DESIGN AND DEVELOPMENT OF LEVEL CONTROL AND BOTTLE FILLING PLANT USING PLC

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ABSTRACT

Programmable Logic Controllers (PLCs) are used in industries nowadays to achieve automation. PLCs have made the traditional expensive method, cheap and time saving. This paper mainly focuses on PLC used for filling bottle with a mixture of fluids as per user-defined volume selection. Level sensors are used to provide level data to the PLC which in turn takes required decisions and thereby turning the pump ON and OFF. The system was implemented in Supervisory Control and Data Acquisition System (SCADA) to create the required Human Machine Interface (HMI).

Keyword: *Automation, PLC, SCADA, Sensors, Ladder logic.*

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1. INTRODUCTION

Automation plays an increasingly important role in the world economy. The trend is moving away from the individual device or machine toward continuous automation solutions. Totally automation is in the soft drink and other beverage industries, where a particular liquid has to be filled Integrated Automation puts this continuity into consistent practice. Totally Integrated Automation covers the complete production line, from receipt of goods, the production process, filling and packaging, to shipment of goods. Automation is used for all control systems and the technology in programmable logic controller (PLC) is used to reduce the human work and helps in increasing the production. PLC plays an important role in the world of automation industry. It acts a major function in the automation field which tends to reduce the complexity, increases safety and cost efficient [1].

1.1 Programmable Logic Controller

According to National Electrical Manufactures Associations (NEMA), PLC is a digitally operated electronic system for use in an industrial environment, which uses a programmable memory for the internal storage of user-oriented instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic to control, through digital or analog inputs and outputs for various types of processes [7]. Figure1 shows Allen Bradley PLC.

PLC consists of an I/O unit, central processing unit, and a memory unit. The input/output unit of the PLC acts as an interface to the real world. Inputs from real work are given to the input unit which is manipulated based on the programming, and the results are given back to the real world through the output unit of the PLC. All logic and control operations, data transfer and data manipulation operations are done by the central processing unit. The results and statuses are stored in the memory of the PLC. PLC's are used for a wide range of applications especially in the field of control and automation [4].

Fig -1: Allen Bradley PLC

First PLC was evolved from conventional computers which were manufactured by Modicon. It was used by General Motors to replace electromechanical relays, mechanical timers, counters and sequences.

1.2 Supervisory Control and Data Acquisition System

Supervisory control and data acquisition (SCADA) is a control system architecture that uses computers, networked data communications and graphical user interfaces for high-level process supervisory management, but uses other peripheral devices such as programmable logic controllers and discrete PID controllers to interface to the process plant or machinery. The operator interfaces which enable monitoring and the issuing of process commands, such as controller set point changes, are handled through the SCADA supervisory computer system. However, the real-time control logic or controller calculations are performed by networked modules which connect to the field sensors and actuators.

1.3 Problem Statement

The conventional liquid level control and bottle filling process have disadvantages such as:

- In conventional liquid level control, tanks are manually filled by opening control valves, to let the flow of liquid into tank in case of no liquid in the tank.
- The problem of manual control is, sometimes workers forget to close the valves which results in overflow of liquid.
- The conventional liquid level control methods are not reliable as the extent of human intervention is much more than the new methods of control which is governed by automation. More the human intervention more the system prone to errors.

2. OBJECTIVES

There are four objectives to be achieved in this work. Below are the following objectives:

- To design appropriate model for automatic bottle filling and tank level control.
- To design program using PLC for automatic bottle filling and tank level control.
- To interface PLC module with the inputs and outputs components.
- To design a human interface for monitoring and controlling the system.

3. PROPOSED SYSTEM

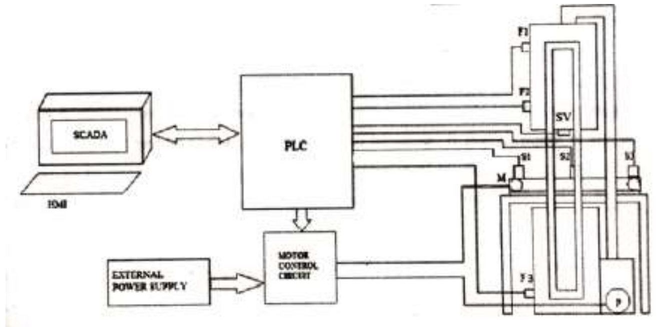

Fig -2: Layout of the proposed system

Figure 2 shows the layout of the system where,
F1, F2, F3 are the level sensors.
M is the DC motor used to run the conveyor belt.
P is the submersible pump.
SV is the solenoid valve.
S1, S2 are the filling stations.
S3 is the exit station.

The system consists of following components:

1. Storage Tank

The storage tank is used to store water which is to be lifted using submersible water pump. It also possesses float type sensor to detect fault i.e. non availability of water.

