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Automatic beverage making process

(PLC & SCADA)

Prof. Pamale Vidya
(*Guide*)
Dept. of Instrumentation engineering
Vidyavardhini's college of engineering and technology
Mumbai, India.
vidya.patil@vcet.edu.in

Shivankar Surabhi
(*Author*)
Dept. of Instrumentation engineering
Vidyavardhini's college of engineering and technology
Mumbai, India.
surabhi.p.shivankar@gmail.com

Pal Rohit
(*Author*)
Dept. of Instrumentation engineering
Vidyavardhini's college of engineering and technology
Mumbai, India.
rohitpal59000@gmai.com

Patil Viraj
(*Author*)
Dept. of Instrumentation engineering
Vidyavardhini's college of engineering and technology
Mumbai, India.
patilvirajvijay.vp@gmail.com

Yadav Kuldeep
(Author)
Dept. of Instrumentation engineering
Vidyavardhini's college of engineering and technology
Mumbai, India.
Kkyadav6538@gmail.com

Abstract— **In India, small scale and mid-cap beverage industries play a vital role in "robust growth trajectory". With the growing industrialization, automatic machines play a crucial role in attaintment of immediate needs of the society. In a challenge to the competitive industrial world, a system has to be flexible, efficient as well as cost-effective; automation in machines being very much essential. Automation being versatile, it brings gradual development in almost every field. New beverages are increasing day by day in the market, so this project provides a method of manufacturing beverage drinks in an approach by the implementation of automation using PLC and SCADA enabling beverage preparation, filling and packaging. The objective of this project is to motivate small scale beverage industries to use automation in a beverage process plant. This project implementation has uniquely shown low power consumption, low operating cost, no human efforts, high accuracy and precision along with the flexibility to the system. Thus, the complete-process offers execution of beverage manufacturing using the principle of batch process that will help a company streamline operations, maximize profits by bringing products to market at an affordable cost.**

Keywords— PLC, SCADA, Automation, Conveyor, Sensors, Valves.

I. INTRODUCTION

Industrial Automation is utilizing Control Systems to control Industrial Machinery and Processes with reduced human intervention. The beverage industry is surpassing the global market. This project is to design and develop a sophisticated approach for manufacturing beverage using PLC & SCADA. As an introduction to automation, the prototype depicts a commercial beverage preparation and a filling unit which is controlled using a programmable logic controller (PLC) and the whole process is monitored using supervisory control and data acquisition (SCADA) also projecting an animation which after packaging is served as a finished product on a conveyor belt. The plant involves several operations running simultaneously with the help of PLC[2]. Firstly, the process begins with a user input for selection of flavour (Lime or Orange) with the feed pump simultaneously pumping the ingredients to the process ingredient tank from the reservoir. Secondly, the liquid concentrate of the chosen flavour is mixed with the solution in the mixing tank forming the desired drink. Lastly, it fills the containers with the beverage drink and then moves to the packaging unit by a conveyor which it operates on a conveyor motor. Entirely, these automated processes leads to more accuracy with the additional flexibility of the system. By designing this system, we intend to provide an HMI Interface for the hardware such that, it will provide features Batch Management Software (BMS) with SCADA giving a real-time analysis of each process taking place providing data of each process undertaken throughout.

II. LITERATURE REVIEW

In the 1960s, beverage- production was through machinery that enabled the running of 150 bottles per minute. As productivity increases with the demand, the beverage drink manufacturer began to orient towards new and quick production technology.

Mechanism for filling lines were developed that allowed running of 1,200 containers effectively per min at a minimal downtime for flavour change, in turn, maximising profits. In 1970, sugar substitutes were introduced such as aspartame and NutraSweet.[4] In the period from the 1980s and 1990s, beverage drinks were most commonly used in combination along with flavours as it did not provide the desired mouth-feel and after-taste of sugar.

