Design and Implementation of Automated Tablet Filler Prototype for Pharmaceutical Application Using PLC

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Abstract— This project implements a prototype of commercial tablet counting and filling machine for pharmaceutical application, controlled using Programmable Logic Controller (PLC). In the first study, the operation system of the counting cum filling machine is designed and developed. It is the geared DC motor based, controlled by switching of sensor through PLC. Secondly, the conveyor system for feeding the bottles for the tablet filling process is designed and developed, which is also based on a geared DC motor. A sensor near the filling station on the conveyor, senses the arrival of bottle and stops the conveyor. Simultaneously it initiates/triggers the counting/filling module to fill the arrived bottle in station. Then conveyor starts and carries the filled bottle. Arrangements were made to feed the bottles to conveyor and to store the filled bottles taking off the conveyor. The entire process is completely automated using PLC. The programming language used is Ladder Diagram (LD), which is quite easy to understand the dataflow and easier to modify the functionality.

Keywords: Programmable Logic Controller, Conveyor, Sensor, Relay, Tablets

I. INTRODUCTION

In this era of industrialization, the revolution in technology, more specifically, the automation has had a notable impact in a wide range of industries beyond manufacturing. When we look at the current industrial scenario, it is clearly notable that the birth of new products and private brands is sharply rising the competition among industries. In order to hold out the promise of timely delivery of product, high tech automated production is essential.

Automation is the use of control system and information technologies to reduce the need of human work in the production of goods and services. The concept of Automation is so versatile that it can bring radical development in almost every field. In the scope of industrialization, automation is a step beyond mechanization. Mechanization provides human operators with machinery to assist them with the muscular requirements of work, whereas automation greatly reduces the need for human sensory and mental requirements as well.

In small industries, the filling system usually operates in manual mode and even this is true for some other industries also. Literature suggests that microcontrollers are being used in these industries as it brings a cost effective solution for controlling the process. Although PLCs are costly, still those are also used in industries. The implementation of PLC for commercial tablet filling plants is not discussed widely in literature. Therefore in this work, an endeavor is made to bring out important facts about its commercial use.

In some of the industrial situations and their internal environment, the microcontrollers are not well suited since they are less immune to electrical noise, vibrations and temperature. Whereas PLCs are designed for multiple analogue and digital inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Since PLCs can operate electric motors, pneumatic and hydraulic cylinders, magnetic relays, solenoids, analog outputs, the complete automation of the process can be achieved.

II. LITERATURE SURVEY

1) describes a methodology for filling and capping bottles simultaneously in a synchronized manner with user-defined volume selection menu through which the user can input the desired volume to be filled in the bottles using PLC.
2) briefs about a machine that can be used for automatic filling of liquid into the bottle of different height and is fully controlled by the PLC.
3) describes an automatic method of mixing and filling the Ayran (which is a yoghurt drink produced in Turkey, traditionally manufactured by addition of water at a level of 30–50% and salt at a maximum level of 1% to yoghurt) into pet bottles with improved efficiency.
4) describes the system suitable for situation that requires exact amount of liquid with 2 different flavors to be filled in the different bottles with 2 color stickers where each color sticker will represent each flavor of water.
5) describes a liquid dispenser machine with touch screen interface for metering and monitoring the dispensing processes like coffee dispensing, etc.
6) presents a prototype of commercial bottle filling system with the provision of mixing any number of liquids in any proportion with high degree of flexibility and remote control.
7) describes the belt conveyor monitoring system and fault detection in the same.

III. BLOCK DIAGRAM AND METHODOLOGY

The design of the automated tablet filler prototype can be broken into 2 parts, namely:

- Hardware design and
- Software design.

The hardware design can be further divided into

- Mechanical structure and
- Electronic components.

The mechanical structure can be further divided into

- The feeding system,

- The transfer system,
- The filling system and
- The storage

A. MECHANICAL STRUCTURE

In the shown figure of proposed prototype, M1, M2, M3 are three geared dc motors of 24VDC. And S1 is the proximity sensor.

