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DESIGN AND IMPLEMENTATION OF PLC BASED PNEUMATIC STAMPING SYSTEM

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Abstract

Pneumatic stamping system is the system for stamping a logo onto items by air pressure. This is the combine of electrical control and mechanical system. The pneumatic system is one which is done by the use of gas or pressurized air. The pneumatic system can be controlled through manual or automatic solenoid valves. Example of mostly used pneumatic system are air brakes on buses, trucks and trains, compressed-air engine for pneumatically powered vehicles, cable jetting which is a way to install cables in ducts, dental drill, etc. And, the next is stamping. Stamping system is for branding or stamping a logo of the products or items. The combination of pneumatic system and stamping system is a perfect pneumatic stamping system. This system can be used not only for industries but also for domestic business. In this paper, this system is controlled by Programmable Logic Controller (Kinco K205-16DR).

Keyword: Kinco K2 series PLC, Photoelectric sensor, Solenoid valve, Double acting pneumatic cylinder, Compressor, 12V DC Gear motor

1.INTRODUCTION

The pneumatic stamping system is controlled by Kinco K205-16DR PLC and the control program is written by KincoBuilder software. There are five types of PLC programming languages but this Kinco K2 series can use only two types, ladder diagram and instruction list. Between these two, ladder diagram program is used to control the system. Photoelectric sensor and two push buttons are used as inputs and the outputs are 12V DC gear motor, solenoid valve and two pilot lights. Programmable Logic Controller (PLC), Kinco 24V DC power supply, eight pin relays and connectors are placed in the control panel and push buttons and pilot lamps are placed at the front cover of panel.

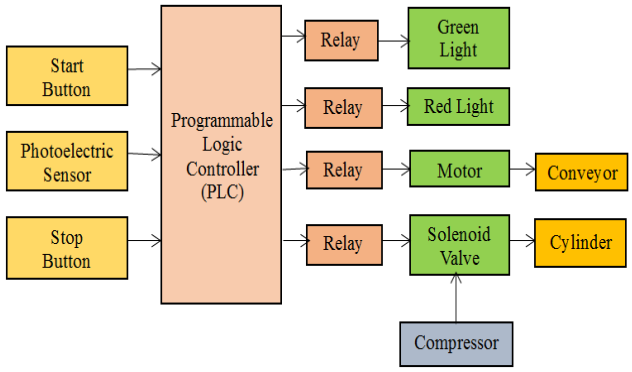

Figure 1. Block Diagram of Pneumatic Stamping System

There are two main parts in this system, pneumatic system and motor conveyor drive. Compressor is used to get air supply for pneumatic system and solenoid valve is used to control double acting cylinder. A stamp is joined with double acting cylinder for stamping. In motor conveyor drive section, the conveyor is driven by 12V DC gear motor. So, this pneumatic stamping system is the combination of electronic control and mechanical system. In this system, three inputs and four outputs are included. And, these are connected with programmable logic controller. At the output terminal, relays are used for switching the output devices by PLC program. This is as shown in Fig. 1.

2.MAJOR COMPONENTS OF THE SYSTEM

Major components used in this system are:

- Programmable Logic Controller (Kinco K2 series PLC)
- Photoelectric sensor (E3JKDS30-M1)
- Solenoid valve (4V210-08 24V)
- Double acting pneumatic cylinder (MAL 20*50)
- Compressor
- 12V DC Gear motor

In this pneumatic stamping system, the main AC power supply, 220V is fed to Kinco power supply and three pilot lights. Then, Kinco power supply converts 220V AC to 24V DC for PLC, solenoid valves and photoelectric sensor. Moreover, the gear motor and the compressor are driven by 12V battery. So, the voltage values of 220V AC, 24V DC and 12V DC are required for this system. Fig. 2 is the power supply system of this pneumatic stamping system.

