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Automatic Water / Liquid Filling System using PLC for Industrial Automation

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Abstract: ***Industries have undergone a drastic automation change over the years; working patterns of labors have changed and also led to increased efficiency in terms of increase in production output, decreased need of laborers, increase in rate of production etc. Industrial automation has also led to the changing work pattern and the work earlier done by labors is now done by automated machines and at a speed far greater than that of humans. The quality control team regularly monitors the output efficiency and takes measures to constantly maintain and increase the quality of production. Automation although provides many benefits but comes with a heavy price of installation of machines and change in infrastructure. There are many industries that needs the task to be automated for maintaining hygienic conditions generally these tend to be food and beverage industries, where involvement of humans in packaging section can also lead to transmission of diseases if a person is infected. Small scale industries or small startup companies do not have huge investment capital hence automation is not a feasible option until a economically feasible and affordable option is developed. The implemented project is designed for a small scale industry dealing in mineral water production and beverage production. The design is a liquid filling system for bottles which makes use of an economically feasible design and conveyor belt assembly. PLC is used to design and implement this system which has increased the efficiency of this unit by manifolds. The human machine interface allows for smooth operation of the unit where the problem of liquid spilling and wastage of liquids is removed.***

Keywords: PLC, automation, beverage manufacturing and packaging, HMI

I. INTRODUCTION

Automation of tasks that are based on core software base is economically feasible as it only changes the working pattern and not the hardware infrastructure. But whenever an industry needs automation it has to first look for investment capital which is a huge amount and also changes in infrastructure according to machine design has to be considered. These high investment costs are recovered in a specified duration by increased production, replacement of human labors etc. small scale industries or startup brands do not have large investment capital and also the initial profits are low hence maintaining labor on monthly wages is the only option left. There are certain safety standards prescribed for production and manufacturing units of food industries which also involve certain hygiene standards to be maintained by the working staff. The implemented system is designed using the PLC to make an economical and feasible automation of water/ liquid filling system for bottles. The main design considerations were related to the spilling of liquid, measurement of exact quantity to be filled, filling the main tank system with liquid once it is over. Also the need to monitor and stop the conveyor belt assembly if the overhead liquid tank is empty and make sure it is refilled again quickly. The designed system makes use of sensor which helps to detect bottles on the conveyor belt assembly and also stop the conveyor belt once the bottle is detected and to fill it with a specified quantity. The system design also ensures that in case there is an emergency situation or a failure in working mechanism, an option to control the system manually has been made available. According to the users basic knowledge, switches are also provided and the user feasibility is kept in mind to ensure this system can be used by any normally appointed supervisor staff also.

II. LITERATURE SURVEY

In the past there have been many attempts made to design automation tasks that require less capital investment and is feasible for the use of small scale industries like use of DTMF based systems for automating the task according to requirements, use of GSM based systems to automate each task according to the users commands, preprogrammed controllers for performing specified tasks.

The main problems associated with the Dtmf based systems is it requires auto call response system to be activated and it doesn't provide current status of the system also it can only perform one task at a time.[1] GSM based systems are dependent on the users commands for turning on/ off and it can provide the status of operation being performed, but this again comes with the limitation of being confined for certain tasks only [2]. Another option proposed by man authors is the use of controllers which are preprogrammed and to make its full utility in industrial grade operations, use of PLC is suggested.

III. METHODOLOGY

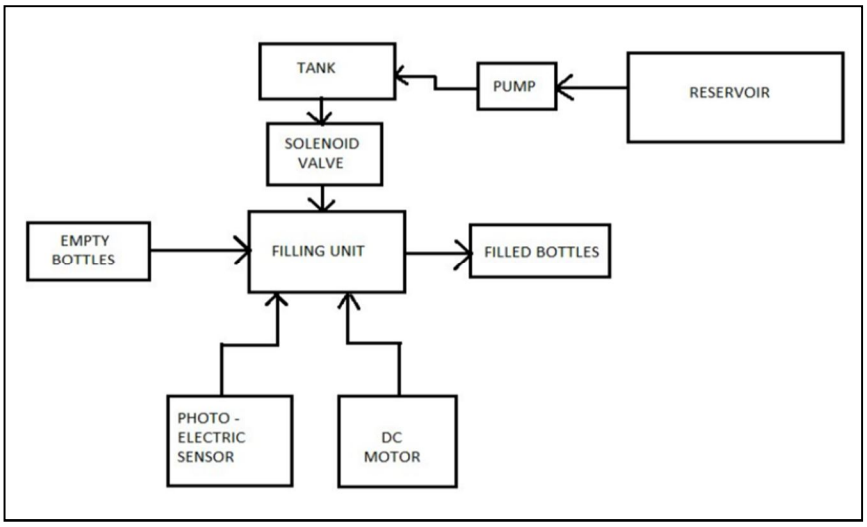

Fig i. block diagram of PLC based bottle filling system

The above figure shows the basic block diagram of the proposed system. It includes the reservoir which has stored unit of liquid or beverages which has to be filled in the bottles. It is first transferred to a tank which is fitted with solenoid valve; it will allow the liquid to flow in bottles as soon as it is detected on the conveyor belt. The detection of bottles is necessary hence a photoelectric sensor is used.

