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IMPLEMENTATION OF PLC BASED AUTOMATIC SORTING SYSTEM

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ABSTRACT

The The sorting system is usually used as a load handling system in the industrial applications in order to increase the production rate, reduce human error, and increase the efficiency. There are two types of sorting system applied in the industrial applications such as manual sorting system and automatic sorting system. Most industries still using the manual sorting system compared to the automatic sorting system. The problem of manual sorting system is because of the efficiency during the production sytem. The purpose of this project was to presents the design and implementation of PLC based automatic sorting system for industrial applications. The system consists of a conveyor, limit switch, double acting cylinder, and Programmable Logic Controller. Omron PLC CPM2A was used to control the system based on the height of the box. The resulting box sorting system was capable to separate the height of 4 cm block and the height of 1 cm block into their respective location.

***Keywords**: sorting system, automatic, PLC, industrial application*

1. INTRODUCTION

Many sorting systems have been used in the industrial applications in order to increase the production rate, reduce human error, and increase the efficiency. (Rajkumar et al., 2021) (Syufrijal et al., 2020) (M Eriyadi et al., 2020) However, most industries still using the manual sorting system. The problem of manual sorting system is because of the efficiency during the production process. The automatic sorting system have been developed to overcome that problem. (Hao Hu et al., 2021) (Ran, W et al., 2021) The sorting method can be based on color, shape, volume, size, and type of materials. (Hamzah, 2022) (Syufrijal et al., 2020) In many industries, various size-based objects are moved on the conveyor belt and need to separate into the specific location in the manufacturing line. It is using the sensors that connect to the controller for making the right decision for the system.

PLC is one of the controllers commonly used in the industries especially for manufacturing process and machinery. (S Vandana et al., 2021) (Khaing et al., 2018) (Fathahillah, 2020) There are many advantages by implementing PLC in the industries such as remote monitoring, reducing human error, faster operation, reprogrammable, need less maintenance, financing and its flexibility compared to the hardwired control. (Bolton, 2015) (Eriyadi et al., 2020) Most of PLC come with the software to design a desired control system. There are two types PLC such as compact and modular. For the compact PLC, the Input / Output modules is built as one, while the Input / Output for the modular PLC is separated. (Pathade, 2014)

This automatic sorting system used an OMRON PLC Sysmac CPM2A as a controller for the system and limit switches to sort two different heights of loads. The loads were transported along the conveyor belt. If the height of the load is more than 4 cm, the load will be taken out by the double acting cylinder. If the height of the load is less than 4 cm, then the load will be transported until the end of the conveyor.

2. MATERIAL AND METHODS

This project consists of three phases. The first phase is to build the station and attached all the electrical components. After that, install Programmable Logic Controller (PLC) and program the ladder diagram for the system. Lastly, the system was tested for the purpose of the maintenance.

2.1 System Design

The design of the system was illustrated by Computer Aided Design (CAD) shown in Figure 1. The software used to design the system by using Solidwork.
The station can be separated into 5 parts as listed in Table 1 such as actuator and control, structure (base and side), cylinder attachment to body, gripper part and limiter. Actuator and control part consists of double acting cylinder and solenoid valve. Then, the gripper part is attached to the double acting cylinder in order to sort out the taller load, and the limiter is used to hall the load in place before it is being sorted out by the double acting cylinder.