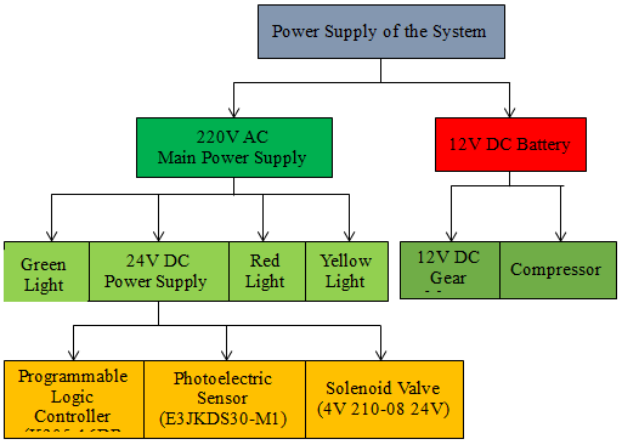

Figure 2. Power Supply of Pneumatic Stamping System

3.OPERATION OF PNEUMATIC STAMPING SYSTEM

When the start button is pressed, green light and 12V DC gear motor turns on simultaneously. The motor drives the conveyor. Then, items are put on the conveyor. Once the item reaches in front of the photoelectric sensor, the sensor senses the presence of item and informs to the PLC. And then, the conveyor stops. A delay time is set for each sensor sensing action. After that delay time, the stamping action start. There are three steps in stamping action. The first is the forward motion of the cylinder piston. The second is stamping on the item which is sensed by the sensor. And, the final step is the reverse motion of the piston. The former two steps happen when the 24V DC power to solenoid valve is on. The power supply of the valve needs to switch off for the final step. So, another delay time is set to switch off the power supply to the valve. After stamped, the conveyor runs again and the sensor is ready to sense the next item. This operation sequence is presented as a flow chart in Fig 3.

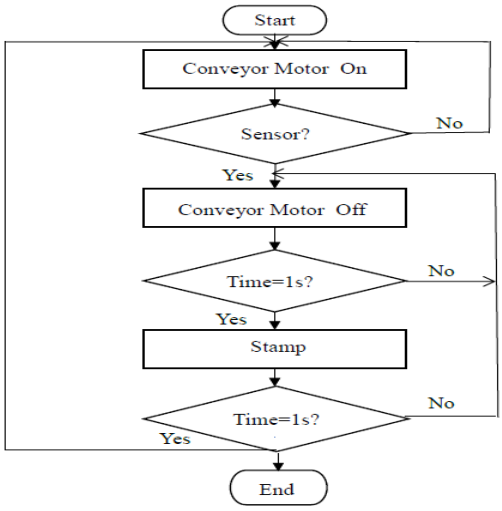

Figure 3. Flow Chart of Pneumatic Stamping System

3.1. Pneumatic cylinder

The first step in choosing a cylinder is deciding whether to use the single or double acting version. Single-acting cylinders use compressed air to move the load in one direction and double-acting cylinders use compressed air for movement in both directions. With double-acting cylinders use more air (both for the extend and retract), they are well suited for loads that require both pushing and pulling. The doubling acting cylinder has two ports to connect with solenoid valve to get air supply. Fig. 4 shows design and placement of double acting cylinder and stamp.

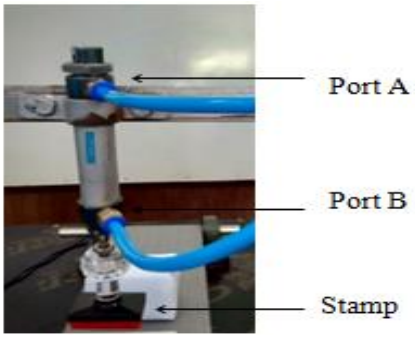

Figure 4. Design of Double Acting Cylinder and Stamp

3.2. Solenoid valve

After the cylinder is selected, the next step is to consider the flow rate and pressure of compressed air needed. Fig. 5 shows how the solenoid vlave is connected with double acting cylinder This type of 5/2 way valves have two output ports, commonly designed A and B or 2 and 4. And, they have one inlet port designated P or 1, and two exhaust ports, designated R and S or 3 and 5. In one position, inlet port P or 1 is connected to output port A or 2, while the port B or 4 is exhausted through exhaust port S or 5. This means the pneumatic cylinder is extended. In the other position of the valve, P or 1 is connected to port B or 4, and port A or 2 is connected to the exhaust port R or 3. This means the cylinder is retracted. Power consumption of the current valve is 24V DC and the pressure resistance is 1.2 Mpa.

