PLC Based Automatic Liquid Filling System For Different Sized Bottles

Ameer L. Saleh[1], Lawahed F. Naeem [2], Mohammed J. Mohammed[3]

1,2 Department of Electrical Engineering, College of Engineering, University of Misan, Iraq
3Department of Information and Communications, College of science and technology, Basrah University, Iraq

---***---

Abstract – *An Automation is the utilization of different control techniques for operating equipment's such as operations in factories, aircraft and other applications with reduced human power. The filling process is a mission performed by a machine that fills liquid products such as water or cold drinks. Traditional bottling methods include placing bottles on a conveyor belt and filling only one bottle at a time. In this paper, it has been designed and implement water filling machine system for different sized bottles by using PLC. Where the water filling machine system includes design and implement prototype of a flat belt conveyor with dimensions (120*70*30) cm and automatic process for water filling machine using the solenoid valve and sensors which gives the appropriate information to control unit then design the controller using PLC. The PLC plays important role to implement automatic filling process by using PLC programing software and ladder diagram language. It was found that the water filling machine using PLC is less operational cost and less power consumption than the traditional control systems, in addition more flexible and time saving.*

*Key Words***: *PLC, conveyor, DC motor, laser sensor, solenoid valve, Relay, etc..*

1.INTRODUCTION

Industry automation becomes a spacious field in manufacturing which had important role in an extensive range of industries beyond manufacturing [1,2]. Nowadays the rapid development of manufacturing and technology has led to an increase in production level.. Where the production managers are faced challenged to reduce the cost of the product with maintaining product quality within a time framework and due to the increased demand for on consumer products so competition among manufacturing companies has become dependent on cost, accuracy, time, and quality for that the key to such a problem is the use of integrated processes in the industry[3]. Programmable logic controller(PLC) is extensively used in industrial automation and it act as a brain in industry application. PLCs in the industrial field are utilized to control a certain process in order to get better performance and higher accuracy to give more production in an efficient manner. This paper present, design and implementation water filling machine system for different sized bottles by using PLC. The water filling machine system consist of prototype conveyor section, filling section with sensors and control section using PLC. The PLC control unit is utilized to reduce the human work and increasing the production with less time[4]. A water filling

machine with PLC controller allows the user to choose the size of bottles with helping the sensors. The filling process is based on the selection of the size of the bottles by the user, through which the user can select the size of the liquid to be filled. A laser sensor is placed on the conveyor to sense the location of bottle under the valve and the corresponding valve is switched on to fill the bottle by using control unit. In this paper, first present a short introduction about conveyor system and the filling system and the second part talk about the hardware system and the programming of PLC.

2. Description of Conveyor System

Nowadays with many industrial applications, a conveyor system is used to move object from one location to another in effective way to reduce losing time and effort and it is very useful in packaging process. A conveyor system has several forms but in this paper, a Flat belt type is used to move the bottles as shown in Fig.(1). Conveyors are especially useful in applications which including the transportation of heavy or large materials. A Flat belt conveyer has a dimensions of (120*70*30)cm the belt is made from elastic material. Six pulleys a distributed along the belt, the first one rotates with the rotation of motor shaft and it usually called drive pulley and the other five pulley called idler pulley[4]. The Flat belt is fitted with aluminum plate between the pulleys to support the belt.

Fig-1: Flat belt conveyor.

3. Describe Water Filling Machine

3.1 Hardware System

One of the important applications of PLC is the water filling machine. In this paper, several bottles were filled in short time and the filling process became flexible to use any

shape or kind of bottle by simply change the program of PLC. Implementing this whole process manually will take a long time and the process will not be accurate with less productivity[2,4].

The hardware system contains on three main components; the moving part which is the conveyor move by DC motor, water filling and control equipment using PLC. The system therefore have conveyor belt, PLC, DC motor, electrical valve, sensor. Also there are tank, plastic tube, relay.

3.1.1 Programmable Logic Controller(PLC)

A Programmable Logic Controller, PLC is a digital computer used for automation. It is an interface between program and the inputs. It is a programmable software. A PLC is an example of a real time application and therefore used to control various devices[5].In other words, the PLC is an electronic(solid state logic elements) device designed to operate as industrial computer which reduces the need for manpower and increases productivity with less time and cost. All types of PLC are consist of a power supply, central processing unit (CPU), memory, input/output(I/O) modules and programming device[6], as shown in Fig.(1).The physical connection between the input and output module is done by the programming unit. Where the PLC acts as an interface to the real world through the input/output modules.

