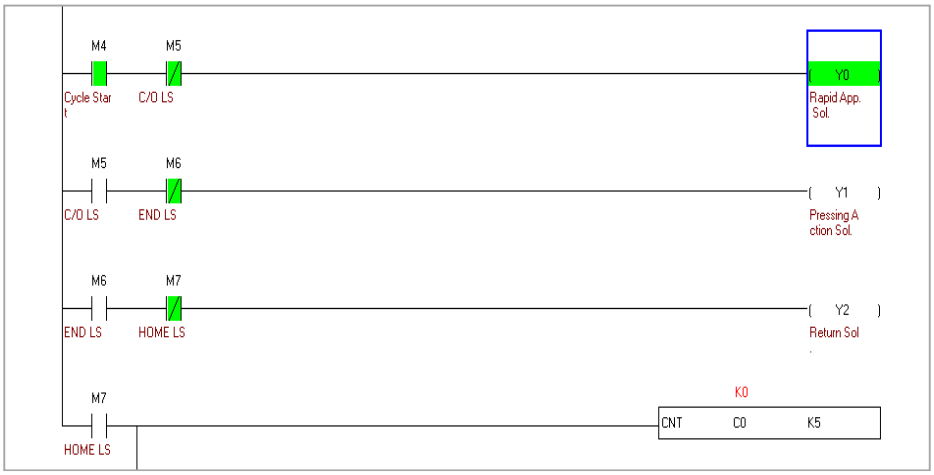

Fig. 4.PLC ladder diagram

The above figure shows the inputs M4, M5, M6, M7 and the outputs are Y0, Y1, Y2 and counter C0. The inputs and outputs denote the following:
M4: Cycle start
M5: Changeover Limit Switch
M6: End Limit Switch
M7: Home Limit Switch
Y0: Rapid Approach Solenoid
Y1: Pressing Action Solenoid
Y2: Return Solenoid
C0: Counter

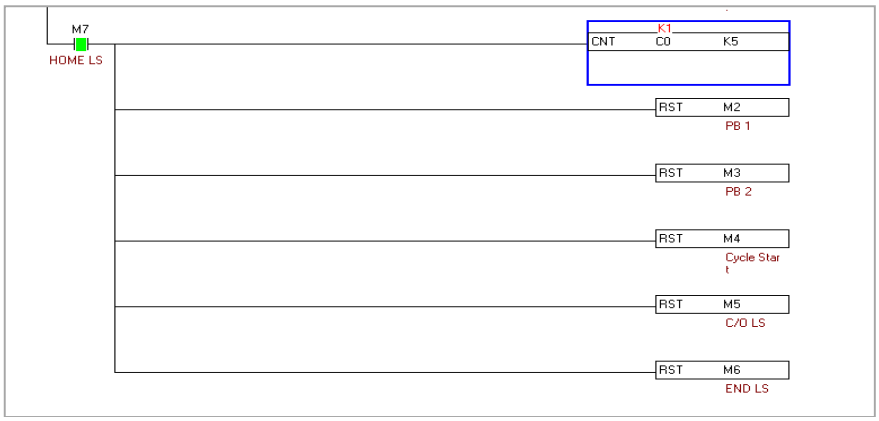

Fig. 5.PLC ladder diagram

The above figure shows the input M7 and output C0 and reset conditions

CONCLUSION

This work describes the design and experimental implementation of a control system for a hydro-pneumatic press machine. Prior to the actual implementation, simulation is carried out for evaluation and identification of its normal operation and performance. This machine has low energy, low power consumption, no pollution. Depending on the way the PLC has been programmed, the mechanical

movements of the machine get carried out accordingly. This project facilitates the operation of the press for a wide range of pressing applications.

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