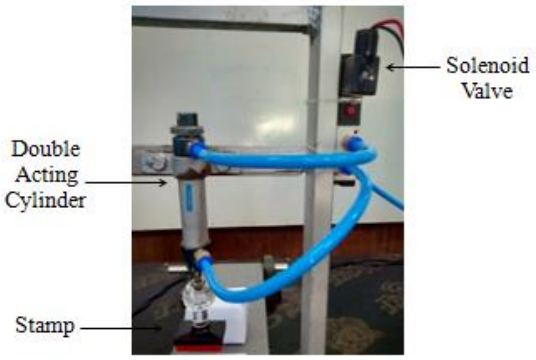

Figure 5. Design of Solenoid Valve and Double Acting Cylinder

3.3. Compressor And Air Tank

For stamping on an item which is not metal, the cylinder does not need much force and the cylinder piston also does not need to move fast. So, low-pressure air compressor without tank is chose for this pneumatic stamping system and an external air tank and non-return valve are added to it to get steady pressure.

Figure 6. Design of Air Tank and Compressor

3.4. Design of Conveyor Motor Drive

A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. The conveyor in this pneumatic stamping system is driven by 12V DC gear motor. The length of conveyor is 88cm and the width is 15. And, this conveyor has four revolutions per minute.

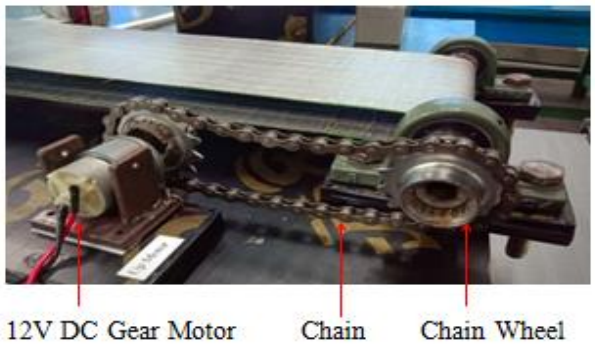

Figure 7. Design of Conveyor Motor Drive

4.DESIGN OF PNEUMATIC STAMPING SYSTEM

After all the hardware components and conveyor design are ready, the next step to consider the hardware setting. The double acting cylinder and stamp are placed at the middle of conveyor run way, as shown in Fig. 8. And, photoelectric sensor must be near the stamp to sense the item and then stop the conveyor. A stop button is to cut off the 24V DC power supply which is used by the PLC, solenoid valve and the sensor. Also, the red light is on when the stop button is pressed. Toggle switch is used as the emergency switch of the system to cut off the main AC supply to the system.

Figure 8.Hardware Design of Pneumatic Stamping Machine

5.TEST AND RESULTS FOR POWER SUPPLY AND PILOT LIGHTS OF THE SYSTEM

First of all, AC 220V must be supplied to the system. And then, yellow light will be turned on to indicate that the system gets the power supply. After that, the start button (I 0.0) is needed to press to start the system. Fig. 9(a) shows the hardware results of start condition. And Fig. 9 (b) shows the program, when start input (I 0.0) is get, power output is out because the stop input (I 0.0) is written as normally contact. And, green light (Q 0.0) turns on simultaneously to indicate that the system is started.

Figure 9 (a).Control Panel Result for Start Condition

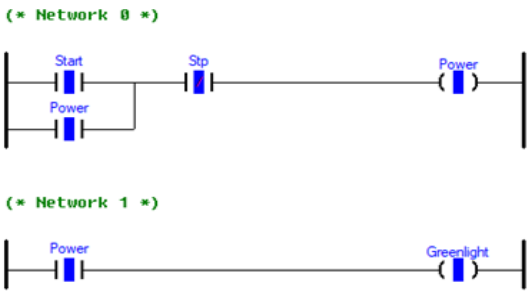

Figure 9(b).Simulation Results for Start Condition

To stop the whole system, stop button (I 0.1) is also included. When the stop button (I 0.1) is pressed, red light (Q 0.1) turns on. And the power supply to the system will be cut off simultaneously because a start button is a kind of push button and the stop input changes to open contact as shown in Fig 10(a) and (b).

