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DEVELOPMENT OF PLC BASED CONTROLLER FOR BOTTLE FILLING MACHINE

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ABSTRACT

The growth in Food industry and Healthcare industry has seen a rapid increase in demands of beverages as well as medicines. Precision while filling these beverage containers is required. Non-precision will not only lead the economic loss in the beverage industry but also a danger to consumer health in healthcare industry. A typical manufacturing facility of this kind will require precision as well as velocity in filling operation, to achieve both manually is tedious task. Also to operate manually in hazardous chemical industries is safety concern to workers. To make automated bottle filling machine to achieve both accuracy and speed in filling, is requirement of the time. This can be achieved by help of PLC programming and PID controller. This paper describes the application of PLC programming and PID controller in the field of bottle filling operation. In this paper PLC is used along with various sensors as input to the system and valves are used as output to the system. This paper describes about logic developed to sense the position of bottle on the conveyor and its condition, that is whether it is filled or not. This will give accuracy of the amount to be filled and will drastically reduce the cycle time to fill one bottle ultimately resulting in any goal of any manufacturing facility that is quantity with quality.
This paper also describes about the parameters like level and flow of a liquid to be controlled. These parameters are to be controlled with the Programmable Logic Controller (PLC) and the whole process is further controlled by SCADA. PID controller are used to minimize the error. A Human Machine Interface (HMI) can be used so the user can change the set values of different parameters as required.

KEYWORDS: PLC, PID, Automation, SCADA, HMI, Filling Machine

INTRODUCTION

To survive in the competitive world, company should use the latest technologies. The field of automation had a notable impact in a wide range of industries beyond manufacturing. Automation is the use of control system and information technologies to reduce the need for human work in the production of goods and services. High degree of flexibility is basic requirement of manufacturing. Industries face many other challenges like continuously increase in the production volume and reduction in the cost. Also industries need to 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.

New technologies are required that will reduce water usage, increase energy efficiency and minimize downtime in high-speed beverage production environments. The various process of this system is controlled by PLC. PLC is heart of the system and the system is controlled according to the programmed PLC. The automatic filling control system based on PLC control system has advantages of smooth operation, low accident rate and high filling speed. So In order to improve the production efficiency and the filling accuracy, it is quite necessary to apply PLC (Programmable Logical Controller) in automatic filling system. Ladder logic is used to control the process. Filling is controlled by using various methods using motor, sensors, conveyor belt, PLC, flow control valve.

PLC and similar methods are used in various researches all over the world. Mallardhya et al (2013) [1] used timer system, this system deals with the present value of the timer. The value is switched ON for that specific period of time and the filling is finished. This system is best use of mechanization exceptionally for large scale manufacturing businesses as different kind of part handled in brief timeframe that build creation. This uses different height of bottle for filling operation. Ahuja et al (2014) [2] utilized the Programmable rationale control (PLC) and Supervisory control and data acquisition (SCADA) for process monitored that gives the high level of adaptability to the programmed filling system. This helpful for blending any number of fluid in any extent. This framework give rapid generation utilizing minimum system necessity additionally give high exactness and accuracy in extent of fluid blended. This framework observed by SCADA as procedure can be start and stop by SCADA. That helpful when an issue occur during procedure.

Lu et Al (2015) [3] researched in the system which utilizes human machine interface straightforwardly with the PLC communicate with one another without programming through the man machine interface can finish the system parameter setting and checking. This programmed filling control system has high level of automation straightforward operation. This give high exactness estimation. Ozkana (2012) [4], conducted the experiment with the assistance of PLC that gives elective answer for the as of now available system. As semi-automatic systems cannot mixing capability. They have one and only tank for filling. But this PLC based system has 3 material tank and mixing bowl. This has been adaptability highlight to the PLC based frameworks. Baladhandabany et al (2015) [5], talked about the utilization of PLC in the filling system. This system for the most part helpful in the businesses such as mineral water industry. In this system roughly stand out jug fill each one in turn. The procedure can be proficiently utilized as a part of water filling framework. These sorts of liquids are taken care of predominantly by the solenoid valve and spout utilized. Situating the solenoid valve is a basic issue and legitimate consideration is required. It utilizes a DELTA DVP PLC, 24V DC Relay, Photo electric sensor, Flow sensor and Solenoid valve.

