

# Improvement in Productivity of Bottle Filling Operation by using Multi-Nozzle PLC System

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## Abstract

Productivity is a key factor in utilizing the resources such as labor and material. The maximum reduction in the cycle time is possible only after controlling and reducing operation time. Productivity may be improved by introducing a better method to increasing material utilization, labor efficiency and effective arrangement of facilities etc. This paper represents the study of improvement in operation time for bottle filling operation by belt conveyer which is operated by PLC.

In the automated bottle filling machine, to attain both precision and promptness in the filling, is a requirement of the time. This can be achieved with the help of PLC programming. In this paper PLC is used along with various sensors as input to the system and designates about logic developed to sense the position of the bottle on the conveyor and its condition, that is whether it is filled or not. This will give correctness of the quantity to be filled and will drastically decrease the cycle time to fill one bottle eventually resulting in any goal of any manufacturing industry that is quantity with excellence

**Keywords:** Productivity, Reduction cycle time, PLC, Logic

## Introduction

In the competitive world, industry should adopt the latest technologies. The automation has excellent impact in a wide range of industries beyond manufacturing. Automation is nothing but the use of control system and information technologies to reduce the need for human work in the

production. Basic advantage of the automation system is the flexibility. Another challenge in front of industry is, continuous increase in the production volume, reduction in the cost and operate safely. In older systems as there will be continuous increase in production also increases the maintenance cost. So the manufacturer face problem as higher cost, high downtime and unsafe operation.

In the given paper PLC system is used for the automation. Most of the operations of this system are controlled by PLC. PLC is brain of the system and all processes are controlled according to the programmed PLC. This system based on PLC control system has advantages of smooth operation, less accident rate and high filling speed. So In order to improve the production rate, it is quite necessary to apply PLC (Programmable Logical Controller) in automatic filling system. Ladder logic is used to control the process.

PLC and similar methods are used in various researches all over the world. In this project [2] it was discussed about the design and implementation of automated multiple water filling machine using Geneva mechanism. The function of the machine is to fill the water automatically into bottles through a moving bottle plate. This project is the combination of Geneva and electrical synchronous motor system.

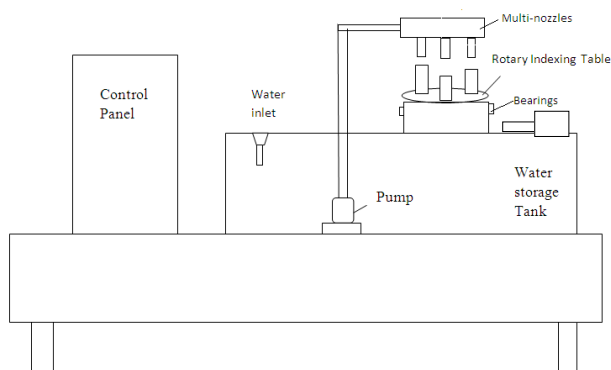
Prof. Anup G. Dakre [1] developed a system which was controlled by the help of PLC and the ladder diagram. There he had used Allen Bradley (AB) Pico-controller and the process is monitored with the help of SCADA.

In the paper [3] it 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.

The project entitled “Automatic tablet filler using PLC” [4] was an automating tablet filling processes in pharmaceutical companies. The new method was implemented instead of traditional method which is used in the industries in various aspects such as sensors, conveyor belt, motor and PLC logic being used currently throughout the industries. This project focused on automatically filling the tablets into the selected bottles using PLC ladder logic. It requires no human interference during the tablet filling process once bottle is loaded manually at starting point on the conveyor. It is highly efficient and reliable system of tablet filling which will reduce the overall cost at great extent. It is user friendly and non-hazardous for workers who will be working in the vicinity of installed system.

In the paper [5] it describes the belt conveyor monitoring system and fault detection in the same.

### Block Diagram



**Figure 1:** Block Diagram of Workstation

### Components and Function

The design of the system can be divided into two parts, namely: Hardware design and software design.

