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Review Article

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Automatic Bottle Filling Machine

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Abstract The objective of the paper is to provide an idea of the designing, developing, and monitoring of an automatic bottle filling system. Automation is the field which reduces the human efforts and labor requirement. One of the crucial applications of automation is within the soft drinks and other beverage industries, where the actual liquid has got to be filled continuously [1]. This is accomplished using a PLC (Programmable Logic Controller). It's a digital computer used for automation. An Ethernet cable is used to interface the computer with the PLC machine. Ladder Logic programming language is used in developing programs or software for PLC's. Other components include solenoid valves, conveyer belt, motor, sensors. Supervisory Control and Data Acquisition (SCADA) is used to monitor and control the system functioning in one place.

Keywords Automation, PLC, SCADA, sensors, ladder logic, Allen Bradley

Introduction

The project aims to design PLC Based automatic bottle filling system that senses the presence of a bottle and level of liquid in it and then fills it accordingly up to a fixed level. SCADA is interfaced with the PLC to check the live production and that we can even see the counts of bottles on our visual display unit using SCADA. We can also start-stop our project, change the value of the counter from SCADA. The filling is a task carried out by a machine that packages liquid products such as cold drinks, water or any other liquid. Traditional methods of bottle filling include placing bottles onto a conveyor and filling just one bottle at a time. This method is time-consuming and expensive. But now due to Industrial Automation, the filling and capping of the bottles are done simultaneously. The filling and capping operation takes place in an exceedingly synchronized manner. The whole system is more flexible, time-saving and efficient. The filling and capping operations are controlled using Programmable Logic Controllers (PLC) [2]. This is because PLC's are very flexible, cost-effective, space-efficient, and reduces complexity. By programming the PLC, we control the whole system. Some of the PLC manufacturing companies are Mitsubishi, Motorola, Allen Bradley, Omron, Panasonic, and Echelon. SCADA (Supervisory Control and Data Acquisition) is employed to observe the process.

Process Description

At first, the 'Auto start push-button' is selected and the motor starts and the conveyor belt starts moving. The DC motor used is a DC geared type motor whose shaft is coupled directly with the shaft of the roller. The motor selected should be such that can achieve a high starting torque at a constant speed. The reason for such a high torque is because heavy rollers are used on either side of the hardware which is mounted with a conveyor belt. Then two to three bottles are placed simultaneously on the conveyor belt. Now as the bottle approaches towards the photoelectric sensor, the sensor senses the bottle and the conveyor stops running. As the conveyor stops, the solenoid valve gets energized and the water starts filling in the bottle. After a given period is over, then the solenoid valve gets de-energized completely and water flowing through the valve is stopped and the conveyor

belt starts moving. The valve remains de-energized until the bottle is sensed by the sensor again. Then as this process is continued the water level in the tank keeps on decreasing with time. A water float switch is used which is dipped into the tank filled with water. It's used to know the level of water inside the tank. When the water level is low, it closes the circuit connection with the relay which results in pumping the water directly to the water tank from the reservoir. As this process takes place the entire system is turned OFF automatically. It remains turned OFF till the tank is refilled with water up to a required level where the float switch comes to a completely horizontal position. After the tank is filled with liquid the activity of the motor and the belt is resumed respectively. Emergency Switch has also been introduced in the system which works like a circuit breaker that disconnects the entire PLC system whenever any unfavorable conditions arise.
Following table shows the steps in an automatic bottle filling process:

Table 1: Steps of the process

Step No.	Process
STEP 1	Press the "START" Push Button.
STEP 2	Then the "MOTOR" starts and the conveyor moves forward.
STEP 3	If the sensor detects the presence of the bottle which is In position with the solenoid valve, then the conveyor will stop.
STEP 4	If the sensor does not detect any presence of the bottle, the conveyor keeps on moving.
STEP 5	After some delay, the valve turn "ON" and therefore the bottle will get filled till the timer gets off.
STEP 6	After the bottle is filled, a delay is provided and then after the delay, the motor starts running.

PLC Basics

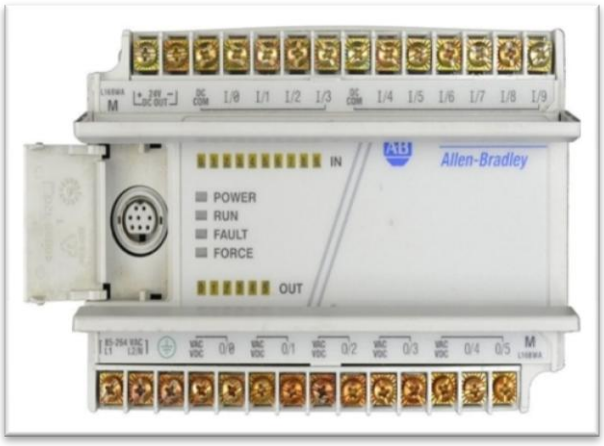

Figure 1: PLC (Allen Bradley) [3]