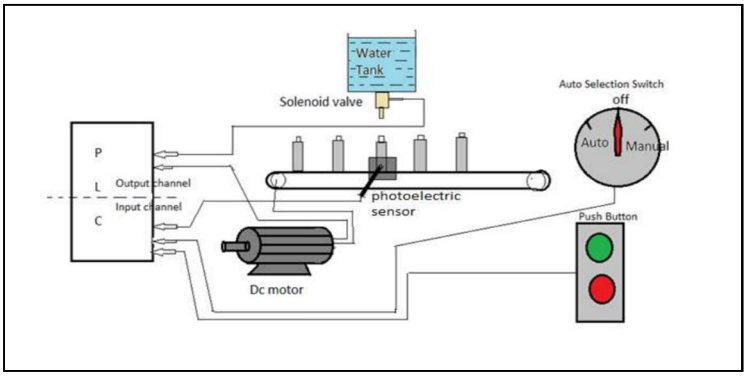

Fig ii Schematic diagram of proposed system

A. Components used in Implemented Design

1) PLC (programmable logic controller): It is an industrial grade controller with high functioning capacity and specifically used for input output and control applications which deal with high speed, current and voltage requirements of machines. It supports different styles of programming. In this project we have preferred the graphical programming style which is ladder design programming. Siemens software is used for programming and GUI design which will help to monitor the operational working of the system also in online mode.

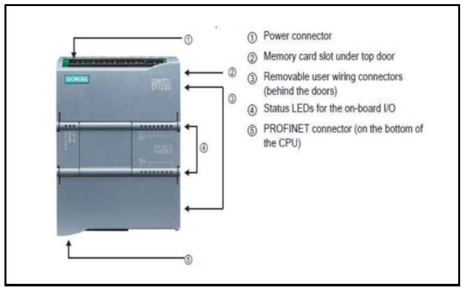

Fig iii: PLC

2) *Conveyor belt Assembly:* Conveyor belts are widely used in industrial operations for transfer of products over assembly line without the need of manual intervention.

Fig IV: conveyor belt assembly

The conveyor belt is driven by high torque DC motor which will help to drive the assembly and also it will be easily controlled by controller signals for turning on/ off once it is detected and filled

3) *Photoelectric Sensor:* It is used for detection of bottles on assembly line; it detects presence and absence of objects using light transmission process and provides the output signal to the PLC.

Fig V. sensor for detection of bottles

4) *Solenoid Valve:* The liquid filled in tank should be allowed to flow in the bottles once it is detected on the assembly line, the solenoid valves are used in industrial applications for allowing and stopping the flow of liquids.

Fig V: Solenoid valve

The controller sends the signals to turn on / off for the solenoid valves and hence it is controlled accordingly.

5) *Toggle switches:* Switches should be made available for turning on/off the systems as well as it should be used wherever manual operation is provided. Industrial grade toggle switches are durable for long term use and also add to the comfort of user accessibility.

Fig VI: implemented design with switches

6) *Pump for Water Tank:* The production and packaging is done in batches and for each drink different temperature and humidity requirements have to be considered hence the main quantity of raw material or liquid is stored in tanks is known as reservoirs and liquid is then transferred to the tanks from reservoir as soon as the level in the tank drops. To keep a check on the level a float switch is used which monitors the level and if it's below a specified level then conveyor belt assembly is stopped till it is refilled again, this helps to remove the fault of empty bottles moving in the assembly lines

7) *SMPS (Switch mode power supply):* A 12v and 24v SMPS was utilized in this designed system to maintain voltage regulation and efficiency. All the components in industries need to be protected against the faults hence SMPS is a very crucial component in terms of power supply

