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# PLC Based Hydraulic Auto Ladle System

Amogh Tayade*, Anuja Chitre**, Amol D. Rahulkar
*(Department of Instrumentation and control, University of Pune, India)
** (Department of Instrumentation and control, University of Pune, India)
(Department of Instrumentation and Control, A.I.S.S.M.S.Institute of Information Technology, University of Pune, India).

**ABSTRACT**
In this paper we have implemented a PLC based Hydraulic Auto Ladle System for Casting Department of Victory Precisions Pvt. Ltd. Chakan, Pune. This project work presents the study and design of PLC based Hydraulic Auto Ladle System. Aluminium pouring is the key process in Casting and Forging industry. Different products are manufactured by the company for automobile sector using aluminium. Programmable Logic Controller (PLC) is used for the automation of pouring process.
Automation is done to increase the accuracy and consistency in the quality of the product. Human errors, while pouring the aluminium, which in-turn results in defective production are eliminated by introducing automation.
***Keywords***- PLC based, Hydraulic, Casting and Forging, Auto Ladle System, Accuracy.

## I. INTRODUCTION

The project is sponsored by Victory Precisions Pvt. Ltd. Victory precisions is a casting and forging industry, wherespare parts of automobiles are manufactured.

Molten Aluminium is pouredinto the dye or mould to get final aluminium product. While pouring, velocity, angle and time of pouring are very important things. If any of these parameters goes wrong,it results into faulty production. Cost of faulty product is highly considerable and there is 6%material loss in recycling of aluminium. The existing pouring system before the project was manually operated which is automated through this project.

A pallet is designed in such a way that pouring process is done smoothly without anyturbulence. Tilting of pallet is done using hydraulic cylinder. Position feedback isgiven by limit switches. Boiling point of aluminium is 610ºC. Temperature of molten aluminium before pouring is kept around 740ºC. Temperature loss is one of the major problems in pouring process which in turn can affect the required temperature profile during the process of casting. Automation of pouring process also helps to reduce this temperature loss.

Programmable logic controller (PLC) used in the controlling purpose is MESSUNG XMP8:11. PLC is mounted in the control panel along with SMPS, MCBand Relay board. The mainpurpose of PLC is to control flow of hydraulic oil to the Hydraulic Cylinder whichultimately controls the ladle tilting process.

## 1. Review of existing system

### 1.1 Existing System

According to our review, most of the existing aluminium pouring systems in Casting Industries in India mainly include manual operation. There are many drawbacks of these manual systems. Some of them are listed below:

- No Accuracy or Repeatability in production.
- Pouring process requires skilled workers.
- There are comparatively more possibilities of health hazard.
- Amount of material wastage is more.
- Manual process is time consuming process.

### 1.2.Equipments in existing system

1.2.1Boiler:

Figure 1.2.1 shows the boiler containing Aluminium at around 740ºC. Hand wheel isplaced at one end of the boiler. Using this hand wheel, boiler can be tilted to pour the aluminium into the saucer. Saucer is placed at the bottom of the boiler.


Figure 1.2.1: Boiler

1.2.2 Saucer:


Figure 1.2.2: Saucer

Figure 1.2.2 shows the saucer containing molten aluminium. The saucer is made up of cast iron. Boiling point of cast iron is around 1100ºC, which is higher than boiling point of aluminium and hence the material becomes suitable for this service. Two castiron rods are welded at two ends of saucer. Two workers hold those rods and bringthat saucer near the Dye. During transition of the aluminium, temperature of aluminium gets reduced by approximately 15ºC.

1.2.3Dye station:

The die station is shown in figure 1.2.3. This is vertically operated Hydraulic dye station. Lower half of the dye remains steady and the upper half is lifted using hydraulic system.Hydraulic system is used foropening and closing of the dye. A hole is provided on top of the dye through whichthe molten aluminium is poured [1].Molten Aluminium takes 30 sec to cool down. After the solidification of molten aluminium in the mould, the hydraulic system is opened to get the product.