Maitrey Trivedi et al (2014) [6], built up the programmed filling framework in light of control of shut circle transport framework. With the assistance of PLC programming the fluid filled into jug. The control of transport utilizing PLC and sensor is a shut circle control framework. This framework is extensively used to fill diverse sorts of fluid, for example, water, syrup, icy beverage, soda pop, hard drink, milk and so on into the container. This framework comprise of elastic transport line, DC engine, vicinity sensor and fluid filling gadget as solenoid valve, software engineers as PLC and different gadgets such edge structure on which the complete framework will stand. Rishabh Das et al [7], shaped the framework that consequently control the level. This doesn't required human supervision. This utilizations PLC and SCADA with human machine interface (HMI). This framework didn't utilize skim sensor additionally mean exact level. With the goal that it diminishes undesirable vibration furthermore lessens cost. Ashwini P. Somavanshi (2013) [8], made an attempt to reduce overall cost. This system

utilizes microcontroller it is most suitable for small scale industries as the procedure is set by programming embedded controller are the heart of a modern control system or a procedure control application. By this system the machine can fill ten containers in one moment. By this strategy revision in volume diminishes the loss of filled fluid that decreases the expense of manufacturing and customer.

EXPERIMENTAL SETUP

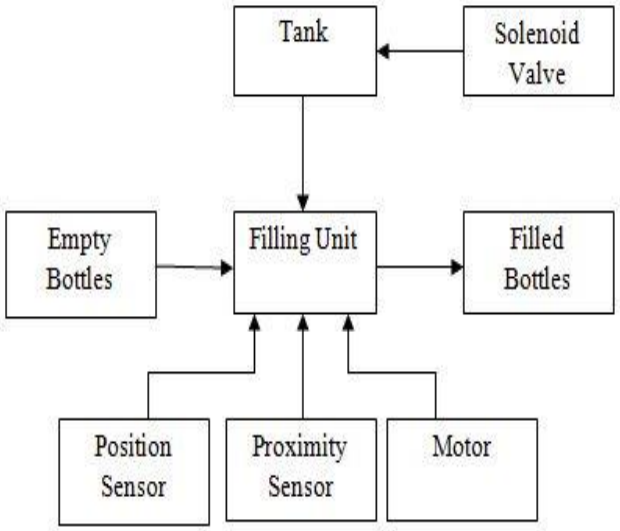

Fig.1 Automatic Filling Process

Fig.1 shows the complete process of automatic bottle filling system. The empty bottles sent in to the filling unit by the conveyor. The proximity sensor senses the bottle whereas position sensor check whether the bottle is at perfect position to fill it.
After getting signal form the proximity and position sensor the solenoid valve operate for time period that mentioned in the programming.

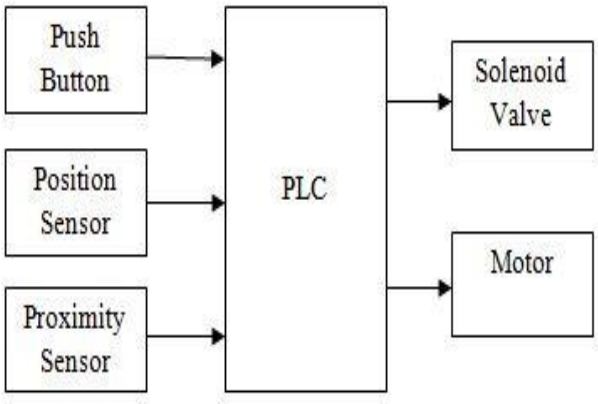

Fig.2 Automatic filling control system

Fig.2 shows the control system for automatic filling system. The functions of the each part of control system
PLC: Siemens PLC as the control centre of filling system
Sensors: It includes proximity and position sensor for detecting object and checking the position of the object.
Solenoid Valve: The valve opened for the time as given in PLC program.

METHODOLOGY

This work is a complete application of automation. The processes controlled by PLC and monitored by using SCADA. PLC and SCADA are important part of the bottle filling system. As the system controlled according to the programmed PLC and SCADA is used to monitored the process in system. This system utilizes a start/stop control of the engine when we on the switch then motor will be on. Bottles are kept over a conveyor line which will be appended with the motor. When motor will switch on then conveyor will start moving. At the point when bottle go under the tank then a sensor sense the bottle and the valve open for the particular time that set in the programming for that time the liquid filled in to the bottle. The position of the valve affects the flow rate of the valve. The filling operation depends on user characterized volume through which user can pick the volume of fluid to be filled.