All logical and control operations are done by the CPU which is the heart of the PLC[6]. PLC has many programming languages but the most famous and important language is Ladder diagram language which are used to programming the PLC in this paper. The ladder diagram language is execute by using computer to write a certain program through special software for each type of PLCs and then loading the program to the PLC through connector cable(USP, RS-232C Cable).The PLC used in this paper is XEC-DN32H (LSIS) of the relay type.
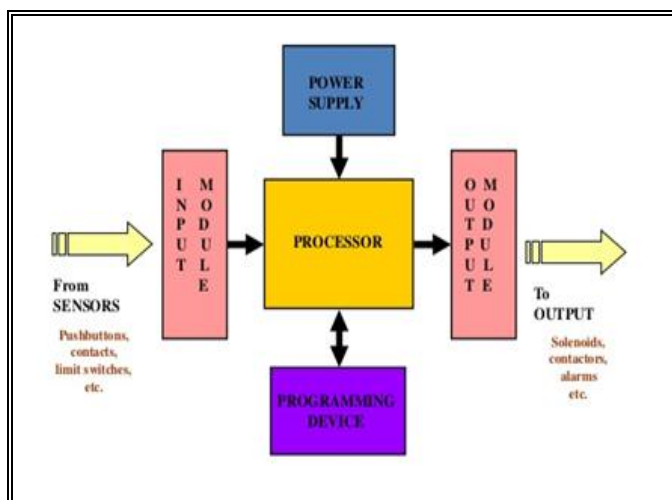

Fig-2: PLC architecture.

3.1.2 DC motor

DC motor is type of rotary electrical machines that convert electrical current into mechanical motion. In this paper a DC motor is used to rotate the conveyor belt to move the bottle first under the valve and after it filled move it away from valve[7]. This DC motor operate 12 DC supply with gear box which is used to increase the torque and reduce the speed as required as shown in Fig.(3).

Fig-3: DC motor with gear box

3.1.3 Water solenoid valve

A solenoid valve is an electromagnetic controlled device utilized to control the flow of liquid or gas by opening and closing a gate by a certain value of current as shown in Fig.(4). When a current applied to the coil of the solenoid it will become like magnetic which exerts a force on a piece of iron to close the gate and pulled it toward the center of the coil so it open the gate and allow liquid to flow[5]. A tank used to provide the liquid(which is a water in this paper) to the solenoid.

Fig-4: Water solenoid valve.

3.1.4 Laser sensor and Photoelectric Sensor

In this paper, the Laser and photoelectric sensor are used to provide the information to the controller to give the instructions of the motor and water solenoid valve. The laser is used as a source of light due to high accuracy in the

examination and the photoelectric sensor is used to detect the location of bottle as shown in Fig.(5). When the bottle is cut the laser, the receiver (photoelectric sensor) responds to that and give the signal to the PLC to stop the conveyor and start water solenoid valve.
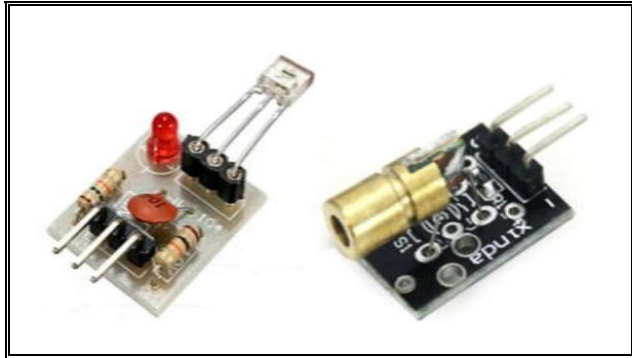

Fig-5: Laser and photoelectric sensor.

3.1.5   Relay

A relay is an automatic switch which is triggered by a certain voltage[7,8]. The relay controls a high voltages by using control voltage(low voltage) as shown in Fig.(6). The low voltage that the relay will accept to control the switch is 5 V. The laser and the sensor worked are on 5V but the input to PLC is on 24 V DC so the relay is used to connect the laser and sensor to the input of the PLC. In the output side, the relay is connected from the output of the PLC to each of the DC motor and the solenoid valve for the purpose of protection.
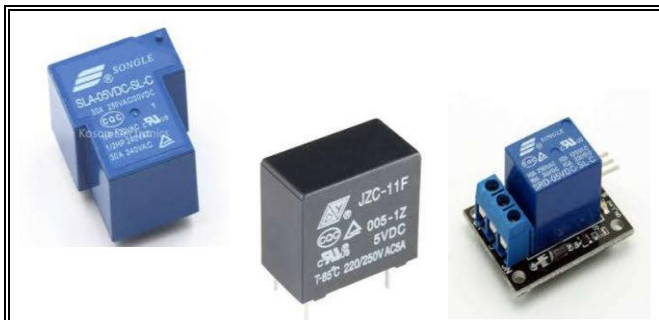

Fig-6: Relay.

