Automatic Slag Pressing Process Using PLC

B.Sajitha
Assistant Professor
Department of EEE
SNS College of Engineering
Coimbatore 641 107, India

GOWTHAMRAJ E
UG Scholar
Department of EEE
SNS College of Engineering
Coimbatore 641 107, India

S.Prasanth
UG Scholar
Department of EEE
SNS College of Engineering
Coimbatore 641 107, India

Saravanan T
UG Scholar
Department of EEE
SNS College of Engineering
Coimbatore 641 107, India

VinothKumar R.
UG Scholar
Department of EEE
SNS College of Engineering
Coimbatore 641 107, India

Abstract: Here the automation of a slag pressing machine using programmable logic controller. Generally, the manual operation of the slag pressing machine is automated. The main objective is to reduce man power, cost, production time and to increase the quantity and quality of production. The existing system of slag pressing process are manual controlling of solenoid valves for slag pressing and unloading and the chance of human errors and production time are more. In order to overcome these errors, slag pressing machine is automated. The slag pressing machine using embedded system, VLSI and programmable logic controller is automated. Automations like Embedded system and VLSI are complex in programming, error detection and rectifying, future expansion of the system. Interfacing of new device is quit complex and reliability of the system is less when comparing to programmable logic controller. In programmable logic controller the error detection & rectifying, programming interfacing of new device is simple and hence the machine is automated using PLC.

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I INTRODUCTION

Automation plays a major role in all fields, especially in the production field. In earlier days more number of persons was involved in production field. To reduce the time consumption and men power, the automation came into play. Here the automation of the slag pressing machine using programmable logic controller is carried out.

The solenoid valves are controlled by programmable logic controller to automate the slag pressing machine. Here a 10HP hydraulic pump motor is started using star delta starter. The pump will pumps the hydraulic oil to the pressing cylinder via solenoid valve. In between this solenoid valve and cylinder we are using pressure switch to give the feedback signals to the programmable logic controller.

The pressure switch will sense the pressure at the solenoid valve and gives the

signal to programmable logic controller. Now the programmable logic controller will control solenoid valve according to the preset pressure values. There are four solenoid valves used in the slag pressing machine, each valve are operating at different pressure levels. The cycle of process in slag pressing machine starts with door open, door close, cake.c.up, cake.c.down. These processes are operating under solenoid valve at different pressure. For each solenoid valve output one pressure switch is used.

The pressure levels for different valve are 10bar for door close and cake.c.up. 160bar for door up and 150bar for cake.c.down. The cycle of operation is programmed in the programmable logic controller by ladder logic. The number of I/O's in the PLC is 20 in which 12 inputs and 8 outputs.

Output of the programmable logic controller is isolated by 8 channel relay module. From that relay we are controlling the solenoid valve of the slag pressing machine. For programmable logic controller we are giving a 220V ac and for relay 24Vdc using a 24V, 50W SMPS. Due to this automation of slag pressing machine the production time get reduced, quantity and quality of product increases, labour cost is reduced and error detection and rectifying become more easy and flexible.

II BLOCK DIAGRAM

For proper and efficient working a press, it is necessary to maintain the pressure of cylinder to obtain the desired pressing process. This can be achieved with the help programmable logic controller. The heart of the concept is Programmable Logic Controller. Which is used for control the solenoid valves to control the direction of oil flow to the hydraulic cylinders. The oil can be compressed by the hydraulic pump. The