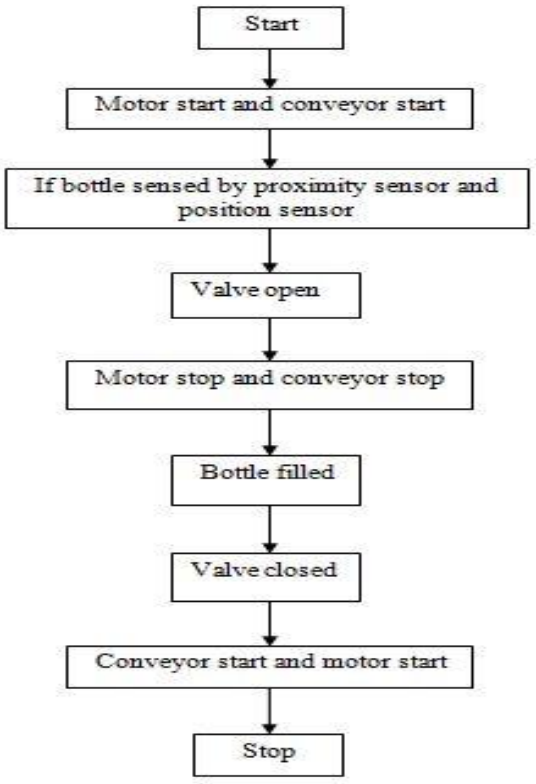

Fig 3. Process flow chart

Here a clock added in which that gave a period esteem for filling a container. Depending upon the pre-set value of the timer the valve is switched on for that specific timeframe and the filling is finished. For various pre-set value and different angle of valve with PLC and PID controller to locate the better arrangement that will increase the production rate.

SYSTEM COMPONENTS

PROGRAMMABLE LOGIC CONTROLLER (PLC)

PLC is a programmable device developed to replace mechanical relays, timers and counters. Programmable logic controllers are used in various industries for all controlling operations. The bottle filling machine is controlled by PLC with the help of ladder logic. As ladder logic is a one of the method of programming a PLC.
The ladder logic language which was developed to simplify the task of programming PLCs. PLC consist of input/output (I/O) unit, central processing unit (CPU) and memory. As 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. PLC have 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 in a plant.
A programmable logic controller (PLC) is a digital computer used for automation of industrial process such as control of machinery on factory assembly lines. The PLC is designed for multiple inputs and outputs arrangement. Program to control machine operation are typically stored in battery backed or non-volatile memory. A PLC is an example of a real time system since output result must be produced in response to input conditions within a bounded time, otherwise unintended operation will result. A PLC is device that was invented to replace the necessary sequential relay circuit for machine control.
PLC is a solid state device. They are well adapted to a range of automation task. All control operations are performed using the PLC. The entire bottling process is automated by feeding the necessary condition into the PLC using ladder logic. Ladder logic is one of the methods of programming a PLC. Thus depending on the logic developed the various operation takes place and the filling of bottles are performed. PLC is the most useful and usage controller unit in automation systems. PLC's are arguably the most important tool for control of automated production systems. PLC is powerful controller and allows monitoring and available with SCADA software. Economical life and usage, programming, design feature and design requirements that selecting PLC for a main control unit.

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)

PLC and SCADA combination gives the advantages of better control and monitoring of the Plant. SCADA system gives the complete view and interacts with the working of entire operations through graphical representation of their production process. SCADA runs on PC and is generally connected to PLC.

HMI (HUMAN MACHINE INTERFACE)

The Human Machine Interface is the interface through which the operator interact with the system. The HMI is the controller operating panel. Through HMI panel operator can check the current status of the system communicated with the operator. The user can also ON or OFF various functions from interface. The panel comprises a numeric keypad and a LCD screen that displays text.

An HMI is a software application that presents information to an operator or user about the state of a process and also the operators control instructions. An HMI is often a part of a SCADA system. The HMI was created by Siemens TIA software. Tags were used for the communication of the PLC ladder logic operation with HMI.

INPUTS

Input interface modules accept signals from the sensors. The input includes the proximity sensors, float switch, position sensor and start/stop switches. The output of all the sensors are used as input to PLC. The proximity sensor uses to detect the presence of bottle. Sensor placed before filling unit from where the empty bottles passes. The position sensor used to sense the position of bottle on a conveyor. Float switch used for the liquid tank by which the level in the tank can be maintained. Float switch output gives starting and stopping of water pump. Push button used to start and stop the cycle.