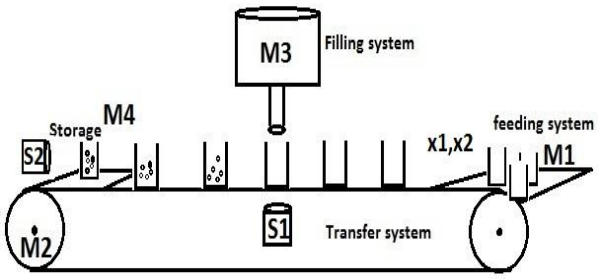

Fig. 1: Block of Mechanical System

1) THE FEEDING SYSTEM

The bottle feeding system is a circular disc coupled directly with dc geared motor M1, with a narrow piece of obstacle placed along its radius towards the transfer system at a suitable angle. During the operation of the prototype, when the disc rotates, the bottles placed on the disc are fed into the transfer system due to narrow piece of obstacle.

2) THE TRANSFER SYSTEM

The transfer system is a custom-made conveyor which is composed of a belt, motor M2, roller and metallic housing.

Conveyor design:

- Conveyor length and width : 1m and 18cm
- Conveyor belt length : 2m
- Roller diameter : 12cm

Motor specification:

- Motor with metal gear box
- 24 V DC
- Rated torque- 15 Kg-cm
- Rated speed- 15 rpm
- Rated current- 0.5 A

The two rollers are placed at the extreme ends of the rectangular metal housing of 1m length. One of the roller is coupled with the motor M2 of above given specification. The nylon belt is used in this conveyor since it exerts less friction on metal housing during its operation.

3) THE FILLER SYSTEM

The filler system is comprised of a cylindrical vessel, a circular disc that fits into cylindrical vessel and a motor to rotate the disc and a vibrator motor. The vessel is fixed to conveyor with a stand, the circular disc within the vessel is coupled with the motor so as to rotate in the vessel. On the disc, number of holes equal to the number of tablets to be filled to each bottle is made and the vessel on the one corner has a mouth corresponding to the orbit of holes made on disc. This entire filler system is fixed to conveyor with suitable inclination and the bottom of vessel is fixed with a vibrator motor for easier loading of tablets into the holes. The vessel is filled with tablets and when the motor is supplied with power, the holes on the circular disc are loaded with the tablets and as it rotates, the tablets are unloaded at the mouth of vessel and hence the bottle under the system is filled.

Filler design:

Number of holes on disc: 5

Motor specification (Coupled to disc):

- Motor with metal gear box
- 12 V DC
- Rated torque- 10 Kg-cm
- Rated speed- 30 rpm
- Rated current- 0.5 A

Vibrator motor specification:

- 5 V DC

4) THE STORAGE SYSTEM

A suitably placed obstacle on the end of conveyor guides the filled bottles into a storage space.

B. ELECTRONIC COMPONENTS

The electronic components may be classified into (1) the control system, (2) the sensors, (3) the actuators.

Control system: The control system is a Programmable Logic Controller (PLC). For this prototype, Rexroth IndraLogic L20, from Rexroth, Bosch group has been used.

PLC specification:

- Rexroth IndraLogic L20, from Rexroth, Bosch group
- 24 V supply

1) Sensors

A sensor is a transducer which senses (detects) events or changes in quantities and provides a corresponding output, generally as an electrical or optical signal. One type of feedback frequently needed by the industrial control systems is the position of one or more components of the operation being controlled. Sensors are devices used to provide information on the presence or absence of an object.

2) Sensor specifications

- Infrared (IR) sensor
- Operating at 5 V DC

The sensor is used in our prototype to sense the arrival of bottle to the filling station. It is a 5V IR sensor and we know PLC can operate its input/output with 24V only. So the sensor output acts as control input to the relay which is giving 24 V to PLC on behalf of sensor.