2. Feeder Tank

This tank is used to feed water to bottles. It also host various sensors to indicate water level to PLC and also solenoid valve to control the flow of the water.

3. Submersible Pump

This is motor which has hermetically sealed motor close couple to the main body. Whole assembly is submerged in the fluid which is to be pumped. The pump used in this project is the miniature of large submersible pumps.

4. Conveyor

It is the mechanical arrangement consisting of the belts (either of canvas or cotton material) running over the drums. One of the drum is connected to motor drive. Containers or bottles are kept over conveyor belt which are to be filled.

5. Sensors

- **Photoelectric Sensors**

Photoelectric Sensors detect objects, changes in surface conditions, and other items through a variety of optical properties. A Photoelectric Sensor consists primarily of an Emitter for emitting light and a Receiver for receiving light. When emitted light is interrupted or reflected by the sensing object, it changes the amount of light that arrives at the Receiver. The Receiver detects this change and converts it to an electrical output. The light source for the majority of Photoelectric Sensors is infrared or visible light (generally red, or green/blue for identifying colors).

- **Capacitive Sensor**

Their operating principle is based on a high frequency oscillator that creates a field in the close surroundings of the sensing surface. The presence of any material (capacitive) in the operating area causes a change of the oscillation amplitude. The rise or fall of such oscillation is identified by a threshold circuit that changes the output state of the sensor. The operating distance of the sensor depends on the actuator's shape and size and is strictly linked to the nature of the. A screw placed on the back of the capacitive sensor allows regulation of the operating distance.

- **Level Sensor**

Level sensor is the float type switch used to sense the level on the tank. It can be easily converted from normally open to normally close.it provides discrete output. It consists of a snap-action switch and a long lever arm with a float attached to the arm. As the liquid level rises, the lever arm presses on the switch's actuator button. It can be easily converted from normally open to normally close.it provides discrete output.

6. Relay

A relay, or contactor, is an electromagnetic device composed of a frame (or core) with an electromagnet coil and contacts (some movable and some fixed). The movable contacts (and conductor that connects them) are mounted via an insulator to a plunger which moves within a bobbin. A coil of copper wire is wound on the bobbin to create an electromagnet. A spring holds the plunger up and away from the electromagnet. When the electromagnet is energized by passing an electric current through the coil, the magnetic field pulls the plunger into the core, which pulls the movable contacts downward. Two fixed pairs of contacts are mounted to the relay frame on electrical insulators so that when the movable contacts are not being pulled toward the core (the coil is de-energized) they physically touch the upper fixed pair of contacts and, when being pulled toward the coil, touches the lower pair of fixed contacts. There can be several sets of contacts mounted to the relay frame. The contacts energize and de-energize as a result of applying power to the relay coil (connections to the relay coil are not shown). When the coil is de-energized, the movable contacts are connected to the upper fixed contact pair. These fixed contacts are referred to as the normally closed contacts because they are bridged together by the movable contacts and conductor whenever the relay is in its "power off" state. Likewise, the movable contacts are not connected to the lower fixed contact pair when the relay coil is de-energized. These fixed contacts are referred to as the normally open contacts. Contacts are named with the relay in the de energized state. Normally open contacts are said to be off when the coil is de-energized and on when the coil is energized. Normally closed contacts are on when the coil is de energized and off when the coil is energized. Those that are familiar with digital logic tend to think of N/O contacts as non-inverting contacts, and N/C contacts as inverting contacts.

7. DC Motor

In a simple dc motor when the coil is powered, a magnetic field is generated around the armature. The left side of the armature is pushed away from the left magnet and drawn towards the right causing rotation. The armature continues to rotate. When the armature becomes horizontally aligned, the commutator reverses the direction of current through the coil, reversing the magnetic field. The process then repeats. When the current passes through the coil wound around a soft iron core, the side of the positive pole is acted upon by the upward force, while the other side is acted upon by a downward force. According to Fleming's Left Hand Rule, the force causes a turning effect on the coil, making it rotate. To make the motor rotate in a constant direction "direct current" Commutators makes the current reverse in direction in every half cycle (in a two pole motor) thus causing the motor to continue to rotate in the same direction. DC motor is commonly constructed with wound rotors and either wound or permanent magnet stators. The rotational speed of a DC motor is proportional to the voltage applied to it, and the torque is proportional to the current.

Table 1 shows the specifications of the components used in the experimental setup shown in figure 3.