Proximity Sensor: Proximity sensor is a sensing device which sense objects nearby without any physical contact up to nominal range or sensor's vicinity. In brief we can also say that Sensors which convert information on the movement or presence of an object into an electrical signal are called proximity sensors.

Position Sensor: Position sensors are basically sensors for measuring the distance travelled by the body starting from its reference position. How far the body has moved from its reference or initial position is sensed by the position sensors and often the output is given as a fed back to the control system which takes the appropriate action.

Float Switch: Float Sensor is an electrical ON/OFF Switch, which operates automatically when liquid level goes up or down with respect to specified level. The Signal thus available from the Float Sensor can be utilized for control of a Motor Pump or an allied electrical element like Solenoid, Lamps, and Relays etc. Float Sensors contain hermetical sealed Reed Switch in the stem and a permanent Magnet in the Float. As the Float rises or falls with the level of liquid the Reed Switch is activated by Magnet in the Float.

OUTPUTS

Output interface module convert controller signals into output signals used to control the machine or any process. The PLC output is given to control the synchronous motor and solenoid valve. Synchronous motor used for the rotary conveyor on that the unfilled and filled bottles move. Flow control valve is used for the bottle filling process that valve is connected to the tank. As the flow control valve connected with controller that operate on the programming.

Solenoid Valve: It is an electronic valve used to control various types of liquid by opening and closing automatically.

A solenoid valve, otherwise known as an electrically-operated valve is an automatic valve which serves the purpose of removing the need for an engineer to operate a valve manually. Solenoids operate using an electromagnetic solenoid coil to change the state of a valve from open to closed, or vice-versa. If the solenoid valve is 'normally closed', when the coil is energized, the valve gets lifted open by the electromagnetic force produced by the coil.

MODEL DESIGN

The bottle filling machine worked and controlled under SCADA software. SCADA software is available for powerful monitoring to sending with the system status. Siemens TIA V12 including WinCC advanced being used because of S7 series PLC synchronized and worked properly with this.

In WinCC library there are many application written those programming languages which are used make a new project for industrial control. When starting the application with WinCC the application details and PLC programming output signals are determined. After that tags made for the system used with WinCC library. S7 1214 PLC CPU was communicated with PC. When uploaded the program PC to PLC CPU, WinCC control centre worked properly. WinCC started with the cycling and monitoring application on PC monitor. So WinCC is critical operation on this process.

As per the program written for this work, when the system is switched ON, starts pump to fill the liquid in to the tank and as per the level of liquid the indicators blink. When the bottle present the solenoid valve open. When the bottle is sensed by the sensor a signal is sent to the PLC which stops the drive motors and after the filling process is over the PLC again starts the drive motors to move the conveyor. This complete working is monitored on screen interfaced with the PLC. Ethernet cable is used for the interference of PLC and SCADA. SCADA screen shows all the working of the plant i.e. the whole movement of the conveyor/filling system is visible on the SCADA screen. The plant can be started from the SCADA screen as well as it can be stopped from the same screen only. Thus no waste or harm to the plant if any fault occurs.

