Loading and Unloading of A.C.C. Cement Blocks using Robotic Arm PLC based

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Abstract—The Programmable logic controller (PLC) has evolved as a consequential controller in the industrial automation sector because of its simplicity and ruggedness. A PLC is used to control the different mechanical motions of machines or to control the voltage or the frequency of power source. In this article, the study of the PLC has been done in great detail and also several industrial applications have been studied and realized through ladder diagrams.

The applications on which we have stressed on is loading and unloading of heavy cement blocks into a chamber were autoclaved aerated concrete (ACC) cement blocks are heated for hours. Presently, the cement industries utilize the thermal ovens for heating the ACC cement blocks which require separate cart and cart path for each thermal oven thereby consuming more space, therefore the proposed design is effective to rectify this issue by implementing the cart which is unidirectional in nature.

There are number of heating stations available for heating the blocks. If station 1 is full the cart will move to station 2 and there is another mechanism which is controlling the blocks to load and unload from the stations via a robotic arm, but in this project we are implementing it with only one heating station. The cart has two different mechanisms it moves in to and fro direction and forward and invert which can be controlled by relays via PLC.

Index Terms - Programmable logic controller, Autoclaved aerated concrete cement blocks, Robotic arm, thermal oven, Material handling, Industrial automation, ladder programming.

I. INTRODUCTION

Automation is the use of control systems such as computers, controllers to control industrial machinery and processes, to enhance the efficiency in the manufacturing of goods. While mechanization may assist or fulfill muscular demand at work, but automation significantly reduces the labor's sensory and mental requirements [1] [3]. The modern industries such as aviation and dockyard industries generally use the automation techniques, which benefits them by saving a considerable amount of financial resources by reducing electricity and material costs and improves the quality, accuracy, and precision. The word automation is inspired from word automatic which is derived from the Greek word automatos, It was not widely used until Ford formed the automation department and then industries started to adopt feedback controllers [2]. According to our survey it is seen that in cement industries, the process for loading and unloading of heavy cement blocks into the thermal ovens has separate paths. Before implementation of automation techniques, the blocks were pulled out by man with help of rope or chains, it requires a lot of man effort and it was found to be dangerous and later, the cart system as shown Figure 1 was introduced, for each oven it needs a cart and the function of the cart is to load the object or cement blocks from one side and unload from the other side only which requires more space as shown in the below figure. The figure shown below has one-directional access i.e. loading can be done from one side and unloading can be done from the other side [6].

Fig. 1 Individual cart for each oven

II. Block Diagram and Description.

In order to automate a system and minimize human intervention, there is a need to develop a PLC-based control system that helps to reduce human error and increase the overall efficiency. The block diagrams of the project and design aspects of independent modules are considered. Block diagram is shown in Figure 2. The list of component used for this project is listed in Table 1.