operator panel is connected to control panel give the operator input to the PLC and starter of hydraulic pump. Through this the operator gives the command separately to PLC and starter of hydraulic pump. In the solenoid valve control; the following components are used,
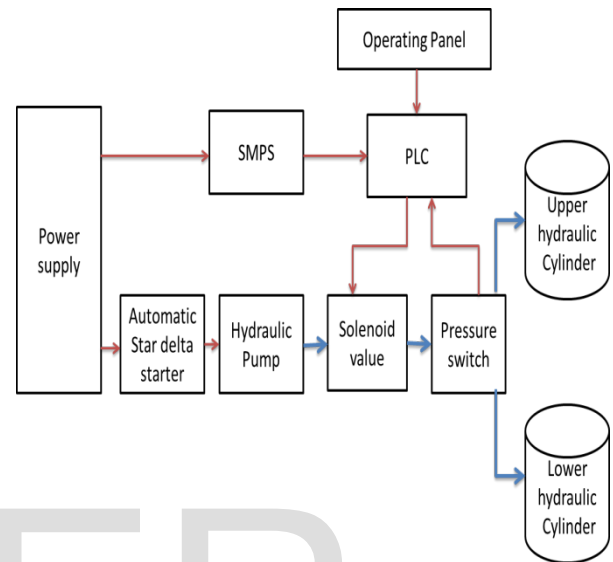
III PROGRAMMABLE LOGIC CONTROLLER (PLC)

A Programmable Logic Controller (PLC) or Programmable Controller is a digital computer used for automation of electromechanical process, such as control of machinery on factory assembly line amusements ride or light fixtures.The abbreviation of "PLC" and the term "Programmable Logic Controller" are registered trademarks of the Allen Bradley (Rockwell Automation). PLCs are used in many industries and machines. Unlike general purpose computers, the PLC is designed for multiple inputs and outputs arrangements, extended temperature range, machine operation are typically stored in battery-backed-up or non-volatile memory.

A PLC is a hard real time system since output result may be produced in response to input conditions within a limited time, otherwise unintended operation will result. A PLC

is an industrial computer monitor control system that continuously monitors the state of input devices and makes decisions based on the custom program to control the state of output devices. Choosing a PLC requires knowledge on inputs and outputs of the system.

3.1 Inputs and Outputs

The system consists of twelve inputs and six outputs. Those following input and output ports for operation.

(i) Inputs

1. Automatic operation switch.

2. Manual operation switch.

3. Cycle start push button.

4. Cycle stop push button.

5. Door down push button.

6. Door up push button.

7. Cake up push button.

8. Cake down push button.

9. Door down (160 bar) Pressure switch.

10. Door up (160 bar) Pressure switch.

11. Cake (150 bar) pressure switch.

12. Cake (10 bar) pressure switch.

(ii) Outputs

1. Door open.

2. Door close.

3. Cake.c.down.

4. Cake.c.up.

5. Cake down indication.

6. Cycle start indication/ Cycle stop indication.

3.2 SOLENOID VALVE

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid, in the case of a two- position valve the flow is switched on or off, in the case of a three- position valve, the outflow is switched between the two outlet ports. Here we are using four-way three-position solenoid operated valve. Were we are using two solenoid valve for upper cylinder (Door) and lower cylinder (cake), model number DSG-O3-3C2

Were

- Make-YOKEN

- DSG-serial number

- 03-valve type

- 3-number of valve position(three positions)

- C-spool spring arrangement (spring centered)

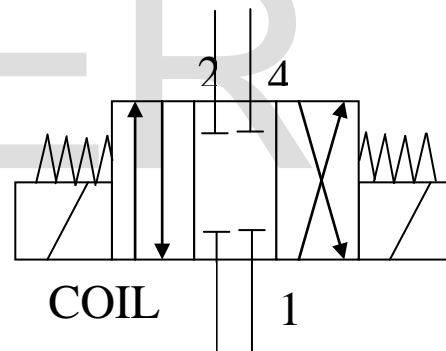- The coil of solenoid valve is energized by 24V dc supply.

