

AUTOMATED CONTROL OF HYDRAULIC SYSTEM USING PLC*

BY

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ABSTRACT

With Industry 4.0 on its implementation track automation has become the priority for all the applications which will assist the industry in having lesser production time and workers with more productivity. The study review that is to be practiced was to automate the hydraulic press machine with the help of a Programmable Logic Controller (PLC). In the industries the current trend is to use a semi-automated hydraulic machine for the process of assembling and dis-assembling of the motor parts; this process is carried out in a high- pressure environment. The high pressure that is included in the process leads to damages that harm the productivity. This study reviews the automation of hydraulic press machine using the programmable logic control (PLC). The Control unit of PLC is connected with the limit switch. The switch will assist the movement of the solenoid in the hydraulic press machine. This will in all help the machine to increase the productivity along with reducing the accidents caused during the process.

KEYWORDS

Hydraulic, Hydraulic Press, Programming, PLC.

I.INTRODUCTION

In the constantly growing world automated machines have reached a higher point in its developing stages. With the implementation of Industry 4.0; automation is also being implemented in the industries. This affects the labor demand in a negative manner. To overcome this the introduction of PLC is done where- in single output is obtained with multiple inputs. PLC is been in used inside industries since a long time with the use of press switches; gradually with the upgrading of the system now human machine interface is being implemented to reduce the ports and reduce the clutter caused. This setup uses the RS232 cable for interfacing the program; this setup also reduces the labor work as well as the ports involved. This can be operated onto various devices by ladder logics programming. An asset of the PLC is that it can be used for simple as well as complex circuits by the help of ladder programming.

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In the study the current method was explored and different ways to help surmount the disadvantages were discussed. The method that was recommended in the study has its advantages over the current method that is followed. The semi-automated setup discussed was of the CRI pumps. They use the semi-automated machines for disassembly of motor parts where the pressure generated is very high and can cause damage to the parts [1].

The process of motor assembling and dis-assembling is all done with the help of the semi-automated hydraulic mechanism. The process uses a solenoid movement for the assembling and dis-assembling.

Hence both the process is carried out in the same pressure zone. The process from a worker's point of view is very simple and minimal; Switch on the motor with help of the button given; press down switch for moving the solenoid downwards; similarly for the upwards movement the up switch is pressed. The mechanism speed is not controllable. This speed depends on the motor speed and also the hydraulic fluid velocity. This the basic working of the semi- automated hydraulic machine.

The automated machine is basically the integration of the up and the down switch into one operation switch. The process of controlling the solenoid's motion path and the time is done by installing a limit switch into the mechanism. The cable that is the used for the communication is RS232 and method is coding. This coding is responsible of the motion time delay caused into the machine and also can be adjusted much hassle free and also can be adjusted for seconds as well as milliseconds. This works universally and also give ease of access and supports all the applications whilst also reducing the ports that are being used in the PLC [2].

II. Hydraulic System

Mechanical and hydraulic presses have an important component known as hydraulic die cushions. They have slight dominance over the air cushions.

- Forces that are much larger usually can be contained in the same area of spread.
- Timed cushion lock-down or return delay: the deforming of the part is averted.
- The instantaneous pressure can be controlled with the use of a servo valve.

So once the Hydraulic die cushion pressure is in control, the blank holder force can be optimized. Which serves as an added advantage to the system.

The pressure of the cushion that are air actuated have a growth of about 10% or greater as it travels the path. For nitrogen cylinders and system manifolds there is a pressure increase of approximately 40%. This pressure increase causes the blank holder to be going through some serious wear and tear inside as the motion cycle finishes. This wear and tear can cause a

catastrophe. Hence the use of the hydraulic die cushion assisted with programming is capable of optimizing the forces of the blank holder alongside the forming sequence.

III. Proposed Method

Hydraulic fluid is the main component of the hydraulic machine as the hydraulic present in the machine cylinder is responsible for generation of pressure with the help of the resistance present. For the fluid to be controlled automatically they are attached with the control valves and are dispersed through various hoses and tubes. The major advantage of these hydraulic machines is that they are and can be used for applications that demand higher power that is transfer through the small pipes and hoses these are clubbed with actuators with are also drawing power through the pressure generated. This hydraulic machine has an incompressible fluid that is the main power transmitter in the hydraulic machinery.

Principle:

All the hydraulic powered systems work on the principle of PASCAL'S LAW. The law states that "Pressure exerted anywhere in a confined incompressible fluid is transmitted equally in all directions throughout the fluid, acts upon every part of the confining vessel at right angles to its interior surfaces".