A Programmable Logic Controller (PLC), also mentioned as a programmable controller, is that the name given to a kind of computer commonly utilized in commercial and industrial control applications. PLCs differ from office computers within the sorts of tasks that they perform and therefore the hardware and software they require to perform these tasks. While the precise applications vary widely, all PLCs monitor inputs and other variable values, make decisions supported on a stored program, and control outputs to automate a process or machine. The basic elements of a PLC include input modules or points, a Central Processing Unit (CPU), output modules or points, and a programming device. The type of input modules or points employed by a PLC depends upon the kinds of input devices used. Some input modules or points answer to digital inputs, also called discrete inputs, which are either on or off. Other modules or inputs respond to analog signals.
The primary function of a PLC's input circuitry is to change the signals provided by these various switches and sensors into logic signals which will be employed by the CPU. The CPU evaluates the status of inputs, outputs, and other variables because it executes a stored program. The CPU then sends signals to update the status of outputs. The programming device is employed to enter or change the PLC's program or to watch or change stored values.

Ladder Logic Programming Language

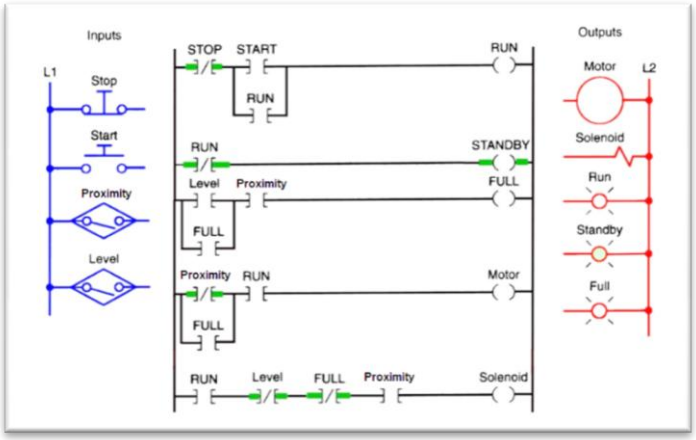

Figure 2: Ladder Logic [4]

The most common language wont to program PLCs is Ladder Diagram (LD), also referred to as Relay Ladder Logic (RLL). This is a graphical language showing the logical relationships between inputs and outputs as if they were contacts and coils in a hard-wired electromechanical relay circuit. This language was invented for the express purpose of creating PLC programming feel "natural" to electricians aware with relay-based logic and control circuits. While Ladder Diagram programming has many shortcomings, it remains extremely popular in industrial automation. Every Ladder Diagram program is arranged to resemble an electrical diagram, making this a graphical (rather than text-based) programing language. Ladder diagrams are to be thought of as virtual circuits, where virtual "power" flows through virtual "contacts" (when closed) to energize virtual "relay coils" to perform logical functions. None of the contacts or coils seen in a Ladder Diagram PLC program are real; rather, they act on bits in the PLC's memory, the logical interrelationships between those bits expressed in the form of a diagram resembling a circuit, being edited on a private computer.

Hardware Specification

1. Water Level Sensor

Figure 3: Water Level Sensor [5]

The above picture shows the water level sensors. Its working mechanism is very simple. When the tank is filled up with water then the float switch "normally opens" (NO) the circuit and when the tank is empty the float switch "normally closes" (NC) the circuit and energizes the hardware connected with it (mostly water pump is connected).

2. Photoelectric Sensors

A photoelectric sensor is an equipment wont to discover the distance, absence, or presence of an object by employing a light transmitter, often infrared, and a photoelectric receiver. They are largely used in industrial manufacturing. It is used to sense the position of the bottles. A round-shaped sensor is employed which can detect opaque, transparent, or any other kinds of objects. The range of sensing the objects is100 mm. It is made of brass or plastic.

Figure 4: Photoelectric Sensors [6]

3. Solenoid Valve

It is normally used to automatically control the flow of the water that shall fill the bottle. When the water bottle placed over the conveyor belt, which is initially at motion, is sensed by the Photoelectric Sensor, the conveyor stops running and at the same time the solenoid valve gets energized and water starts flowing through the valve for a certain period (depending on the time we set on the timer in the PLC programming).

Figure 5: Solenoid Valve [7]

4. Switch Mode Power Supply (SMPS)

Figure 6: SMPS [8]

A switch-mode power supply is an electronic power supply enhanced with a switching regulator to convert electric power efficiently. Similar to other power supplies, an SMPS shift power from a DC or AC source (often mains power) to DC loads, such as a private computer, while converting voltage and current characteristics. Dissimilar to a linear power supply, the pass transistor of a switching-mode supply regularly switches between low-dissipation, full-on and full-off states, and spends no time in the high dissipation transitions, which minimizes wasted energy. Ideally, a switched-mode power supply dissipates no power.

Conclusion

An automatic filling machine user can ensure speed and simple filling processes to make sure efficient filling of liquids or powders into bottles without wastage. It also enables faster filling processes and therefore helps in saving a lot of time for the users. Modern filling machines are equipped with the latest technology like PLC control which allows efficient and easy filling processes. These are preferred for features like no container no filling system and energy saving which supports in saving the energy consumed while reducing product wastage during the method [9]. By the installation of a jet nozzle and strong solenoid valve, one can reduce the time to fill bottles and can efficiently increase productivity.

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