Figure 3.2 Valve Structure

There are many valve design variations. Ordinary valves can have many ports and fluid paths. A 2-way valve, for example, has 2 ports; if the valve is open, then the two ports are connected and fluid may flow between the ports; if the valve is closed, then ports are isolated. The valve structure is in the above Figure 3.2

If the valve is open when the solenoid is not energized, then the valve is termed normally open (N.O.). Similarly, if the valve is closed when the solenoid is not energized, then the valve is termed normally closed

When high pressures and large orifices are encountered, then high forces are required. To generate those forces, an internally piloted solenoid valve design may be possible.[1] In such a design, the line pressure is used to generate the high valve forces; a small solenoid controls how the line pressure is used

3.3 Operation of Solenoid Value:

This is a 4-way, 3-position directional valve. 4-way refers to the 4 ports or connection points on the body of the valve: P, T, A, B.

P=Pressure
T=Tank
A=Fluid path to side A of an actuator
B=Fluid path to side B of an actuator

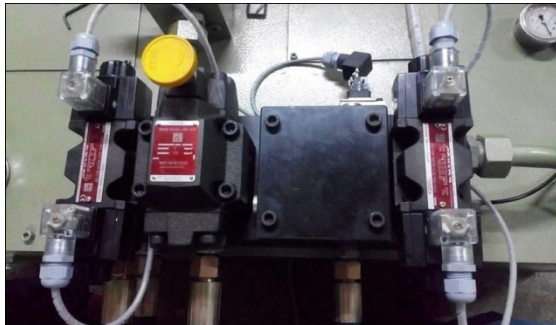3-position refers to the 3 possible operating positions of the valve. Each position (or circumstance) is represented by one of the 3 squares in the diagram. The left hand side square represents the circumstance, when solenoid A is energized. Port A is connected to pressure and Port B is connected to tank (or return to tank), now piston of the cylinder move to forward direction up to its limited by hard stop. The right hand side square represents the circumstance, when solenoid B is energized (which happens to be the opposite condition of the LH square).Port A is connected to Tank (or return to tank), and Port B is connected to Pressure, now piston of the cylinder move to backward direction up to its limited by hard stop. The machine setup of the solenoid valve is shown in the Figure 3.3

The Center square represents the circumstance when neither solenoid A or B is energized. In this case, spring pressure returns the spool to the center position now P and T are blocked and also both ports A and B are blocked. So at the center position the cylinder maintain the previous position.

Figure 3.3 Solenoid Value

3.4 PRESSURE SWITCH

A pressure switch is a form of switch that closes an electrical contact when a certain set pressure has been reached on its input. The switch may be designed to make contact either on pressure rise or on pressure fall.

A pressure switch for sensing fluid pressure contains a capsule, bellows, Bourdon tube, diaphragm or piston element that deforms or displaces proportionally to the applied pressure. The resulting motion is applied, either directly or through amplifying levers, to a set of switch contacts. Since pressure may be changing slowly and contacts should operate quickly, some kind of over-center mechanism such as a miniature snap-action switch is used to ensure quick operation of the contacts. One sensitive type of pressure switch uses mercury switches mounted on a Bourdon tube; the shifting weight of the mercury provides a useful over-center characteristic

The pressure switch may be adjustable, by moving the contacts or adjusting tension in a counterbalance spring. Industrial pressure switches may have a calibrated scale and pointer to show the set point of the switch. A pressure switch will have a differential range around its set point in

which small changes of pressure do not change the state of the contacts. Some types allow adjustment of the differential.

The pressure-sensing element of a pressure switch may be arranged to respond to the difference of two pressures. Such switches are useful when the difference is significant, for example, to detect a clogged filter in a water supply system. The switches must be designed to respond only to the difference and not to false-operate for changes in the common mode pressure.

3.5 Hydraulic Pressure Switch

The contacts of the pressure switch may be rated a few tenths of switches. Often a pressure switch will operate a relay or other control device, but some types can directly control small electric motors or other loads. Another type of pressure switch detects mechanical force; for example, a pressure-sensitive mat is used to automatically open doors on commercial buildings.