#### 1. Proximity switch:

Two proximity switches are used which are photo diffuse type. One sensor is used for detection of the bottle pallet and another is used for detecting the bottle present or not as well as it will use for detecting the water is filled in the bottle or not.

#### 2. Motor:

A DC motor is used to convert the direct current electric power into mechanical power. The DC motor is used to drive the conveyor belt. Motor used is Gear motor for better torque.

#### 3. Buzzer and LED:

Buzzer is used for indication of completion of process. It will also use to inform to operator about the any unwanted condition like bottle is empty or no bottle detected.

LED is used to demonstrate the process carry out at the conveyor.

#### 4. Programmable Logic Controller, (PLC)

PLC is a programmable device developed to replace mechanical relays, timers and counters. PLCs are used successfully to execute complicated control operations in a plant. The PLCs helped reduce the changeover time from a month to a matter of just few days. PLC consists of an input/output (I/O) unit, central

processing unit (CPU) and memory. The I/O unit acts as the interface between PLC and real time systems. All logic and control operations, data transfer and manipulation work is done by CPU. PLCs provide the advantages of high reliability in operation, flexibility in control techniques, small space and computing requirements, expandability, high power handling, reduced human efforts and complete programming and reprogramming in a plant. The PLC is designed to operate in the industrial environment with wide ranges of ambient temperature, vibration, and humidity and is not usually affected by the electrical noise that is inherent in most industrial locations. It also provides the cost effective solution for controlling complex systems. [7]

In this project Allen Bradley 1761-CBL-PM02 PLC is used and Micrologix 1000 RS -232 software is used for LAD programming

#### 5. Control Unit:

The control unit used for controlling the operation of the process. It is having a power source for all the devices connected in the system. The 230V incoming supply is first step down and it is converted into DC. The DC supply is for the motor, proximity sensors as well as buzzer, LED and different indicators requiring on the control panel. The input and output of PLC are connected to control panel through pins.

#### 6. Bearing Block:

The bearing block is used for making the conveyor belt to move along with the roller. Conveyor is wound around this bearing block.

Software Micrologix 1000 RS -232 was configured with PC by connecting through serial port.

### Flow Chart

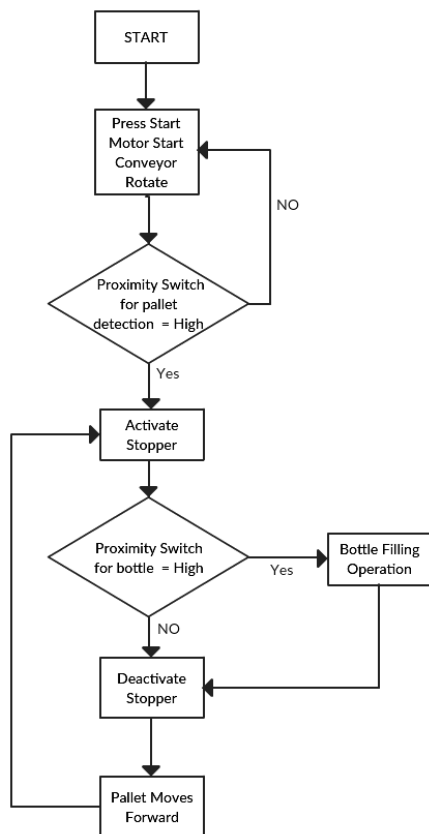


Figure 2: Flow Chart

**Description**

In this system, the cycle begins by activating the motor used for conveyor belt. The pallet is mounted on conveyor belt in which five empty bottles are placed then this pallet moves towards the filling station. This pallet is detected by proximity switch and the signal of presence of pallet is given to the PLC, which stops the conveyor belt and activates the plunger. At the filling station plunger acts as stopper and also ensures the position of pallet with respect to multi nozzle system. Another proximity switch is used to detect the presence of bottle and activation of nozzle. After bottle filling operation the plunger deactivates and pallet moves to next station. The cycle is then repeated.

**Observations and Results**

Three systems are compared with each other and observations are taken.