3.2   Proposed Software System

3.2.1   System Working

The water filling machine starts when the push button switch is pressed and this caused working the DC motor hence the conveyor belt is moving. The bottles move on the conveyor belt until the first bottle reaches under the solenoid valve where the laser is cut by the bottle, hence the photoelectric sensor is sensing the bottle and gives a control signal to the PLC through the relay(24v). This leads to stopping the DC motor and hence the conveyer belt stops

and the solenoid valve operates and the bottle starts filling the water (using timer in PLC to time this process).when the bottle is fully filled with water, the solenoid valve is closed and the motor is working to move the conveyor belt again to carry the bottle away from the solenoid valve. If another bottle is detected under the valve, the process will be repeated and when the stop button is pressed, the whole process will be stopped. The block diagram for water filling machine is shown in Fig.(7) while the overall automatic process is shown in flow chart in Fig.(8).
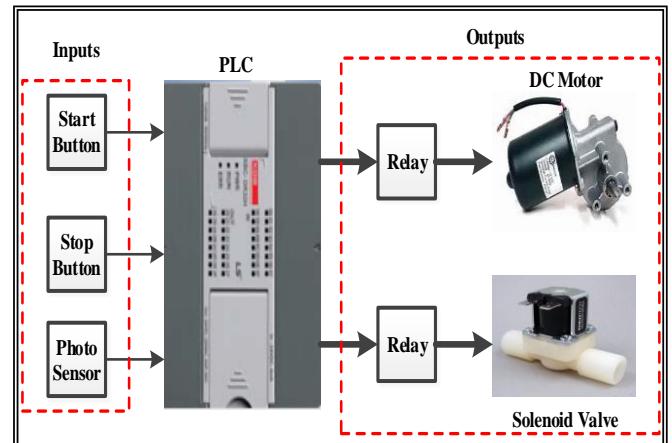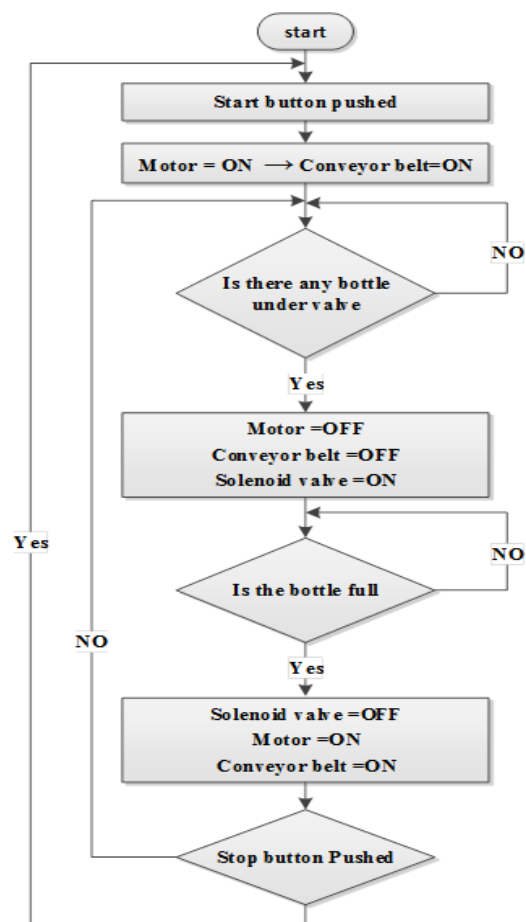

Fig-7: The overall water filling system.

Fig-8: Overall automatic process.

3.2.2   Program description

The PLC used in this paper is of type **LS (XEC-DN32H)** of the relay type and the software program is **XG5000** with **XGB-XECH** type CPU. The Ladder diagram language is used to write the program by using computer. Where the program has been description in four step as shown in Fig.(9):

First step:

Through the first step, push button is switched hence the motor run and the conveyor belt is moving and carrying the bottle towards the valve.The normally closed conntact (valve) is placed to ensure that when valve ON (in step2) the motor is OFF.

Second step:

When the bottle reaches under the solenoid valve, the normally open conntact (sensor) will be ON and make the valve ON and the motor OFF (conveyor stop).