Figure 10 (a).Control Panel Result for Stop Condition

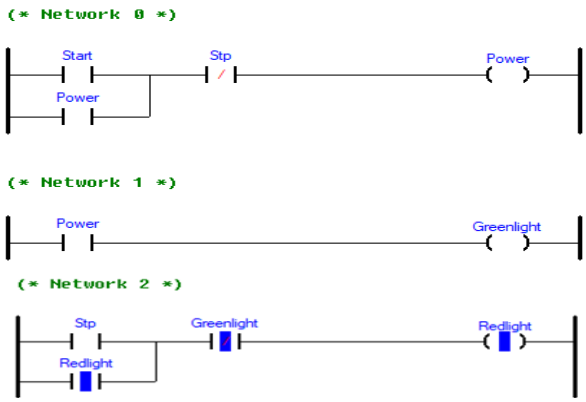

Figure 10(b).Simulation Results for Stop Condition

6.TEST AND RESULTS FOR STAMPING AND CONVEYOR MOTOR DRIVE

The 12V DC gear motor (Q 0.2) drives the conveyor as soon as the start button is pressed, on the other hand, input (I 0.0) is got. The conveyor carries the items to in front of the photoelectric sensor for stamping. Both the simulation result and the control panel result are shown in Fig. 11(a) and (b).

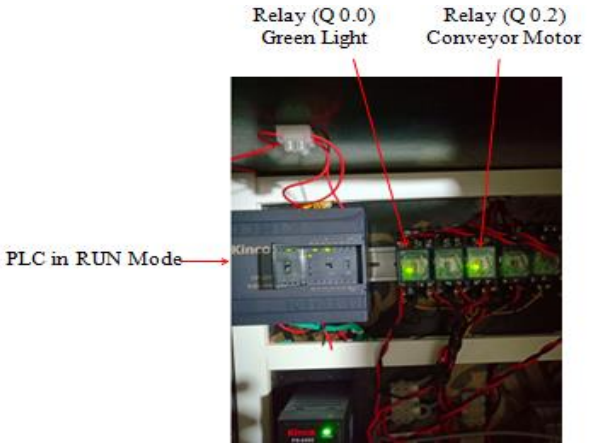

Figure 11(b).Control Panel Result for Start Condition

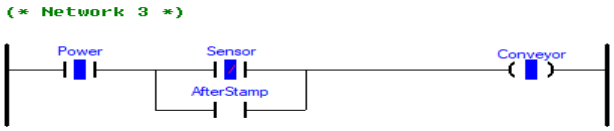

Figure 11(a).Simulation Result for Conveyor Motor

The photoelectric sensor is the third input (I 0.2) of the PLC. Once the photoelectric sensor senses, the conveyor motor (Q 0.2) stops and a time delay one second is needed to wait before stamping. Fig. 12(a) shows that sensor input (I 0.2) is get, and so the normally closed contact of sensor changes to open contact and the power supply to conveyor motor is cut off. The time delay waiting state and timer counting results are shown in Fig. 12 (b), (c) and (d).

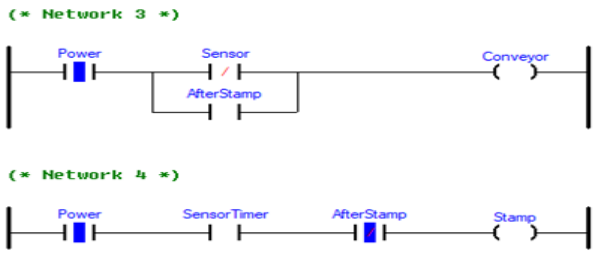

Figure 12 (a).Simulation Results for Sensor Sensing Condition

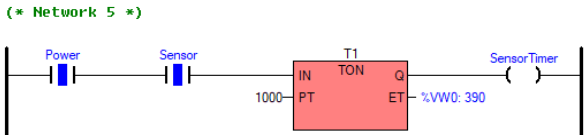

Figure 12 (b).Simulation Results for Time Delay (T1)