Working:

The basics of all the hydraulic systems is Pascal's law, therefore the hydraulic press discussed is also working on similar principle. The basic components of the hydraulic press are cylinders, pipes and hoses, pistons etc. The press working mechanism is elementary; it consists of the fluid (mostly is Oil) that is discharged

into the smaller diameter cylinder; the system is consisting of two cylinders one having smaller diameter and the other cylinder having slightly larger diameter. The cylinder with the smaller diameter is often called to be the slave cylinder force is applied inside the slave cylinder with help of the piston and the oil within the slave cylinder is thrust into the cylinder with larger diameter with help of the pipes.

The cylinder which has a larger diameter is commonly called as the Master Cylinder. The master cylinder then experiences a pressure which pushes the fluid back to the original cylinder with the help of piston. The slave cylinder exerts a force on the fluid which in turn exerts a larger amount of force to cylinder with larger diameter. The main purpose of a hydraulic pressing machine is to press out metals to form thin sheets in the industries. The hydraulic press has the function to either crush or create thin sheets of the material that is provided with not damaging the material of the hydraulic press.

IV. Hydraulic Press:

As the name of these machines suggest they use hydraulic power/pressure as the basic medium of working. These presses lie in the powerful machine tools class due to their force exertion capacity. The fluid present in the cylinders is assisted for increasing or decreasing the pressure by the pumps present along with the valves. For larger applications the capacity of the pumps is also larger. These have advantages in application over larger distances with acting at a constant speed; with a dis-advantage of a slower working rate when in comparison with other types of presses. Their function keeps them in contact of the workpiece longer which affects the cooling of the contact point of the machine while performing hot forming. Hydraulic presses use the incompressible fluids for power and pressure transfer which makes them a part of the most powerful machines. The machine come in various sizes while some being as big as some buildings delivering the most powerful pressure of about 75k ton force. The hydraulic press discussed in the study has an application in metal forging. These machine presses also have an application in the extrusion even though the extrusion process is horizontally performed. The working principle of the hydraulic presses is dependent directly on the fluid pressure present in the cylinder. The fluid that is present in the cylinder below the piston is responsible for increasing the pressure under the piston; this fluid is pumped out into the top and hence reducing the pressure that is above the piston. The pressure difference created is what assists the piston to rise; then the fluid is taken again to the below chamber hence causing the below pressure to decrease whilst the fluid is taken to the upper chamber and causing the pressure in the upper chamber to increase. Again, a pressure difference is created that causes the piston to move downward.

Hydraulic Press Speeds:

Press machines speeds are generally illustrated in the format of strokes per minute. The speeds are painless for determining when a mechanical press is considered and is always a part of the specifications of the machine. The determining of the strokes per minute is done by simple calculations; separate time for each phase of the stroke is done. The calculation of the rapid advance time is done first.

Post the previous calculations the pressing time is calculated. Additional time is taken into consideration if dwell is used. Also, the return cycle time is also taken into account to calculate the total cycle time. For getting an accurate result the valve reaction time delay should also be considered in the determination of the total cycle time. The theoretical production rate determination is often assisted by all the factors calculation when working on a recent process. If the process is in operation, then the measuring is done by the use of a stopwatch. This can be

performed easily without much error as almost all the hydraulic presses are referred to be as slow working machines. By the introduction of automation, the press can handle 20 to 100 strokes per minute or even higher. They are sufficient speeds for the manually placing and removing the workpiece [3]. These obtained production speed rates commensurate with the single stroking mechanical OBI (Open Back Inclinable) also OBS (Single crank gap frame press) presses applications. Only difference would be the lack of clutch and brake wear and tear when compared to hydraulic presses [4].

PROPOSED SYSTEM CONTROL USING PLC

PLC’s solid-state logic computers that are usually used in modern industries for automation purpose. This specific system uses a PLC with Eight input ports and four output ports. For the continuous motion of the machine limit switches are implemented which helps achieve interlocking. In this automated process the motor is turned on by pressing the start button, the solenoid is in up position while starting the motor, the solenoid starts to move downward direction after using the controller. Movement of the solenoid valve is controlled by the limit switches, which is connected with the PLC to open and close the contacts. After completing assemble or de-assemble process the motor is turned off. This is how the process operates.