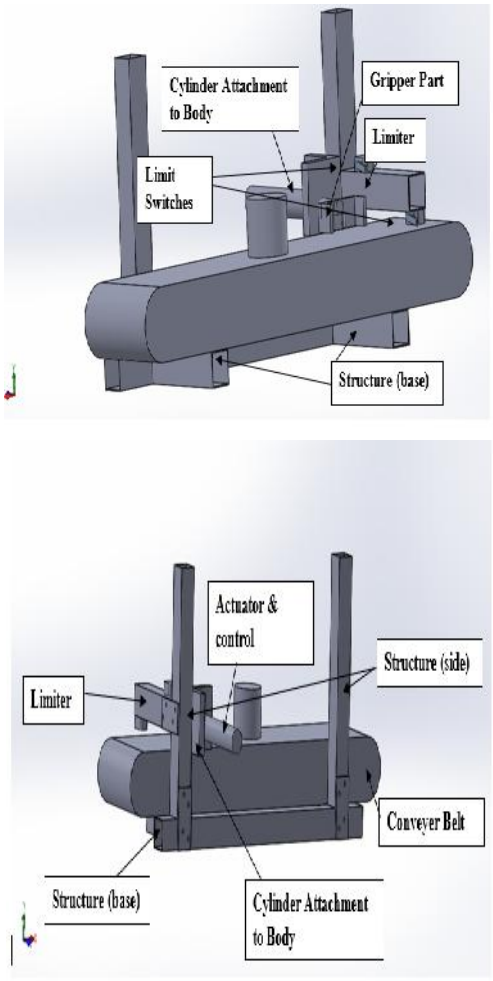

Figure 1. *System Design*

The materials were chosen to play different functions in the system. Mild steel bar was used in the base construction due to its weight for the stability purpose. Squared-aluminum bars were used for the side view structure support and due to its less durability for rivet attachment. Flat aluminum bars were used to hold the aluminum attachment together. L-shaped aluminum bars were used to hold the actuator, the cylinder to the whole structure. After that, two limit switches were used as a sensor to command for the double acting cylinder to extend and retract. Lastly, start and stop push button were attached on a cupboard. All the attachments were done by using the welding technique and the use of rivets, bolts, and nuts.

Table 1. Materials list

No.	Part Description
Actuator and control part	
1	Double acting cylinder
2	5/2 Solenoid directional valve (with spring return)
Structure (base and side) part	
3	Mild steel (base) 110 x 11 x 11 mm
4	Mild steel (base) 298 x 11 x 11 mm
5	Aluminum bar 180 x 12 x 12 mm
6	Flat aluminum bar 30 x 19 x 3 mm
7	M4 rivet diameter 3.19 mm
Cylinder attachment to the body	
8	L-shaped aluminum bar 31 x 39 x 3 mm
9	M4 rivet diameter 3.19 mm
Gripper part	
10	Flat aluminum bar 61.1 x 18 x 3 mm
11	L-shaped aluminum bar 27.9 x 18.1 x 10 mm
12	M4 rivet diameter 3.19 mm
Limiter part	
13	Aluminum bar 120 x 12 x 12 mm
14	Flat aluminum bar 35 x 18 x 3 mm
15	M4 rivet diameter 3.19 mm
16	Limit switches
17	Bolts and nuts diameter 2.62 mm
Additional components	
18	Conveyor belt
19	Push button (start and stop)
20	Programmable Logic Controller

2.2 Pneumatic Circuit Design

The solenoid valve is energized (by holding relay) causing the air entering through the inlet A and exit from the inlet B, pushing the cylinder (extend), sorting the taller load away when normally open limit switch (LS1) is pushed by the taller load. As it reaches the end of the conveyor

and pushes the normally close limit switch 2 (LS2), it will de-energizing the solenoid valve. The spring will force the valve return its original position which caused the supplied air entering the double acting cylinder through inlet B and the air exit from inlet A. Then, the cylinder will retract.

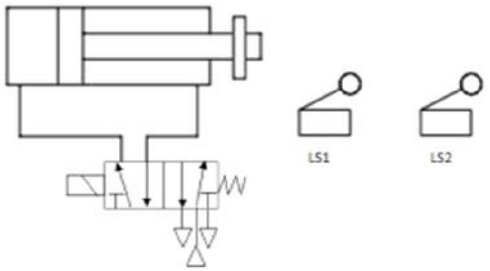

Figure 2. Pneumatic Circuit Design of the System

The control task representation of the automatic sorting system was:

- Cylinder A extending step was represented as A+
- Cylinder A retracting step was represented as A-
- Therefore, the sequence is A+A-

2.3 Sequential Functional Chart (SFC)

The sequential function chart for the system is shown in Figure 2. The system is operating when the start push button (PB1) is momentarily pressed. If the limit switch 1 (LS1) is pressed, the conveyor will stop moving and the double acting cylinder will push out the load. Then, if the limit switch 2 (LS2) is pressed, the double acting cylinder will retract and the conveyor motor will stop moving. The conveyor motor will start moving again if the limit switch 1 (LS1) and the limit switch 2 (LS2) is not pressed. The system can be turned off by pressing the stop push button (PB2) momentarily.