Here we are using adjustable pressure switch in this pressure switch we can adjust the set point of pressure for our process. here we are using four pressure switch those are pressure switch P1, pressure switch P2, pressure switch P3, and pressure switch P4. These pressure switches are used to sense the pressure of oil flow to the two hydraulic cylinders upper hydraulic cylinders (or) door and lower hydraulic cylinder (or) press.

Table 3.1 Pressure Levels Used

Pressure Switch P1	160 bar
Pressure Switch P2	10 bar
Pressure Switch P3	150 bar
Pressure Switch P4	10 bar

Figure 3.5   Hydraulic Pressure Switch

To switch on a warning light if the engine´s oil pressure falls below a safe level. In dust control systems (bag filter), a pressure switch is mounted on the header which will raise an alarm when air pressure in the header is less than necessary to gain or decline energy beyond the set value To control automatic transmission torque converter lock-up. The pressure switch is shown in the Figure 3.5

IV MODES OF OPEATION AND CIRCUIT DIAGRAM

- Manual mode
- Automatic mode

This automatic and manual mode is selected by two position selector switch.

4.1 MANUAL MODE

In manual mode the operator should give the command to the PLC, for the next operation. i.e., in manual mode operator should give the command to do the next step of operation when one operation is completed. In manual mode PLC is only to limit pressure level of the hydraulic pump and it controls the solenoid valve of hydraulic pump. The next sequence commands given by operator for the step by step process of slag pressing machine is follows

The cycle of process in slag pressing machine starts with Door open, door close,

cake.c.up, cake.c.down are the cycle of process given by the operator and also cycle start and auto manual changing modes are given by the operator manually. Here the need for PLC in manual mode is for accuracy in pressing process. Where in previous case of manual operation the operator should jog the machine still pressure reaches and he have stop jogging when pressure reaches the pressure level is always an assumption of operator.

In this manual operation the operator operates the machine push buttons in the operator panel. For the sample check and performance check only the manual modes are used. This may cause poor quality of the slag, and also for each operation it will take more time. When we use PLC for this operation it will sense the pressure level of each operation and it will give the signals to solenoid valve for the operation

4.2 AUTOMATIC MODE

In this auto mode the work of operator is reduced by looping of the operation of the machine. Here the operator should give cycle start command and auto mode in mode selector switch. After choosing the auto mode the sequence of operation of the machine is automatically done by the PLC. The cycle of operation by PLC in the slag pressing machine is as follows:

Here use of PLC for automatic operation, so the sequence of operation is automatically executing. Depending upon the programming the PLC will automatically control the solenoid valve and after controlling the solenoid valves, the feedback of particular operation is sensed by pressure switch. Then the next sequence is executed by PLC.

The sequences of process executed by PLC in slag pressing machine are after

loading the powdered slag in the vessel (or) hollow cylinder, the operator giving cycle start command. Then the PLC actuates the solenoid valve S1 for closing the door, for this operation the pressure switch P1 acting as a feedback sensor.

In this pressure switch P1 the pressure of 160 bars is set. If pressure reaches 160 bars, the pressures switch P1 gives the feedback input to PLC. After getting the feedback from pressure switch P1 the PLC actuates the solenoid valve S2 for pressing the slag. For this operation the pressure switch P4 acts as a feedback sensor and a pressure of 150 bars is set.

If pressure is reach 150 bars, the pressure switch P4 gives the feedback input to PLC. The pressure of pressing the slag has to be maintained less than the door closing pressure, in order to prevent the lifting of the door by slag pressing process. After getting the feedback from pressure switch P4 the PLC actuates the solenoid valve S1 for opening the door, for this operation the pressure switch P2 acting as a feedback sensor. In this pressure switch P2 we are setting the pressure of 10 bars because the 10 bar pressure is enough to lift the door. If pressure reaches 10 bars, the pressure switch P2 gives the feedback input to PLC. Now due to opening of the door, the lower cylinder lifts the pressed slug (or) cake to the surface. Now PLC waits for particular delay (10 sec) in between this time delay the operator unload the pressed slug (or) cake.