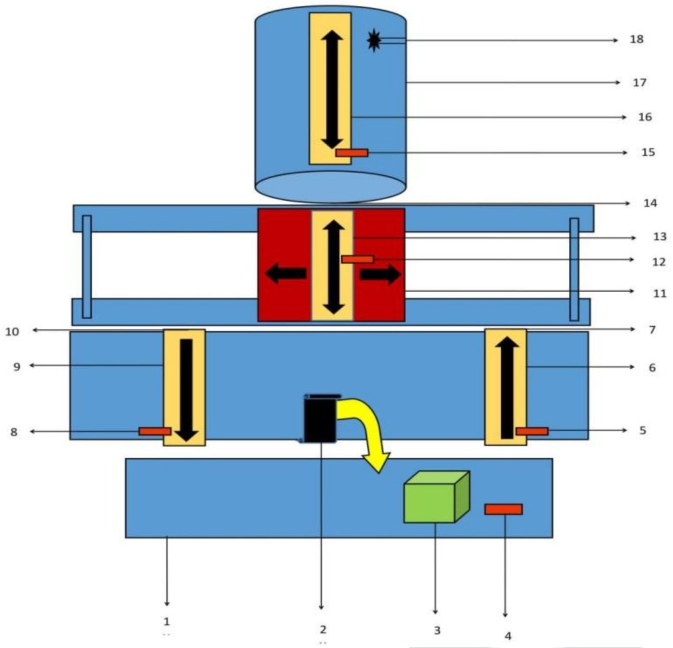


Fig.2 Block Diagram

Table 1: Block Diagram Description

S No	Description
1	Main Station
2	Robotic Arm for pick and place
3	Load or object
4	Proximity sensor (PXS)
5	Proximity sensor of conveyor 1 (PXC1)
6	Conveyor 1 for loading
7	Inductive Sensor for cart dictation loading side
8	Proximity sensor of conveyor 2 (PXC2)
9	Conveyor 2 for Unloading
10	Inductive Sensor for cart dictation unloading side
11	Bidirectional cart left and right
12	Proximity sensor of conveyor 3 (PXC3)
13	Bidirectional conveyor belt
14	Inductive Sensor for oven dictation
15	Proximity sensor of conveyor 4 (PXC4)
16	Bidirectional conveyor belt for oven
17	Oven
18	Heater or led

III. HARDWARE COMPONENT DESCRIPTION

The controlling mechanism can be achieved by using a microprocessor and microcontroller, PID controller or using PLC. Programmable logic control (PLC) provides an easy and sophisticated method to design automation in industry. It also provides easy troubleshooting method and flexibility. Generally, the industry has an emergency stop button to stop the whole process instantly, if any error occurred during operation. The emergency stop buttons are normally closed type. To start the mechanism a start button (normally open type) switch is used which is connected after stop button. When the start button is made ON the IR proximity sensed the load and robotic arm will pick the load and place over conveyor one. There are some interlocks there are some IR sensor on conveyor one and bidirectional cart will come to loading and conveyor 1 and 3 starts conveyor 3 take load to the oven station and there will be a 10 seconds delay and bidirectional cart will come to the oven station and unloading process starts conveyor 4 pick the load conveyor 4 to 3 and it will come to conveyor 2 and robotic arm will pick the load and placed at station. There are Inductive sensors for station dictions and IR proximity for load diction. The major hardware components used in the development of this work are PLC module (make Allen Bradley), Inductive Proximity Sensor, IR Proximity Sensor, High torque DC Motor, SMPS (Switch mode power supply), Relay. The hardware assembly can be seen in Figure 3.

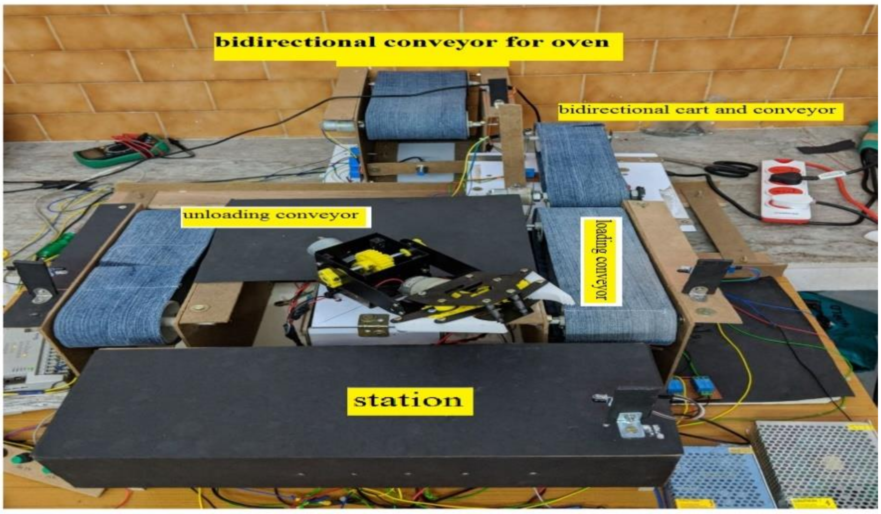


Fig.3 Hardware Assembly

3.1 Programmable Logic Controllers (PLC).

PLC is a digital computer, designed for use in an Industrial Environment, which uses memory for the internal storage of instructions for implementation of specific functions such as ladder logic, to control various machines and processes. The PLC and its peripherals are developed so that they can be easily utilized in any industrial control system. A PLC can monitor inputs, makes decisions based on its program, and controls the outputs to automate a process or machine. Previously before the advent of PLC the control functions of these machines were performed by control relays they were effective but the disadvantages outweighed advantages [7] [8].