3) Actuators

In actuating the motors, direct drive from the PLC was not possible. This is due to the fact that the voltage needed for some motors are more than 24 V and even if it is 24 V, the motor draws more current from PLC which is harm to PLC. Relays were used to convert the PLC signal of 24 V to required voltage.

4) Relays

A relay is an electrically operated switch. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. A relay consists of an electromagnet and contact. When current is passed through electromagnet, it gets magnetized and attracts the switch contact.

5) Relay specifications

a) 24 V DC relays - 3 numbers

In our prototype, three (3) 24 VDC relays are used to control motors. The motors used in prototype must not be connected directly to PLC as they draw more current from the PLC

which can cause harm to the PLC. So separate power supply must be provided via relay to which the control input is from PLC.

b) 5 V DC relay - 1 number

A sensor is used in prototype to sense the arrival of bottle to the filling station. It is a 5V IR sensor and we know PLC can operate its input/output with 24V only. So the sensor output acts as control input to the relay which is giving 24 V to PLC on behalf of sensor.

IV. FLOW CHART

When the system is made on by pressing start button, the bottle feeding mechanism and the conveyor system must start simultaneously. Here there is a possibility of more than one bottle entering the conveyor, so a pair of solenoids are used and these solenoids are made to operate such that one bottle has to be fed to conveyor after the completion of filling of one bottle. When the sensor1 at the filling station senses the bottle, the conveyor is stopped and the filler module is made on for a duration of one rotation of the disc to fill the bottle. The filler module is then stopped and conveyor is started. When the sensor2 near the storage module senses the filled bottle, the storage motor is started to rotate for 1 rotation and solenoid valves are let open to pass one bottle into the conveyor and the same cycle is continued till we press the stop button.

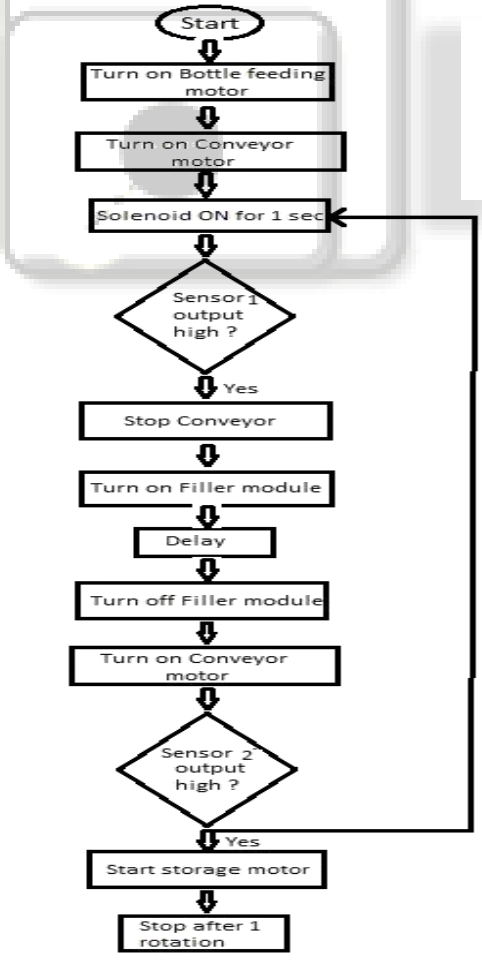

Fig. 2: Flowchart of the Proposed System

V. CONCLUSION

This paper has proposed an application of automation illustrating a PLC based fully automated tablet filler prototype for pharmaceutical application. The system meets the demand of high speed production using least mechanism requirements. The system has proved to work effectively by avoiding the wastage of tablets and also provides high accuracy and precision. Although the proposed system illustrates the filling of tablets in pharmaceutical applications, it can also be used in other industries like food packaging, etc to fill any pellets into the bottles. It is remarkable that the use of PLC is a costly affair particularly for small industries but it offers many advantages that overcome its cost

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