After the delay the PLC execute the next sequence, PLC actuates the solenoid valve S2 for the press to its home position, for this operation the pressure switch P3 acts as a feedback sensor. In this pressure switch P3 we are setting the pressure of 10 bars because the 10 bar pressure is enough to bring

back to its home position by a press. Now the machine is in initial stage.

Here when the pressure reaches the set value the PLC will proceed the next operation by giving signal to the solenoid valve and after completion of operation the PLC will give command for stop cycle. The cycle of process in slag pressing machine starts with Door open, door close, cake.c.up, cake.c.down. These are operation done automatically by PLC.

4.3 CIRCUIT DIAGRAM

Power Supply and Automatic Star Delta Starter

Power Supply and Automatic star delta starter used to start the 10 HP hydraulic pump is represented in Figure 4.2
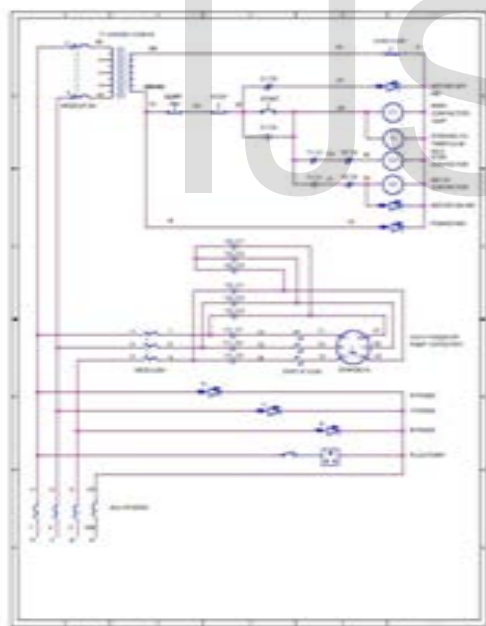

Figure 4.2 Power Supply and Automatic Star Delta Starter

4.4 PLC AND RELAY CIRCUIT DIAGRAM

Figure 4.3 depicts the PLC and 8 Channel Relay where the input from 200 to 207 and the output from 300 to 305.

4.5 HARDWARE DETAILS

COMPONENT	DETAILS	RANGE
PLC	OMRON- CP1E20DR-A	220V AC 24V DC
MCB	2pole – Schneider 3pole – Schneider 4pole – Schneider	2A 25A 25A
OLR	Telemecanique	8-12.5A
Power contactors	Schneider	230V, 3.2A
Pressure switch	-	24V DC
Solenoid valve	-	24V DC
Relay	-	24V DC
SMPS	OMRON S8-JC	24V 50W DC
Control Connectors	-	-
Power Connectors	-	-
10HP Induction Motor	ABB	3ph 440V AC

4.6 ADVANTAGES OF THE AUTOMATION OF A MACHINE USING PLC

Reduction in production time– having a machine that is automated definitely speeds up the production time since no thinking is needed by the machine; there is better repeatability, and less human error. Increase in accuracy and repeatability – when an automated machine is programmed to perform a task over and over again, the accuracy and repeatability compared to an employee is far greater.Less human error – no one is perfect, and we are all prone to making mistakes. This is why a machine that performs repeated tasks is less likely to make mistakes than an