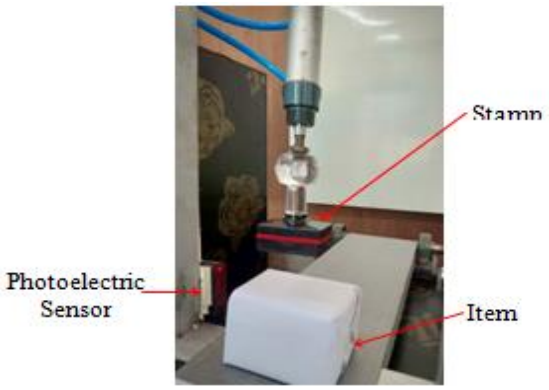

Figure 12 (c).Hardware Result for Sensor Sensing Condition

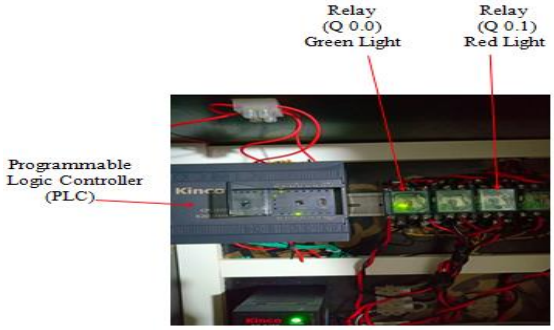

Figure 12(d).Control Panel Result for Sensor Sensing Condition

When one second time delay is over, the solenoid valve output (Q 0.3) is out for stamping. The followings Fig 13 (a), (b) and (c) are simulation results, hardware result and the control panel result to show stamping action.