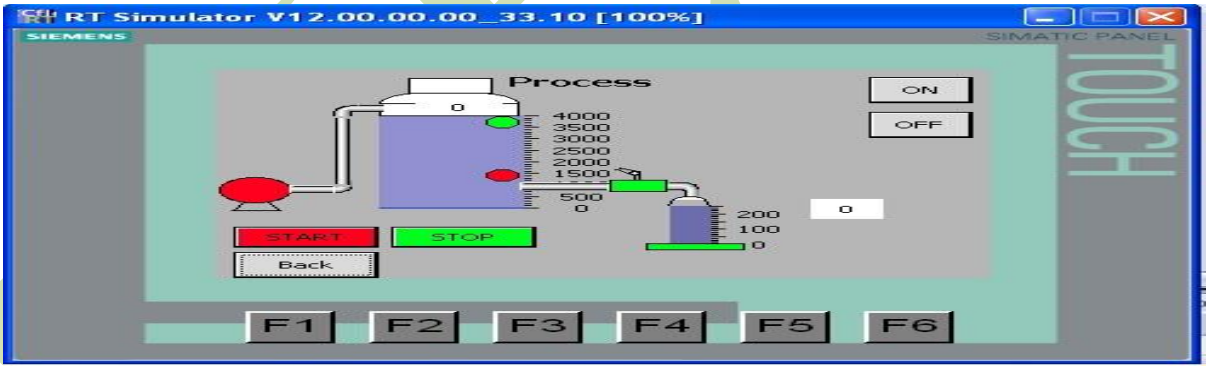

Fig 4 Pump OFF, empty tank in TIA

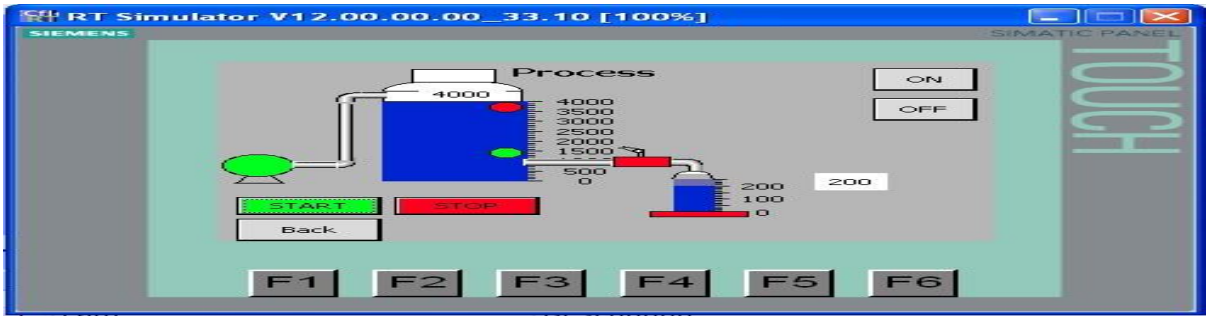

Fig 5 Pump ON tank filled completely in TIA

RESULT AND DISCUSSION

Software test: According to the working process of system the PLC programming, SCADA design and HMI panel design software TIA V12 is used. PLC programming in the form of ladder diagram. The HMI and PLC communicate with each other to control and monitored the bottle filling system.
Pump control: Control of pump to start and stop to fill the liquid tank to run complete system.
Filling process: As the empty bottle sent in to filling area the position sensor and proximity sensor confirmed the perfect position of bottle for filling. Solenoid valve open for particular time to fill required amount of liquid in bottle. After filling the bottle sent for next operation.

Table No.1 Experimental Reading

Time (sec)	Solenoid valve opening (degree)
5.5 sec	90 fully opened
6.1	65. 28
10 sec	52.12
26.5 sec	33.7

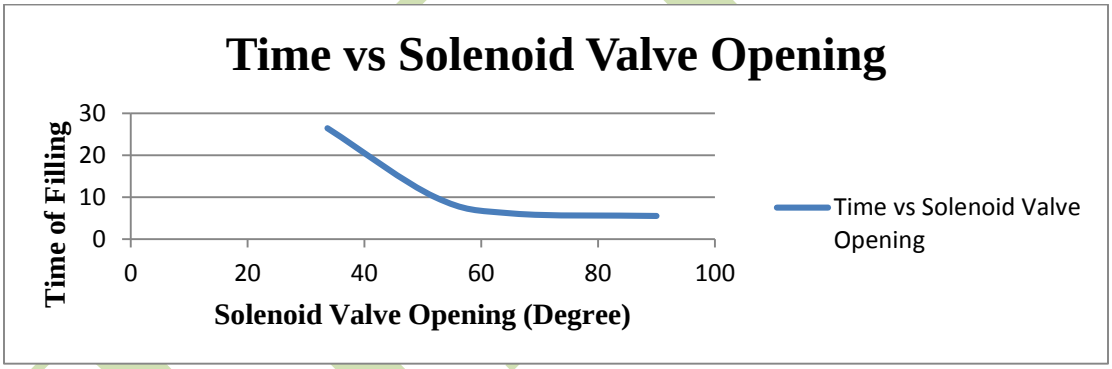

Fig 6 Time Vs Solenoid valve opening

From the fig 6.1 shows that as the solenoid valve opening increases the time required to fill 200 ml liquid in bottle decreases. As the valve angle increases the flow rate increases.
So for filling different amount of liquid in to the bottle the filling time should be constant but the flow rate will be different.

CONCLUSION

The paper presents an automatic filling system controlled by PLC as per the filling requirement which has simple operation. The system has the advantages as simple structure and reliable operation. The system controlled by PLC and controlled or monitored by SCADA also PID controller reduces the errors from the system. The additional feature in the system is the use of SCADA for monitoring the complete system and the process may be

started and stopped through SCADA screen that effectively avoiding unnecessary wastage of liquid. The programming for this system is flexible and easy. The system useful in industries like beverage, mineral water and food industries.

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