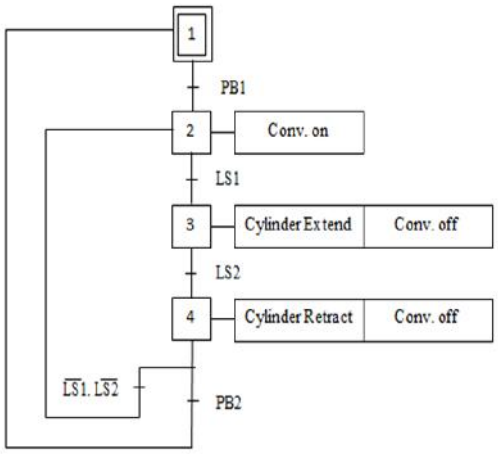

Figure 3. Sequential Function Chart (SFC) of the System

2.4 Ladder Diagram

The input of the system consists of two push button (start push button and stop push button) and two limit switches. Then, the output of the system consists of conveyor motor, and solenoid valve. The input and output assignment address of the automatic sorting system was shown in Table 2.

Table 2. Input and Output Assignment Address of the System

Input / Output	Address
Start_Button	0.02
Stop_Button	1.02
Limit_Switch1	0.01
Limit_Switch2	1.01
Conv_Motor	10.02
Sol_Extend	10.00

The system is operating after start push button (Start_Button) is pressed and it will be stopped by pressing the stop push button (Stop_Button). After pressed the start push button, the coil of the relay (Holding_Relay) will be energized and it will be hold until the load moves and pushes the limit switch 1 (Limit_Switch1) and limit switch 2 (Limit_Switch2) to trigger the next steps. If the taller load pushes the limit switch 1 but the limit switch 2 is not pressed, the double acting cylinder will extend and push the load into the other side. The conveyor motor will stop moving at that time because the limit switch 1 is pressed. The cylinder will push the limit switch 2 and retract automatically after the double acting cylinder pushes the load. The conveyor motor will move again if the limit switch 1 and limit switch 2 is not pressed.

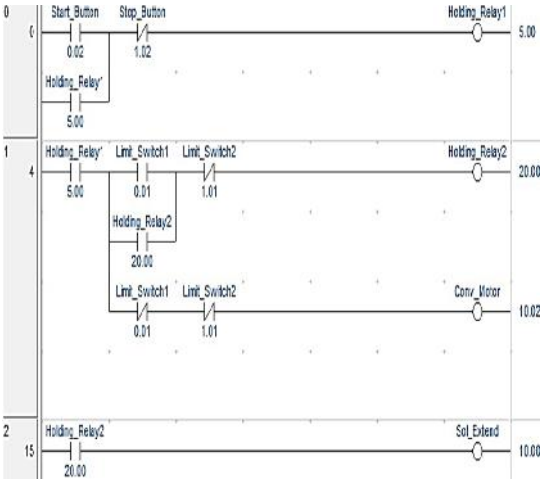

Figure 4. Ladder Diagram of the System

3. RESULTS

The result of testing the input and output was shown in Table 3. Start push button is labeled as PB1, stop push button is labeled as PB2, limit switch 2 is labeled as LS1, limit switch 2 is labeled as LS2, conveyor motor is labeled as Conv.M and extended double acting cylinder is labeled as Sol.Ex. The condition when the start or stop push button or limit switch 1 or limit switch 2 was pressed is labeled as 1. Otherwise, it is labeled as 0. For the output, the condition when the conveyor motor or the solenoid was ON is labeled as 1. Otherwise, it is labeled as 0.