Micro Logix 1200 Programmable Logic Controller Systems.

Bulletin 1762 Micro Logix 1200 Programmable Logic Controller Systems are small compact and powerful enough to handle a broad range of applications as shown in Figure 4. This controller is available in 24-point and 40-point versions as shown in Figure 5. We can expand the I/O count using rackless I/O modules.

Features:-

- Contains isolated RS-232/RS-485 combo port for serial and networked
- Provides four latching or pulse-catch inputs and four interrupt inputs
- Includes built-in independent 20 kHz high-speed counter
- Offers Programmable Limit Switch function
- Includes two built-in ¾-turn trim potentiometers with a digital output range of 0...250
- Provides program data security
- Supports floating point data files
- Expands up to 136 I/O points
- Compatible with 1762 MicroLogix Expansion I/O modules (up to six modules per controller)
- Provides additional programming/HMI port for connectivity to a DF1 full-duplex compatible device (only on MicroLogix 1200R controllers) [9].

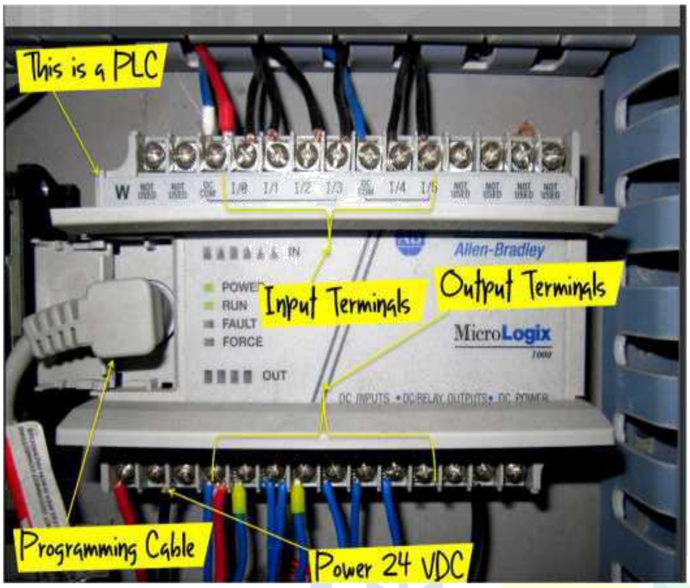


Fig.4 Hardware Assembly

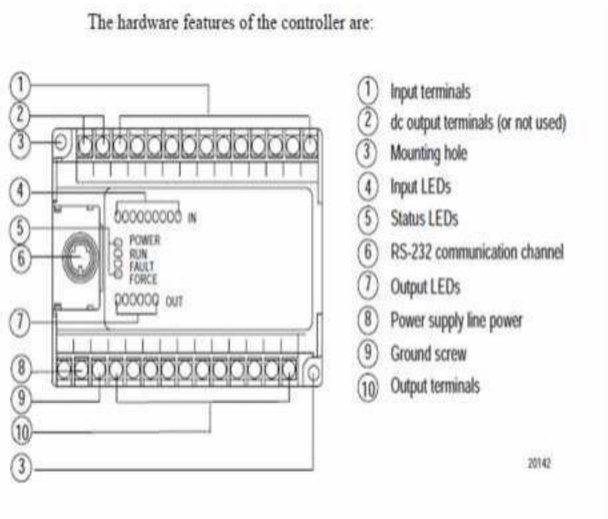


Fig.5 Hardware Assembly

Interfacing PLC with Programming Device.

We can interface the Micrologix1200 programmable controller to a personal computer in which ladder logic is developed using a serial cable RS-232 and the ladder program can be downloaded from PC to PLC. The ladder logic can be developed in PC with the help of software like RS Logix 500. Figure 6 the connection between PC and PLC using RS-232 cable.