Figure 1.2.3: Dye station

1.2.4 Final product:

One of the Final products is shown in figure1.2.4. These products are removed from thedye after solidification process. Sand core is then separated from the object andthen aluminium product is ready for further finishing processes like cutting, polishing etc.


Figure 1.2.4: Final Product

This was the total process which is manually operated. Automation is introduced in only pouring part.

**2. Pallet tilting mechanism**

**Hydraulic control**:

For tilting, hydraulic control is the best choice[3]. There are many reasons behind selecting the hydraulic control system. Some of the reasons are as follows:

- Hydraulic cylinders can handle heavy weights easily.
- Hydraulic power pack is easily available.
- Small sized cylinder is sufficient to lift heavy pallet.
- Hydraulic cylinder stroke is smoother than pneumatic cylinder.
- Hydraulic oil supply can be controlled easily using control valves.

Hence hydraulic cylinders arepreferable.

It is calculated from designing that completion of pouring process is done at an angle of 60º from starting position. Hence, as per the calculations, cylinder having stroke length 750 mm and bore diameter 50mm is selected for pouring purpose.

Time of tilting is kept flexible as per the requirement of different products. Time of tilting is completely dependent on the flow rate of hydraulic oil..

Needle valve is used for controlling hydraulic fluid flow rate as per the requirement of different products. Solenoid valves are used to obstruct and allow the hydraulic fluid flow.

## 3. Design of pallet

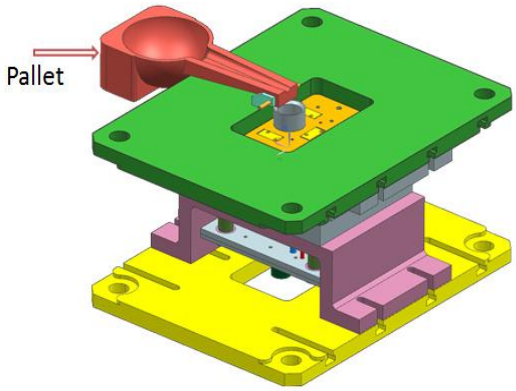


Figure 3.1:Design of pallet

Figure 3.1 is the design of pallet. Due to Semi sphere shape of pallet, sturdiness of pallet has been increased. Semi spherical shape requires lesser material of construction than rectangular or cylindrical shape. Ultimately weight of pallet gets decreased. Hence this type of pallet is quite economical. Also hole of pouring i.e. pouring cup is at the centre of dye. This pouring cup is 400mm far from frame of dye. Hence beak of this type of pallet is 400mm long so that it canreach easily near pouring cup. Required height of pouring is maximum 20mm to reduce the turbulence. If the pallet is mounted on top of the frame, height of pouring increases to80mm which is undesirable as it can create turbulence in the flow of aluminium. Hence this pallet is placed at the same level of frame of dye.

## 4. Control panel

Control panel consists of the electronic components namely single pole MCB, double pole MCB, Relay board, SMPS. Cable trays are used in the panel for proper laying of wires. Figure4.1 shows the basic block diagram of control panel.

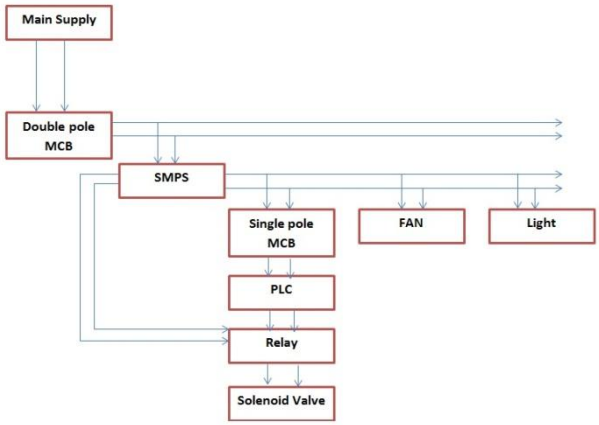


Figure 4.1: Block diagram of control panel

### 4.1 Double pole MCB

Double pole MCB is used for the incoming mains supply. MCB stands for miniature circuit breaker.