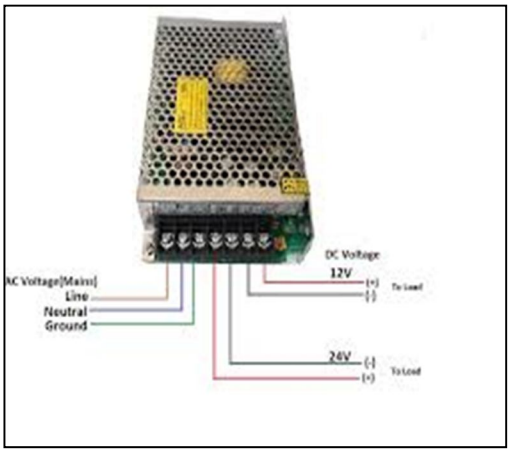

Fig VII: SMPS

IV. SOFTWARE IMPLEMENTATION

A. Flowchart

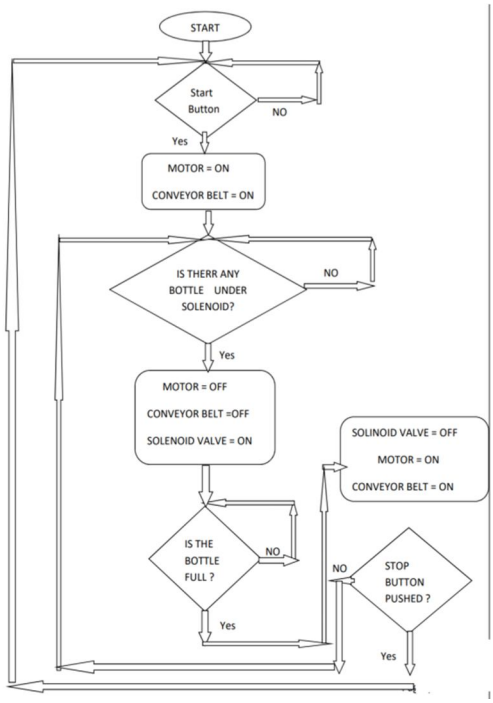

Fig VIII: flowchart

B. Algorithm

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 bottle which is in position with the solenoid valve, then the conveyor will stop.
STEP 4	:	If the sensor does not detects any presence of the bottle, the conveyor keeps on moving.
STEP 5	:	After some delay the valve turn "ON" and the bottle will get filled till the timer gets off.
STEP 6	:	After the bottle is filler , a d3elay is provide and then after the delay the motor starts running.
STEP 7	:	And the process respects itself repeats itself from step 3

Table I. Algorithm for programming logic

C. Working

Initially system is turned on and the float switch first checks if the tank is full or not, if it is not filled; the pump is switched on and liquid from reservoir is pumped in. if liquid is already filled, the conveyor assembly turns on and bottles are placed on the conveyor belt as soon as bottles is detected by sensor, it will stop the movement of conveyor belt and solenoid valve connected to tank will allow the liquid to be filled in the bottle. Once it is filled with desired quantity, solenoid valve turns off and conveyor assembly is switched on again and the process is repeated.