Third step:

When valve ON, the PLC timer (ON-Delay timer) become active hence the valve is filling the bottle at time (5 sec) by the timer. When the timer finishes, the valve will be OFF and motor is ON again and hence the conveyor belt carrying the bottol away from the valve and the whole process will repet again.

Fourth step:

Up counter (by PLC) is connected to the valve to count the number of bottles filled which means that every time the valve the counter will be count.
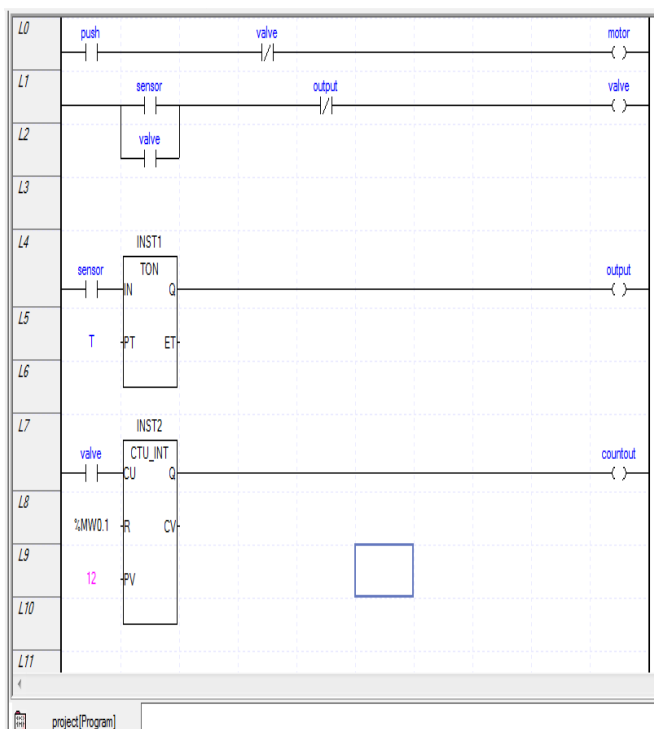

Fig-9: Overall software program using PLC

3.2.3   Experimental Results

The water filling machine in this paper can fill up to 5 or more bottles in one minute depend on the size of bottle. The power consumed in this system is low because the PLC need only 24v dc for operation and the DC motor operate at 12v while the sensors operate at 5v and also the structure of this system is simple because the wiring of the input and output devices is very easy and the control is done in the PLC through software program. The overall water filling system is shown in Fig.(10). Figure(11) shows the DC motor connection to the conveyor system. The overall water filling system with another size for the bottle is shown in Fig.(12). The Automatic control panel shown in Fig.(13).

Fig-10: The overall water filling system.

Fig-11: DC motor connection to the conveyor system.

Fig-12: The overall water filling system with another size for the bottle.

Fig-13: The Automatic control Panel.

4. Conclusion

An automatic water filling machine system for different sized bottles by using PLC has been developed and implemented. The PLC is used in this system to get more productivity with less time high reliability for and flexible in work. The system is designed to working with different sized bottles by simply change the program. The ladder diagram language is used in this paper because this language is very useful and has a lot of functions so that most of the industrial application uses this language.

REFERENCES

[1] A. Dakre , J. Sayed2 , E. Thorat," Implementation of Bottle Filling and Capping using PLC with SCADA", International Research Journal of Engineering and Technology, Vol.2, Dec2015.

[2] T. PRATAP, S. SINGH, "Automation of Bottle Filling System in Industries using PLC and SCADA", International Research Journal of Engineering and Technology, Vol.3, Sep.2016.

[3] T. Kalaiselvi, R. Praveena, " PLC Based Automatic Bottle Filling and Capping System with User Defined Volume Selection", International Journal of Emerging Technology and Advanced Engineering , Vol.2, August 2012.

[4] D. Baladhandabany, S. Gowtham, "PLC Based Automatic Liquid Filling System", International Journal of Computer Science and Mobile Computing , Vol.4, March 2015 .

[5] A. Dakre, J. Sayed, "PLC Based Automatic Bottle Filling and Capping with Metal can Ejector and SCADA", International Journal For Technological Research In Engineering , Vol.3, December-2015.

[6] Chitra.S, V. Raghavan, "Conveyor Control using Programmable Logic Controller", International Journal of Advancement in Research & Technology , volume 3 , Aug 2014.

[7] P. Sajjan, A. Unnibhavi, "PLC Based Automatic Flow Control in Cold Drinks Manufacturing Industry", International Journal on Emerging Technologies. Vol.7, Feb. 2016.

[8] Shaukat N., "PLC Based Automatic Liquid Filling Process", IEEE Multi Topic Conference, 2002.