employee.Less employee costs – by adding automated machines to an operation, means less employees are needed to get the job done. It also indicates less safety issues, which leads to financial
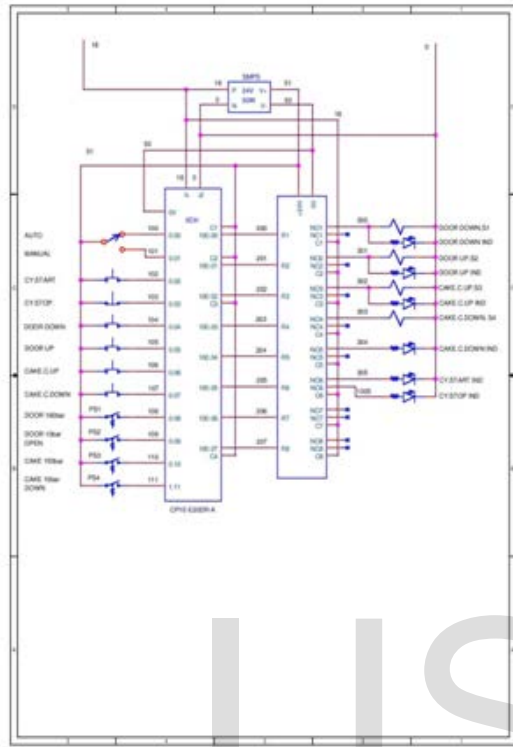

Figure 4.3 PLC and Relay Circuit Diagram

savings. With having less employees, there are numerous costs that are diminished or reduced such as payroll, benefits, sick days, etcetera. Increased safety – having automated machines means having less employees who perform tasks that can be dangerous and prone to injury, which can make the work environment safer. Higher volume production – investing in automated equipment creates a valuable resource Improved quality or increased predictability of quality. Improved robustness (consistency), of processes or product. Increased consistency of output. Reduced direct human labour costs and expenses.

The following methods are often employed to improve productivity, quality, or robustness.

Install automation Increased throughput or productivity in operations to reduce cycle time. Install

automation where a high degree of accuracy is required.

- Replacing human operators in tasks that involve hard physical or monotonous work.

- Replacing humans in tasks done in dangerous environments (i.e. fire, space, volcanoes, nuclear facilities, underwater, etc.)

- Performing tasks that are beyond human capabilities of size, weight, speed, endurance, etc.

- Economic improvement: Automation may improve in economy of enterprises, society or most of humanity. For example, when an enterprise invests in automation, technology recovers its investment; or when a state or country increases its income due to automation like Germany or Japan in the 20th Century.

- Reduces operation time and work handling time significantly.

- Frees up workers to take on other roles.

- Provides higher level jobs in the development, deployment, maintenance and running of the automated processes.

- For large production volumes, which in turn, will increase profitability

Thus these are the advantages of using programmable logic controller for automation of any process from manual operation.

V RESULT AND DISCUSSION

Here slag pressing process using PLC is carried out. The process time for powdered slag pressing process has been reduced along with reduction of man power. When this slag pressing machine is operated manually the productivity of the machine is 2 tons now by automation the productivity of the machine has been increased to 8 tons thereby producing a remarkable productivity. Here the output from the machine is similar to each other in their size

and quality and a single operator can able to operate multiple machines by selecting auto mode in the machine. The main aim of the industry is to increase the productivity of company which is achieved by this automation of the machine using PLC. Here the main panel of automatic slag pressing process is shown in figure 6.1, front view of automatic slag pressing machine is shown in figure 6.2

Figure 5.1 Main Panel of Automatic Slag Pressing Process

Figure 5.2 Snap Shot of Automatic Slag Pressing Machine

Table 5.1   PLC Output Table

Output	Pressure	PLC output
Door close	160 bar	24V output
Cake.c.up	150 bar	24V output
Door open	10 bar	24V output
Cake.c.down	10 bar	24V output

VI CONCLUSION

Here the process of slag pressing is effectively automated with the help of programmable logic controller and it reduces the human error in the manual operation of pressing process and also increases the safety. The set pressure level of hydraulic pump helps the operator to press the slag at correct shape and size which there by helps in obtaining a good quality of product. The preset value of pressure helps in accuracy in pressing process and this preset value can be changed in according to requirement. This can also be extended to automatic filling and removing of pressed slag in the machine.

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