D. Implemented Ladder Design

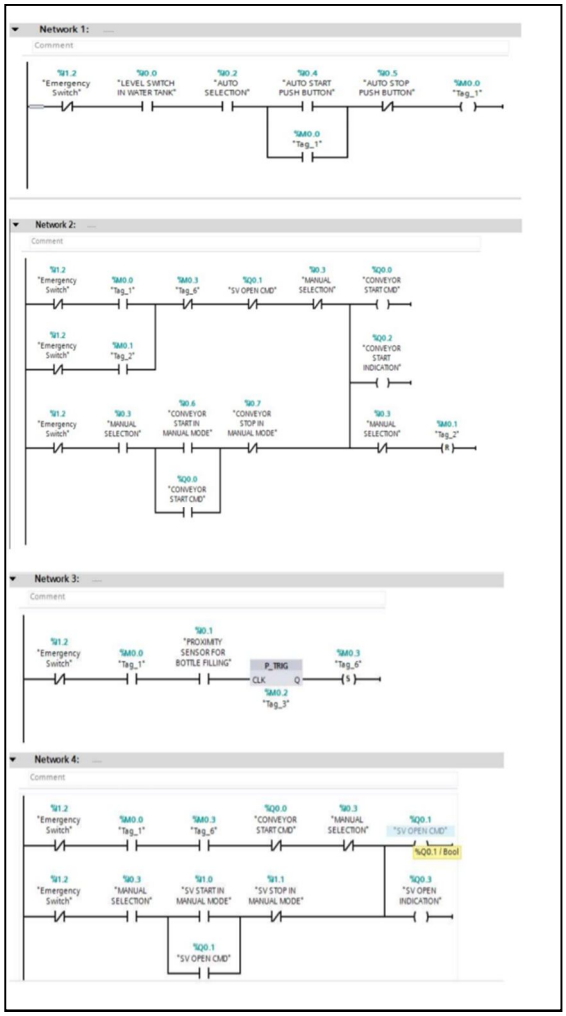

Fig ix: Implemented ladder design

V. RESULTS AND CONCLUSION

The implementation of automation of a cost effective water / liquid filing system for bottles using PLC for a small scale industry was done. The cost constraints, space saving options were considered to cater to the user acceptability and keeping in mind the economic and technological feasibility of this designed model, we can conclude that it is not necessary to automate the whole industry rather some tasks which are production oriented can be automated which will save time and money. PLC based automation is a cost effective and efficient design model for use in various industries by simply modifying the standard parameters according to the needs of different industries.

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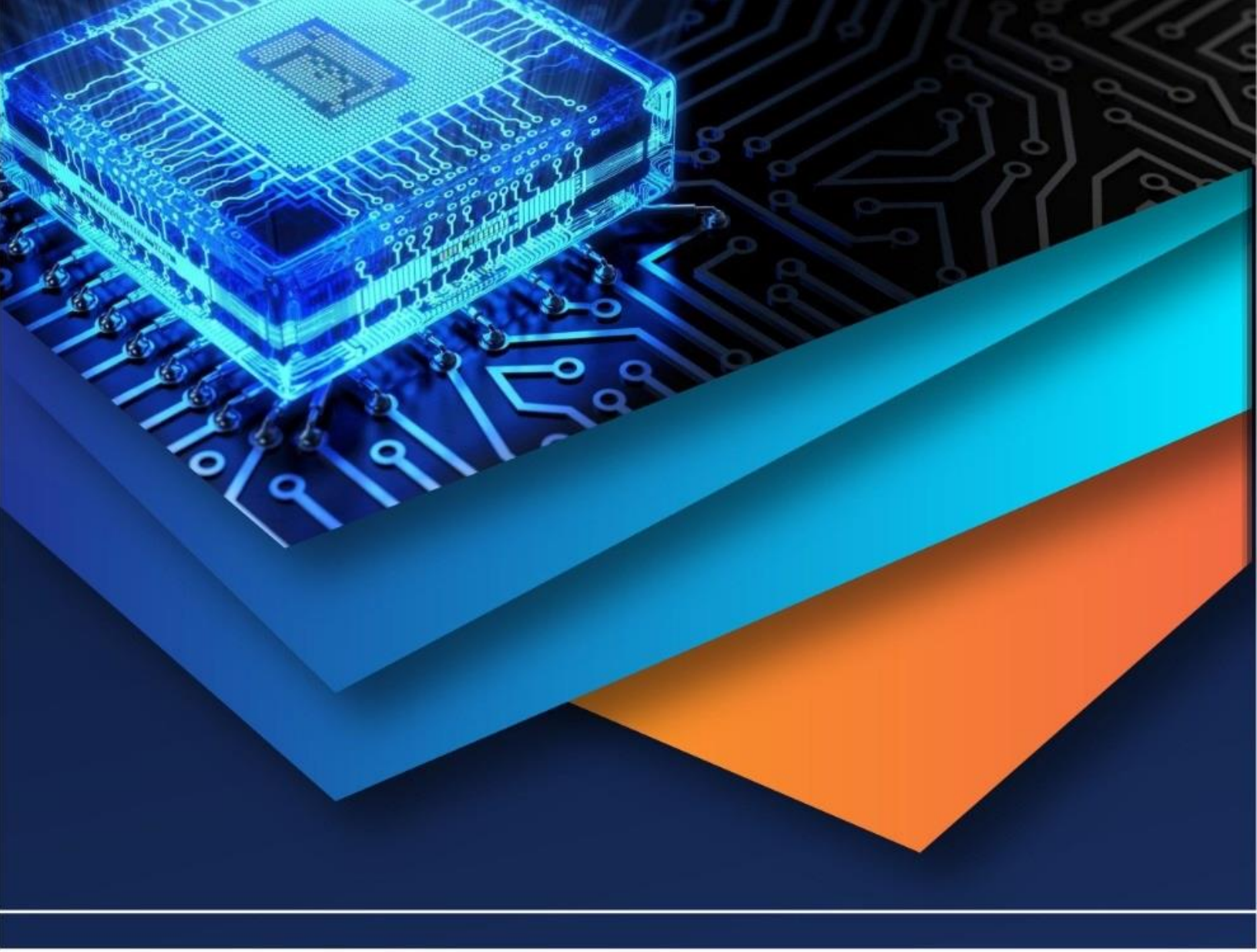

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