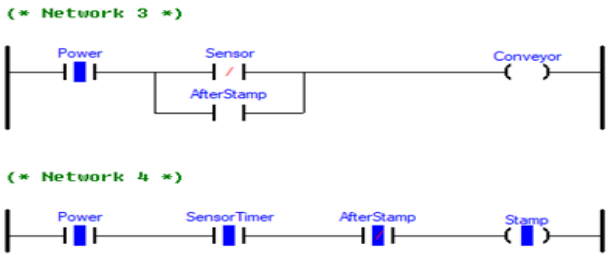

Figure 13 (a).Simulation Results for Stamping

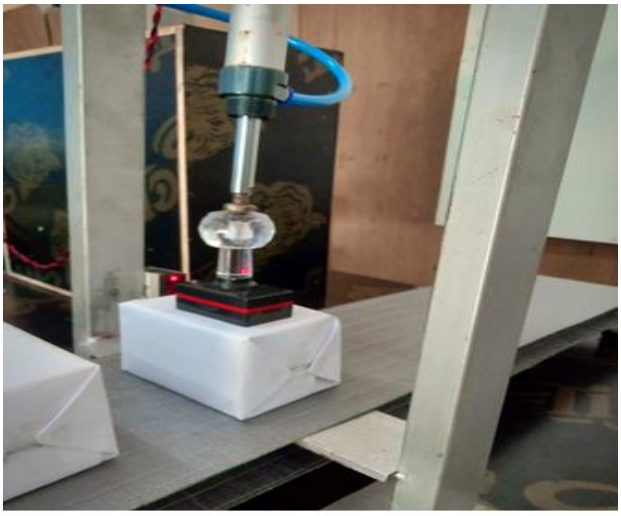

Figure 13 (b).Hardware Result for Stamping

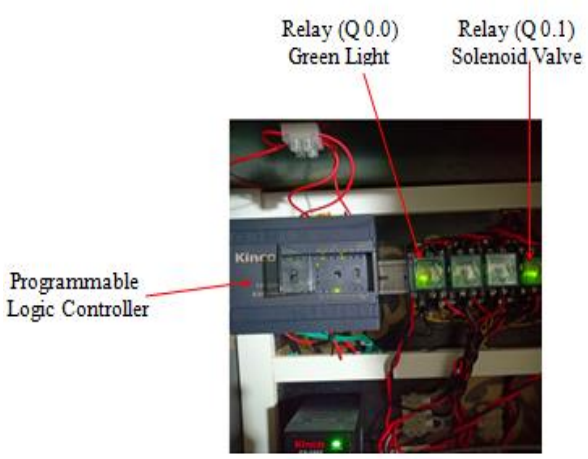

Figure 13(c).Control Panel Result for Stamping

After stamping, there is another one second time delay (Timer T2) to wait. In Fig.14 (a), timer has counted one second, and so the After stamp output is out to run again the conveyor motor (Q 0.2). Also, the power supply to solenoid valve is cut off by After stamp output. Conveyor motor (Q0.2) output and the solenoid valve output (Q 0.3) are shown in Fig. 14 (b). Fig. 14(c) shows the hardware result of timer T2 complete condition.

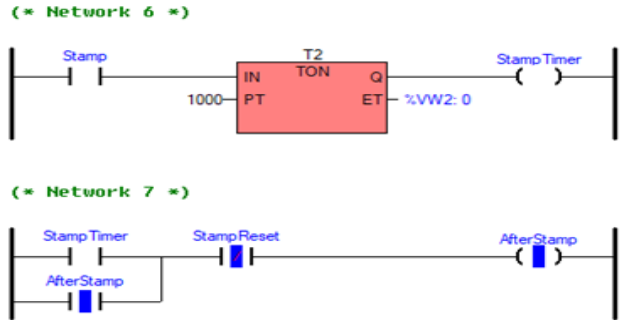

Figure 14 (a).Simulation Results for Time Delay (T2)

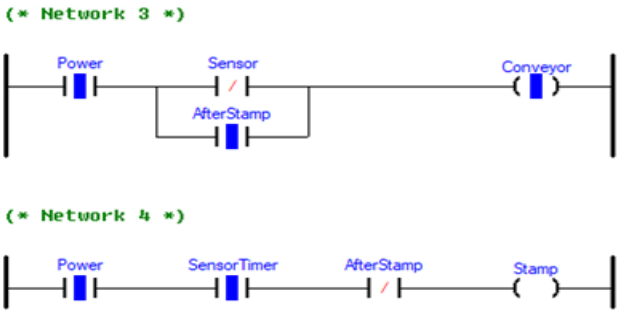

Figure 14 (b). Simulation Results After Time Delay (T2)

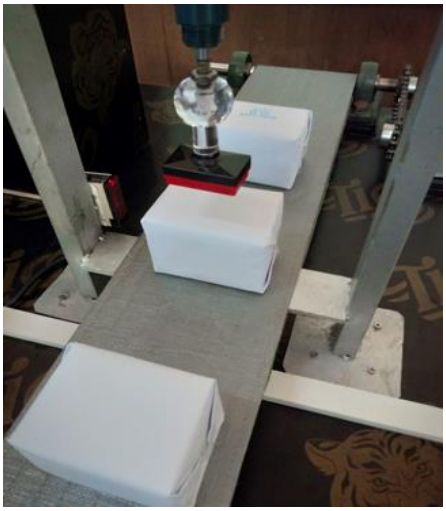

Figure 14 (c).Hardware Result After Time Delay (T2)

7.CONCLUSION AND DISCUSSIONS

The pneumatic stamping system is widely used in industries. The current pneumatic stamping system is aimed for domestic business. It can be used for stamping their logo onto the products. Compare to hydraulic system, pneumatic system has simplicity of

design and control, reliability and very low chance of fire. And, the pressure of pneumatic system is enough for stamping process. Moreover, this system has three strong points over other stamping system. The speed of double acting cylinder is easy to control because of the use of 5/2 way solenoid valve. The hardware design is set up to be able to adjust the placement of stamping cylinder. And, the toggle switch is put as an emergency switch of the system. As the system is controlled by Programmable Logic Controller, so, time and human energy can be saved and human energy can be reduced because of automation. And, this system has high effectiveness and accuracy. But a little noise produced by compressor while stamping and this system has limitations. These two are the weak points of the system.

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