Table 3. Testing the I/O of the System

Step No	PB 1	PB 2	LS 1	LS 2	Co nv. M	Sol .Ex	Material Height
1	1	0	0	0	1	0	1 cm load
2	1	0	0	0	1	0	4 cm load
3	1	0	1	0	0	1	4 cm load
4	1	0	0	1	0	0	4 cm load
6	1	0	0	0	1	0	6 cm load
7	1	0	1	0	0	1	6 cm load
8	1	0	0	1	0	0	6 cm load
9	1	0	0	0	1	0	No loads
10	0	1	0	0	0	0	No loads

First, the start push button was pressed and the conveyor motor was moving. Then, the load with height of 1 cm was put on the conveyor belt and moving through without pressing the limit switch 1 untill the end of the conveyor.

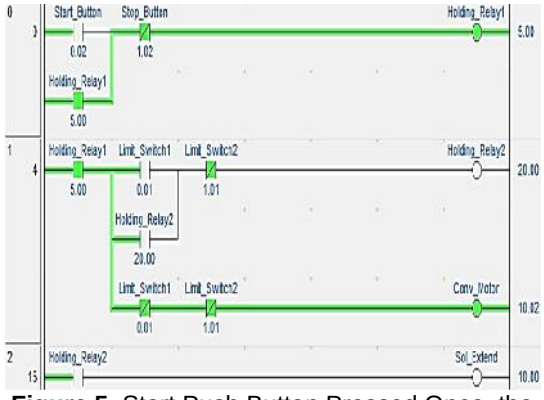

Figure 5. Start Push Button Pressed Once, the Conveyor Motor ON

The load with height of 4 cm was put on the conveyor belt, and moving through the belt. After that, the load with height of 4 cm pushed the limit switch 1. The conveyor motor stopped moving, and then the load was sorted out by double acting cylinder.

Figure 6. Condition when the Objects with the Height of ≥ 4cm Pressed the Limit Switch 1

The double acting cylinder was extending until it pushed the limit switch 2. The double acting cylinder retracted to its initial condition and then the conveyor motor was moving again. The process for the load with height of 6 cm was similar to the load with height of 4 cm. The conveyor motor will not be rotating if the stop push button was pressed.

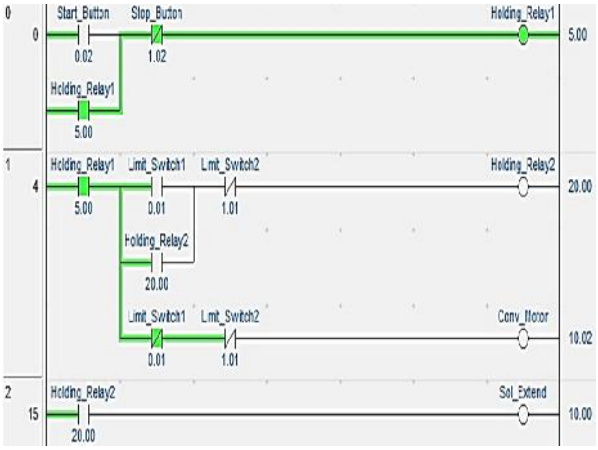

Figure 7. Condition when the Double Acting Cylinder Pressed the Limit Switch 2

4. CONCLUSION

The height of the load variations during the testing of the system were 1 cm, 4 cm and 6 cm has been successfully transported into the respective location. The height of 1 cm load was transported to the end of the conveyor. As for the

height of 4 cm and 6 cm, it will be sorted out by the double acting cylinder into the respective location.

As for the limitation for the system, the double acting cylinder will push two loads at once if there is not a distance or gap between the two loads. The timer can be implemented into the system in order to overcome this problem. Beside that, the double acting cylinder will not extend if the weight or the force of load is not big enough to push the limit switch.

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