This MCB is placed initially at input to protect the whole circuit. Double pole MCB provides breaker for phaseand neutralconnections. Double pole MCB safeguards the system from sudden changes in incoming power.

### 4.2 Switched Mode Power Supply (SMPS)

Switched Mode Power Supply (SMPS)is the key component in panel box. Mains supply is of 240V AC. But all the components require 24V DC. Hence to convert 240V AC to 24V DC, SMPS is used. Typical SMPS consists of isolation transformer, chopper and rectifier. First rectification of input signal is done. Then again this rectified signal is converted into AC voltage using inverter. After that again rectification of AC signal is done and then by chopping process we get 24V DC voltage at its output.

### 4.3 Single pole MCB

The next component in panel box is single pole MCB. This MCB is used to supply DC power to the PLC.

### 4.4 PLC

PLC used for automation is Messung XMP8.11. The technology used is SMD technology and high-speed pulse catch input functions and high-speed counter/encoder functions. Digital inputs and outputs are being used in this project.[2]

### 4.5 Relay board

Relay board is placed to drive the outputs of PLC. It contains 8 relays. Relays are used to provide power to indicating LEDs and solenoid valves. Solenoid valves are used to control the flow of

hydraulic fluid. Solenoid valves and limit switches are not part of the panel box.

**4.6 Miscellaneous components**

Some miscellaneous components like push buttons for process start and emergency stop, indicating LEDs, cable trays, mounting metallic trays,wires are also included in the control panel box.

**5. Overall working of system**

Figure 5.1 shows the final design of the whole system. As shown in the design, pallet is mounted on the vertical dye by lever and crank mechanism. One end of the pallet is kept fixed. Hence flow becomes linear and there is no turbulence in the flow of aluminium.

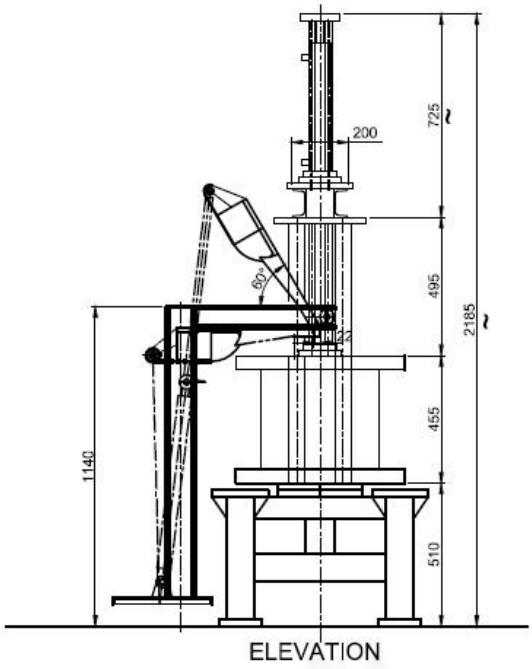


Figure 5.1: Overall working of system.

Hydraulic cylinder having stroke length 750mm is placed on 'L' shaped platform. This platform is mechanically coupled with moving plate of vertical dye. Hence hydraulic cylinder and whole assembly moves along with the upper plate of dye.

When molten aluminium is poured into ladle, the operator shall press the green push button to start the process. Pallet will tilt up to 60º from original point within predefined time. Time can be varied from 5sec to 12sec as per the requirement. This variation of time is achieved by varying the flow rate of hydraulic oil. After the completion of pouring process, limit switch gets actuated providing feedback signal to PLC. After receiving this feedback, as per the logic, the ladle starts returning to back to its original position. The tilting process is finally completed when the ladle goes back to its original position. The completion of this process is also sensed by a limit switch giving feedback to PLC.

## II. CONCLUSION

Thus system designed is very precise and very easy in handling. This system is quite inexpensive so it is advantageous for small scale industries. The components used are readily available which makes construction very easy. The structure is compact which allows the system to be installed on any dye station easily.

## REFERENCES

[1] http://en.wikipedia.org/wiki/Casting
[2] http://pejawarelectronics.com/catalogs/XMP%20Micro%20PLC.pdf
[3] http://en.m.wikipedia.org/wiki/Hydraulic_drive_system