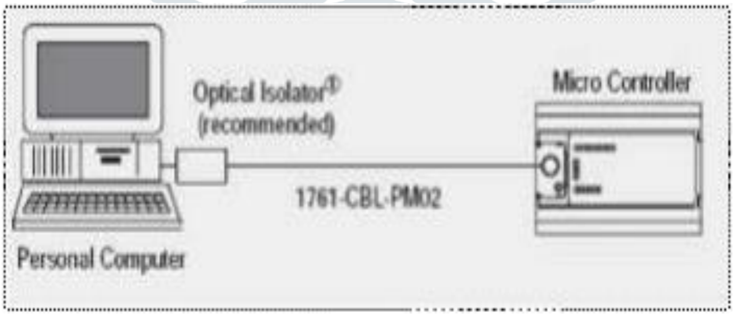


Fig.6 Inter-connectivity between PC and PLC

3.2 Pick and Place robotic arm.

Pick & Place robots are used in different material handling operations; primarily the robot picks the object from one location in the manufacturing process and then places it unto another location. For illustration, a robot is picking a product from the conveyor belt and placing it in packing assembly line. The pick and place operation requires continuous repetitive motion, thus robots can banish human intervention in doing hazardous tasks such as spraying of chemicals or lifting heavy objects. The robots can work for an extended period of time, unlike the human operator, thereby giving a high rate of return on investment. In this application, the robotic arm is used to place the ACC cement blocks on a loading conveyor belt or to pick from unloading conveyor. The working of the robotic arm can be studied with this simple example, let us assume Block is in position A, The gripper is in position B, The object is at position C, Final position is at D. When the switch is on, the automatic control system is operating by using a PLC. Initially the first motor is operated and screw is rotated, the block moves up and down from position A, the block position is maintained to the height of the workpiece in position C. Now the block is in the level of workpiece but the Gripper cannot Grip the workpiece, so in order to Grip the workpiece it is necessary to maintain the Gripper level near to the workpiece, for these automatically the motor attached to pinion is operated and rake moves horizontally. The Gripper attached to the rack, Gripper is a move toward the workpiece. The Gripper is Electromagnetic type. When supply is given to Gripper wire, the magnetism is created in it and the workpiece is to Gripped. Now the Gripper is at position C with the workpiece, the next move is rotated. For rotary motion, the next motor is operated and the whole assembly above the base is rotated clockwise or anticlockwise as per the position of the workpiece storage. Now our aim is to move the workpiece from position C to the position D. If the position D not attained only by the rotary motion then automatically other motors are operated and horizontal or vertical motion is performed in combination with rotary motion. And finally Gripper is coming to position D. When the Gripper reaches to position D, supply is cut automatically, magnetism is cut off. And workpiece is released from the Gripper at the desired position [5].

Fig.7 Robotic arm

3.3 Inductive Proximity Sensor (Proxy Switch).

The inductive proximity sensor belongs to a family of the non-contact electronic proximity sensor. It is utilized for positioning and detection of metal objects. The sensory range of this sensor is dependent on the type of metallic object being used for detection. The metals such as iron and steel, allow longer sensory range, while metal such as aluminum or copper decreases the sensory range by 60%. The output of the inductive sensor has only two possible states, thereby referring it sometimes as an inductive proximity switch.

3.4 Proximity Sensor.

A proximity sensor’s main objective is to detect the presence of nearby body without any physical contact. This task is achieved, is due to the fact that proximity sensors emit electromagnetic radiation, and detects the change in its return signal. The body sensed is generally mentioned as sensors target. For different sensor targets require different proximity sensors for its detection. For instance, a photoelectric sensor may be appropriate for a plastic target but an inductive proximity sensor always requires a metal target.