Block Diagram of Proposed System:

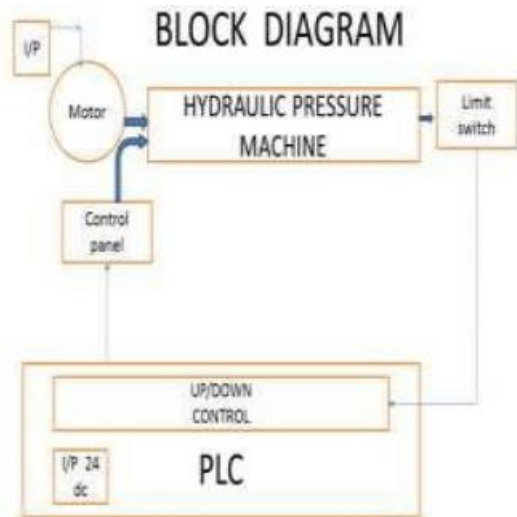


Figure 1: Block Diagram (img Source: [5])

The block diagram mentioned above shows the operation carried out in the system. It is very crucial to maintain the pressure inside the cylinder as constant, it eventually helps in achieving the smooth flow of fluid inside the cylinder and also provides with efficient working of the system. Implementation of PLC makes it possible to obtain the constant pressure and also helps in automation of the process. Limit switches are installed in order to signal the PLC with

the upward and downward motion of the solenoids used in the hydraulic press, the PLC signals the solenoid to wait for a time period in order to achieve interlocking between the motions [5]. Where as in manually operated operations the push button was to be pressed to activate the process which would turn "ON" the motor and the operation would be carried out and after the completion of single action the motor would go to "OFF" condition and again the push button was to be pressed for further operation.

Programmable Logic Controllers (PLC) using Ladder Logic:

Before the PLC were invented the operations using logic controls were carried out with the use of electromagnetic relays. After invention of solid-state logic circuits maximum operations using relays were replaced with PLC's as they can easily be modified to change the operations according to the need and convenience by just programming the PLC. In modern industries systems are barely designed using the electromagnetic relays. The digital computers i.e. PLC offer better flexibility of changing the program by programming. The solid-state logic circuits store the program and made it possible to eliminate the relays making the controller design compact. PLC have many "input" and "output" ports and every input and output port can be programmed to give "high" or "low" signal according to the system need and process. This signals from the "output" port of PLC are used to power the electronic appliances such as lights, solenoids, contactors, small motors, and other devices which can be turned "on" or "off". The PLC programming language was designed to resemble ladder logic diagrams to make it easy to program read as well as manipulate. An industrial electrician or electrical Engineer can easily read the schematics of a ladder diagram and feel comfortable to program a PLC to perform a specific program function. The input and output signals of a PLC is usually 120 volts as it were designed to replace the electromagnetic relays which operated on the same signals. Some of the PCB have the ability to operate on low level DC signals for inputs and outputs this is an option and not a rule in the working of PLC.

LIMITATIONS

Ladder programming is used in cases where only binary variables are applied and the sequencing and interlocking of the control problem is needed. Sometimes the parallel language used for programming may be undefined and this may create some logic race conditions which will produce unpredictable results. So to avoid such consequences the complex programs are broken into simpler ones creating multiple rungs for a single program. Some industries prefer to define the rungs through to avoid this problem keeping the program short but complex. Programmers may have problems in fully predetermining the results of the complex ladder [6]. New PLC available in market may use languages such as BASIC, C or other programming.

Some uses combination of ladder schematic and dialect languages binding it appropriately for real time application.

Output

The ladder diagram for a PLC is shown below. It is also called as program function for PLC.

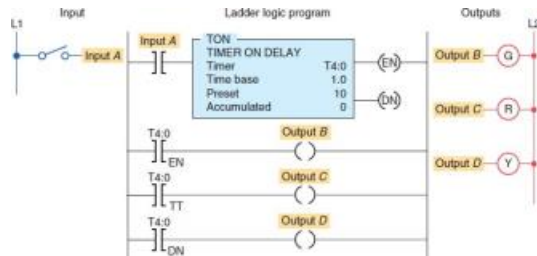


Figure 2: Ladder Diagram

CONCLUSION

The framework discussed in the review is capable of providing full or semi-automation of a hydraulic press machine. The framework assists the machines such that the disassembling of the parts is done in full control along with reducing the damage to approximately nil caused to it in the process. Also, with the implementation of automation in this field; the time is drastically reduced which in-turn increases the productivity. This implementation also has curtailed the involvement of the workers in the process. The automation also gives in fact full control over the machine so as to take control of the time delay that is very essential. This process also as an advantage of being reversible i.e., it can be also implemented in the process of assembling the parts assigned; whilst keeping their clearance at par. Also, this process is moreover universal and thus can be implanted in any industry demanding for automation.

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