1. Manual Control  
 In this method manual operation of bottle filling was carried out and time required for the bottle filling process is observed.
2. PLC Controlled Rotary Indexing System  
 Previously developed rotary indexing system was observed, which fills water in five bottles by one after another in sequence automatically.
3. PLC Controlled Multi Nozzle System  
 In this observations given system is observed and actual time required was noted down for compensation.

The following results were obtained and they were compared, **Manual Control [6],**

Loading Time = 3 sec  
 Operational Time = 15 sec

Unloading Time = 3 sec  
 Allowance = 10% = 2.6 sec

Cycle time for 1 bottle = LT + OT + UT + A  
 = 23.6 sec

Cycle time for 5 bottle = 5 × 23.6  
 = 118 sec

**For PLC Controlled Rotary Indexing System,**

Loading Time = 3 sec  
 Unloading Time = 3 sec  
 Operational Time = 10 + 3 + 10 + 3 + 10 + 3 + 10 + 3 + 10 + 3 = 65 sec

Allowance = 10% = 1.42 sec

Cycle time for 5 bottle = LT + OT + UT + A  
 = 72.42 sec

Cycle time for 1 bottle = 72.42 / 5 = 14.484 sec

**For PLC Controlled Multi Nozzle System,**

Loading Time = 2 sec  
 Operational Time = 10 sec

Unloading Time = 2 sec

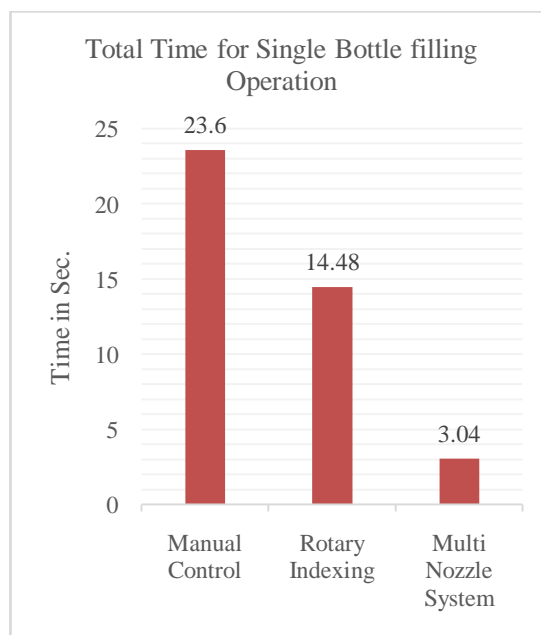
Allowance = 10% = 1.2 sec

Cycle time for 5 bottle = LT + OT + UT + A  
 = 15.2 sec

Cycle time for 1 bottle = 15.2 / 5 = 3.04 sec

Reduction in cycle time with respect to manual control = 20.56 sec

Percentage reduction in cycle time = 87.48%



Graph 1: Reduction in Total Operation Time.

**Conclusion**

The present system will provide a great deal of applications in the field of automation, especially in mass production industries where there are large number of components to be processed and handled in a short period of time which increases the productivity. Cost of installation is not cheap but it can efficiently run for a long period of time. System is more reliable, economical, easily configurable. System reduces the

human efforts and cycle time. Results obtained for bottle filling operation using PLC are shown in the Graph 1 where it is observed that time required for the bottle filling is reduced as the system is approaching towards automation. The final results are as follows,

For Manual Control,

Cycle time for single bottle = 23.6 sec

For PLC Controlled Multi Nozzle System,

Cycle time for single bottle = 2.64 sec

Reduction in cycle time = 20.56 sec

Percentage reduction in cycle time = 87.48%

Hence, by using this PLC Controlled improved device, we can reduce the cycle time up to 87.48%.

### Future Scope

Here in by installation of 5 nozzles, we can fill 5 bottles at a time which reduces the time to fill bottles and can efficiently increase productivity but still some manual interference is required for loading and unloading of the pallets from conveyer belt. This manual interference can be reduced by introduction of the Robotic Arm which can be programmed for loading and unloading operations. Also we can design this device for more than 5 bottles.

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