Fig.8 Inductive Proximity Sensor

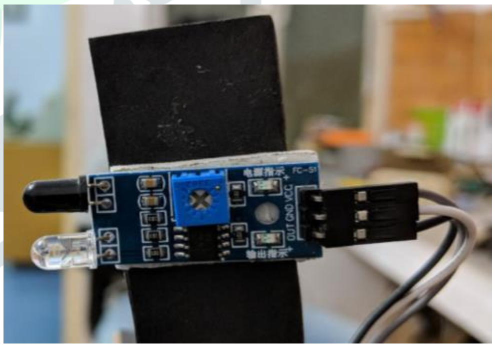
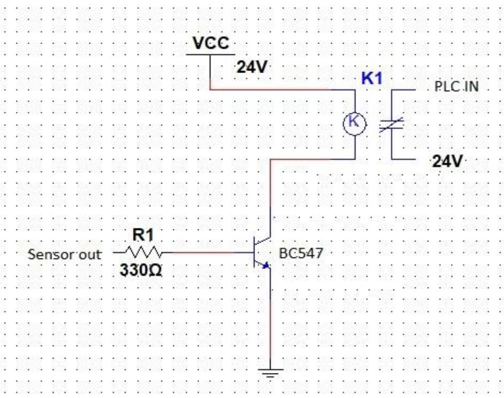


Fig.9 Proximity Sensor

IV. CIRCUIT DIAGRAMS

4.1 Relay driver kit for the proximity sensor.

Proximity sensor or IR sensor needs 5Vdc supply and it gives output as 5V but PLC need 24V to give a command so we used a relay circuit it has 330 ohms resister a transistor BC547 and a 24V relay sensor out signal is given as input to resister and resister is connected to the base terminal of BJT. The emitter of BJT is feed with 24V VCC as shown in Figure 10 which is further connected to the relay coil which gives 24v supply as a command to PLC and collector is grounded [10].



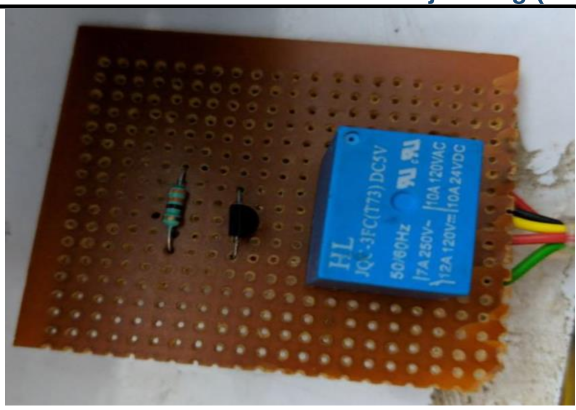


Fig.10 Relay driver kit circuit diagram

Fig.11 Relay driver kit

4.2 Relay driver kit for DC Motor.

12V High torque gain DC motor has operating range is 6V to 12V. For controlling 12V DC motors bidirectional driver kits are designed which has 4 relay which gives a clockwise and anti-clockwise signal to the PLC. As shown in Figure 12. All the negative terminals are connected to the 0Volts of 24Volts power supply. When a forward signal comes from PLC relay one and relay two get active and the motor rotates in the clockwise direction and when a reverse signal comes from PLC relay three and relay four get active and the motor rotates in an anti-clockwise direction.

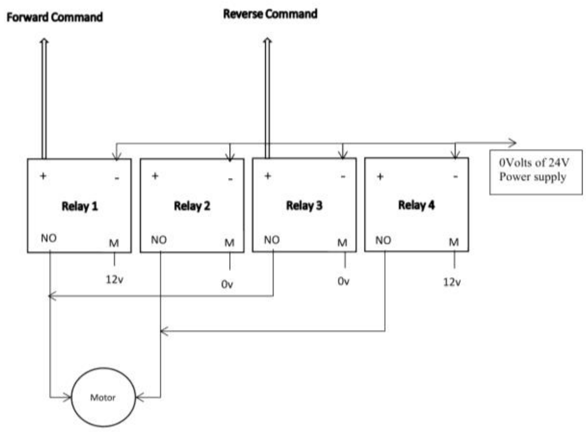


Fig.12 Relay driver kit for DC Motor

V. Project Execution Steps.

Loading Process.