Table -1: Specifications of Components

COMPONENTS	SPECIFICATION
PLC (ALLEN BRADLEY)	Input Power: 120/240 AC 24 DC 20 Digital Inputs 12 Digital Outputs 2 Analog Inputs and Outputs
DC MOTOR (JOHNSONS)	Revolution per minute: 30rpm Torque: 6.5kg-cm Voltage: 12V
SUBMERSIBLE PUMP (TULLU)	Voltage: 80V-240V Frequency: 50 Hz Power: 18 W Output: 400 lit/hr Head: 10 ft Weight: 0.35 Kg
LEVEL SENSOR	Maximum contact rating: 10 W Maximum switch current: 0.5 A Maximum switch voltage: 100 V DC Maximum breakdown Voltage: 220 V DC Temperature Rating: -10°C to +85°C Weight: 25 gms
PHOTOELECTRIC SENSOR (IDEAL)	Sub Type: Through Beam Rated Voltage: 12-24 V DC Sensing Range: 5000 mm Weight: 50 gm Response Time: 1 ms
CAPACITIVE SENSOR (IDEAL)	Power Supply: +10 to +30V DC @ 10mA max Output: 1.8V @200 mA Max sensing Distance: 5mm Wire Color Code: Brown=+V DC Blue=Common Black=Output Operating Temperature: -25°C to +70°C
SOLENOID VALVE (ITALY)	Voltage: 24 V Response Time: <20ms

Fig -3: Experimental Setup of Bottle Filling Plant and Tank Level Control System

4. FLOWCHART

The flow of the process is shown below:

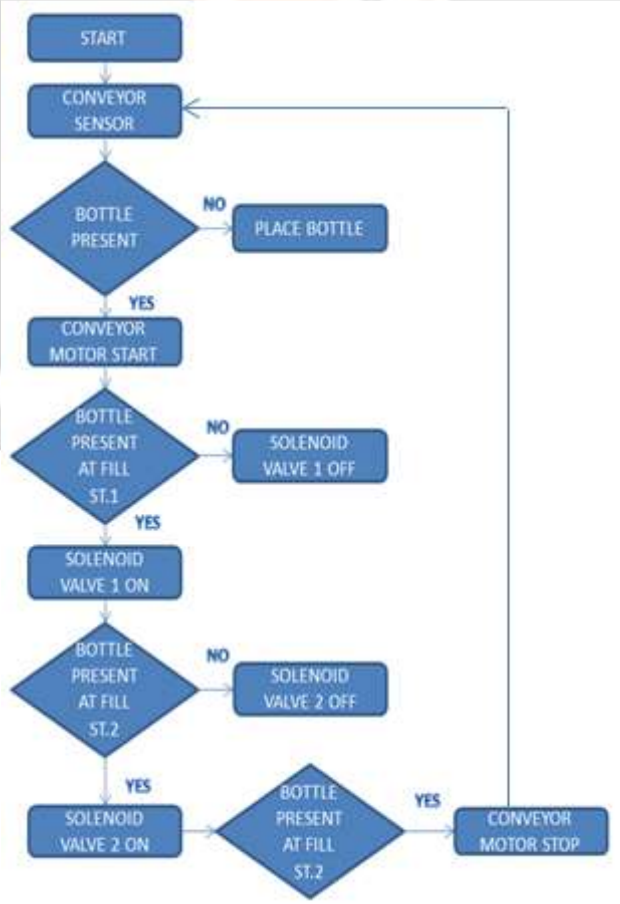

Fig -4: Flowchart

5. LADDER DIAGRAM

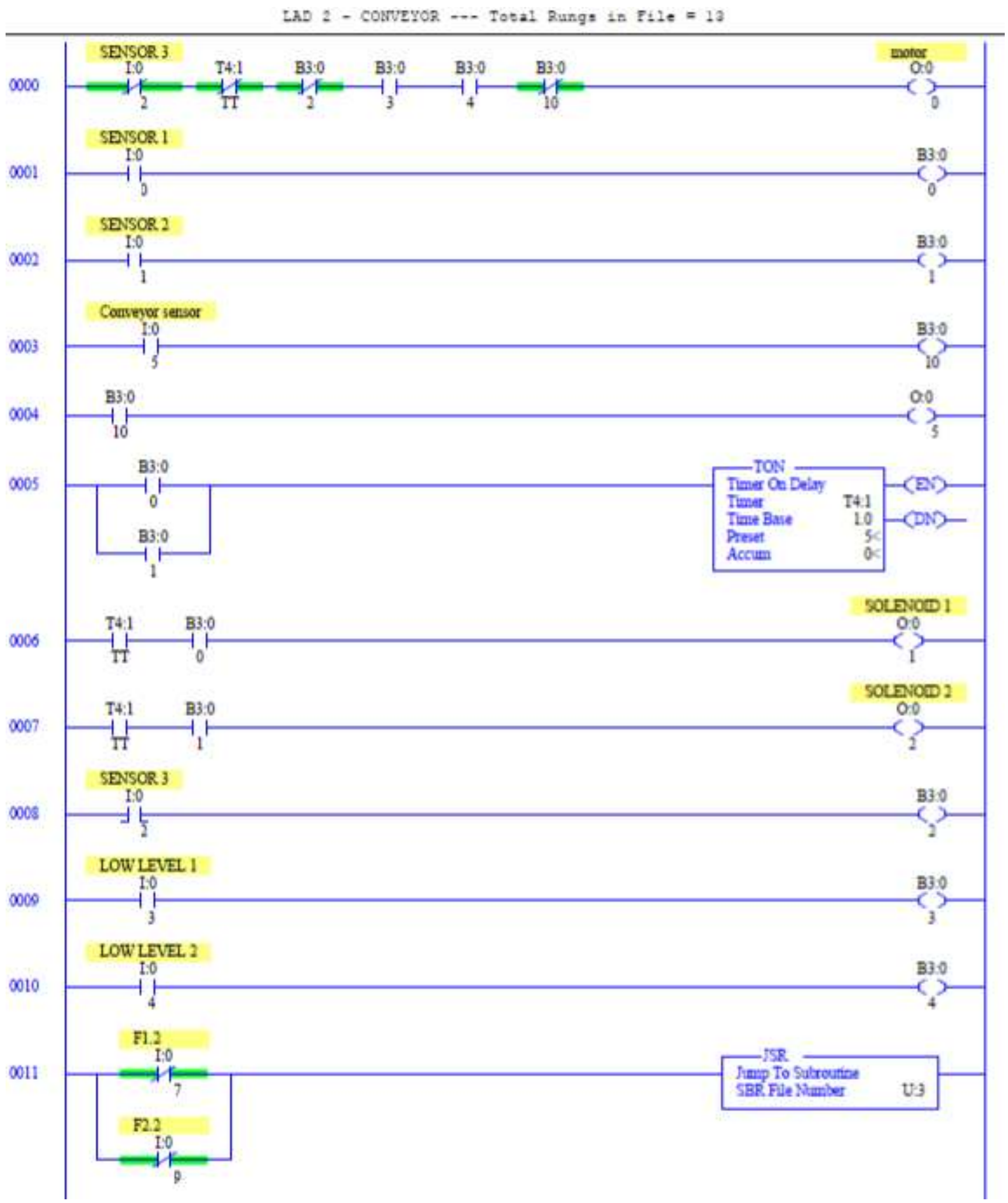

Fig -5: Ladder Diagram

6. CONCLUSIONS

[1] Thus from this paper we can conclude that wrested task of water level control has been accomplished in an efficient and economically viable way.

[2] The unnecessary loss of electric energy is prevented by use of infrared sensor.

[3] SCADA used in this enables the remote access of control equipment through HMI (SCADA screen) to the operator.

[4] Offers unprecedented flexibility for future expansion simply by developing required logic in PLC and adding required components to the system.

7. REFERENCES

[1]. Mamatarani Panny, Dr. M.S Aspalli, "Automatic Liquid Filling to Bottles of Different Height Using Programmable Logic Controller", International Journal of Scientific Engineering and Research (IJSER), ISSN 2347-387, Vol.4 Issue 8, Aug. 2016.

[2]. M. Elango, Shantanu L. Kulkarni, "Development Of PLC Based Controller For Bottle Filling Machine", International Journal of Innovations in Engineering Research and Technology (IJIERT), ISSN 2394-3696 Vol.3, Issue 4, Apr.-2016.

[3]. Gebremaryam Alem , Dr.Krishnanaik Vankdoth, "Automatic Fluid Level Control Using Programmable Logic Controller", International Research Journal of Engineering and Technology (IRJET), ISSN 2395 -0056, Vol.3 Issue 7 July 2016.

[4]. T.Kalaiselvi, R.Praveena, Aakanksha.R, Dhanya.S, "PLC Based Automatic Bottle Filling And Capping System with User Defined Volume Selection", ISSN 2250-2459, Vol.2, Aug. 2012.

[5]. Sagar, Amit, Vikrant, Madhusudhan, "Water Purification with Bottle Filling System", International Journal Of Computer Technology and Electronics Engineering (IJCTEE) ISSN 2249-6343, Vol.3, April 2013.

[6]. Savita, Lokeshwar, "Implementation and Performance Analysis of Bottle Filling Plant Using Ladder Language", International Journal of Science and Research (IJSR), ISSN 2319-7064, Vol. 3 Issue 7, July 2014.

[7]. John W Webb, "Programmable Logic Controller Principle and Application", PHI Learning.

[8]. John R. Hackworth, "Programmable Logic Controllers: Programming Methods and Applications", PHI Publisher.

[9]. Stuart A Boyer, "SCADA Supervisory Control and Data Acquisition", ISA.