Step1: Initiating loading process.
Step2: Object is detected by a proximity sensor (PXS) at main station and signal is sent to the robotic arm.
Step3: The robotic arm picks the object from the main station and places it on the loading conveyor i.e. conveyor 1.
Step4: Proximity sensor (PXC1) which is installed on conveyor 1 detects the object and signal is send to cart to move to the loading position.
Step5: Inductive sensor detects the cart at loading station position; the conveyor 1 moves the object on the cart.
Step6: The cart starts loading the object until proximity sensor (PXC3) installed in the middle of the cart i.e. conveyor 3 detects it and the cart moves to oven position.
Step7: Inductive sensor detects the cart at oven position and cart i.e. conveyor 3 loads the object on conveyor 4 which is inside the oven.
Step8: Proximity sensor (PXC4) detects the object on the conveyor 4 and the heating process is commenced, after heating operation is finished the unloading process is initiated.

Unloading Process.

Step1: After the object is heated for desired temperature and time, the unloading process is initiated the cart moves to oven position which is detected by the inductive sensor, the conveyor 4 loads the object onto the cart i.e. conveyor 3.
Step2: The cart starts loading the object until proximity sensor (PXC3) installed in the middle of the cart i.e. Conveyor 3 detects it.
Step3: The cart moves to unload station which is detected by the inductive sensor, the object is then unloaded from cart i.e. conveyor 3 onto conveyor 2.
Step4: Proximity sensor (PXC2) which is installed on conveyor 2 detects the object and signal is send to the robotic arm.
Step5: The robotic arm picks the object from the conveyor 2 and places it on the main station.

Flow Chart:

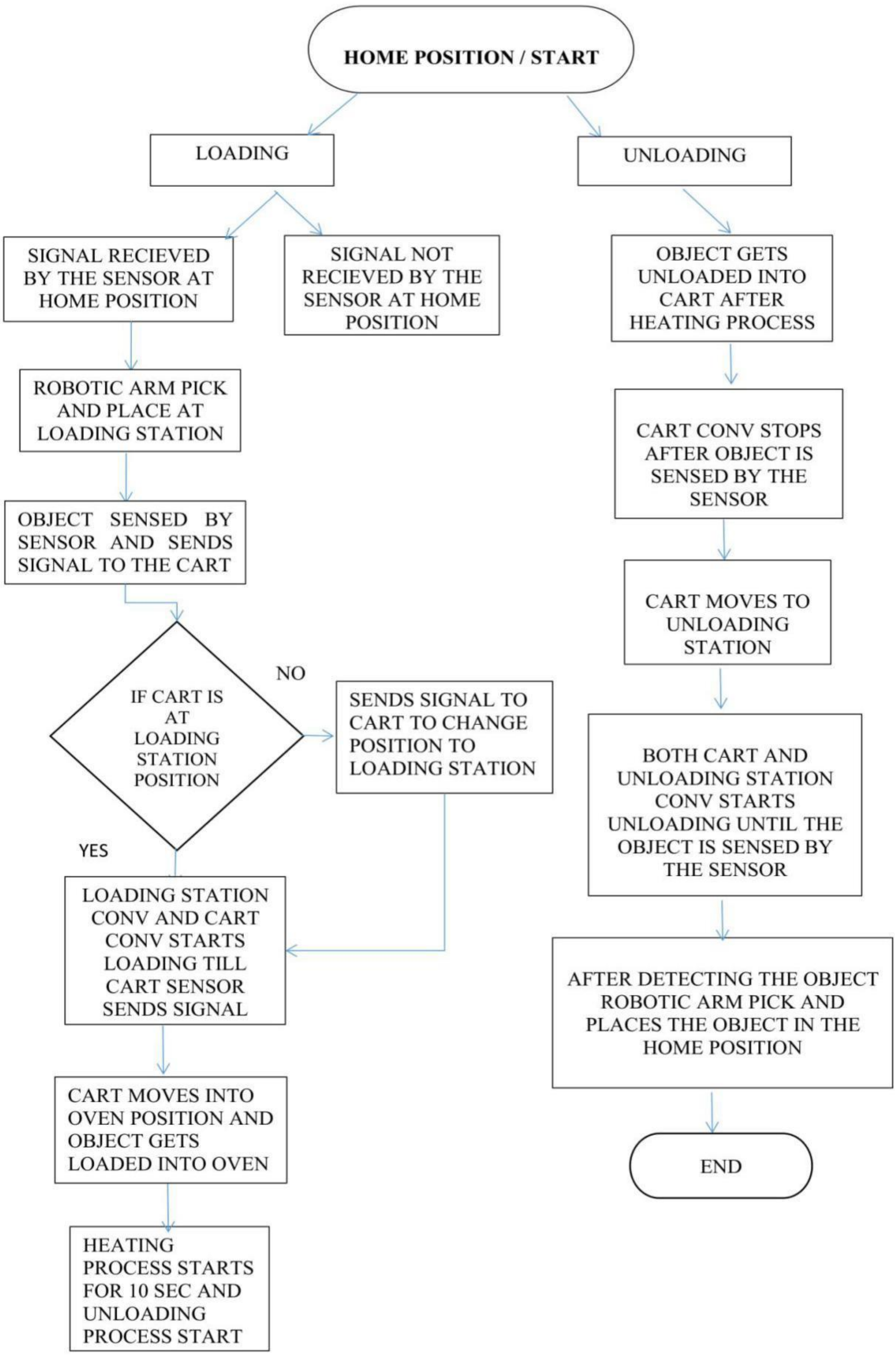


Fig.13 Flow Chart.

Inputs & Outputs of PLC.

Inputs and outputs are listed in tables. We have used 14 inputs and 15 outputs. 14 inputs includes 6 Push buttons and 8 sensors and 15 outputs include 6 commands from the robotic arm, 2 commands form loading and unloading conveyor, 4 commands from the bidirectional cart and bidirectional conveyor, 2 commands form ovens conveyor and 1 command of led or heater. Inputs with tag number are given in Table 2. and outputs with tag number is given in Table 3.

Table 2: Input Components

I:0.0/0	PX3 (proximity sensor 3)
I:0.0/4	A1 Wrist left (Manual Button)
I:0.0/5	A2 wrist right (Manual Button)
I:0.0/6	A3 Gripper hold (Manual Button)
I:0.0/7	A4 Gripper release (Manual Button)
I:0.0/8	PXC1 *(IR sensor 1)
I:0.0/10	PX1 (proximity sensor 1)
I:0.0/11	PX2 (proximity sensor 2)
I:0.0/13	PXC3 (IR sensor 3)
I:0.0/14	PXC4 (IR sensor 4)
I:0.0/20	PXS (proximity sensor home position)
I:0.0/21	PXC2 (IR sensor 2)
I:0.0/22	A5 shoulder up (Manual Button)
I:0.0/23	A7 shoulder down (Manual Button)

Table 3: Output Components

O:0.0/0	Wrist left
O:0.0/1	Wrist right
O:0.0/2	Shoulder down
O:0.0/3	Shoulder up
O:0.0/4	Gripper hold
O:0.0/5	Gripper release
O:0.0/6	Conveyor 1 (Loading side)
O:0.0/7	Conveyor 2 (unloading side)
O:0.0/8	Conveyor 3 (forward direction)
O:0.0/9	Conveyor 3 (reverse direction)
O:0.0/10	Conveyor 4 (forward direction)
O:0.0/11	Conveyor 4 (reverse direction)
O:0.0/12	Cart left
O:0.0/13	Cart right
O:0.0/14	LED

VI. CONCLUSION

This project aims to automate and design an efficient control system for loading and unloading of ACC cement block in cement industries by using a much simpler controller-a PLC, instead of using microcontroller which is more complicated. Moreover, affixing I/O module for expanding slots doesn't require reprogramming, in contrary to using microcontroller or embedded systems. Furthermore, the whole process can be monitored using SCADA. The implementation of bidirectional To-and-Fro cart in this project has resulted in the execution of heating operation with a single oven instead of multiple stations, the robotic arm is found to be effective for pick and place operation of the cement block onto the cart. The block movement is precise due to the strategic positioning of sensors on conveyors and stations. The ladder program developed has led to the smooth running of the loading and unloading process.

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