A beverage depends on the flavour of a drink by balancing the sweetness, tartness and freshness of flavours added in turn giving it a background taste thus, soothing the thirst-quenching experience by stimulating saliva flow naturally.[5] Addition of additives enhance the taste, mouth-feel, aroma, and appearance of beverages making it eye-appealing. An endless range of flavours available may be natural, chemical, synthetic or artificial often consist of water based elements which are easy to use. [5]

- INDUSTRIAL MANUFACTURING -

  Beverage drinks are manufactured locally at bottling and canning companies with brand name franchise companies which grant licenses to bottlers allowing to mix the drinks in strict accordance with their secret formula requirement. Fig.2.1. shows an industrial manufacturing process.

1. Cleaning the water

   The quality of water is of utmost importance in a beverage. The traditional process of a series of coagulation, filtration, and chlorination removes impurities, suspended particles, organic matter, and bacteria, may degrade taste and colour. Coagulation is the involvement of floc into the water to absorb suspended particles. Standardization of water is done with a desired pH level.

2. Processing the water

   Filtering: Process to remove fine particles of floc, the clarified water is poured through a sand filter.

   Sterilization: Process to destroy bacteria and organic compounds that might spoil the water's taste it is pumped into a storage tank and is dosed with a small amount of free chlorine.[3] The tank is not disturbed until the reaction is complete.

   Dechlorination: An activated carbon filter is used to remove residual organic matter with a vacuum pump de-aerates the water before it passes into a dosing station.

3. Mixing the ingredients

   A predetermined sequence pumps the dissolved flavour concentrates into the dosing station according to their compatibility. The ingredients are carefully mixed when conveyed into batch tanks were in, too much agitation can cause unwanted aeration. The syrup may be sterilized while in the tanks while fruit based syrups must be pasteurized. Proportioners sophistically combine water and syrup which regulate the flow rates and ratios of the liquids.

4. Filling and packaging

   The final liquid product substitute is poured into containers which are consequently sealed with pressure-resistant closures, tinplate of metal, twist offs or pull tabs as needed. Before labelling, beverages must be brought to room temperature to prevent condensation because the beverage drinks are cooled during the manufacturing process. It is easy to do the process by spraying the containers with warm water and drying them wherein, the cans are pre-printed with product information and then send to the filling stage. Finally, containers are packed into trays followed by shipping in larger crates to distributors.

Advancement -

In the 1990s with the hype of 450 types of beverage drinks available in the market new flavours has developed to meet market demands. Advancement in technology not only increases the production rate but also with safer methods enable most desired outcomes leading to the achievement of greater efficiency at all stages. A positive impact on trends in beverage drink industry with newer technology and procedural methods of water clarification, sterilization, and pasteurization will result in improvement of production and minimize the need for preservatives in mere future to nullify the concerns with consumer health, safety, and the environment.

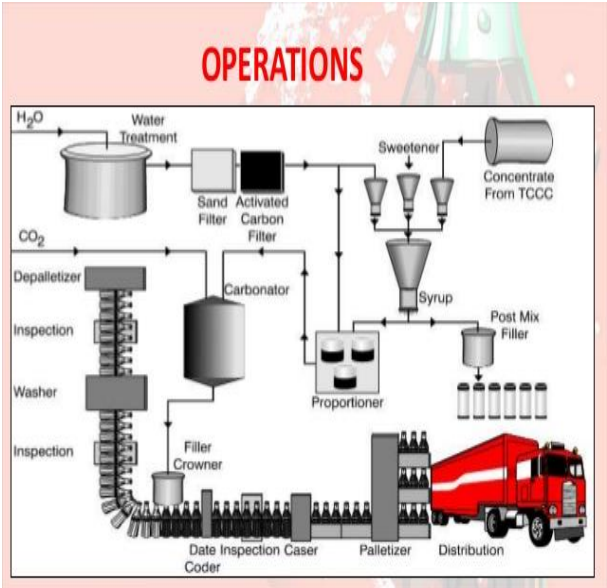

Fig.2.1.Industrial manufacturing process

III. CONCEPT MODELLING

A. Precept

- BATCH PROCESS
  It is a manufacturing process where products are finite and have homogenous masses[6]. Here, product to be manufactured is created stage by stage to increase speed and production with accuracy.

B. Design & Development

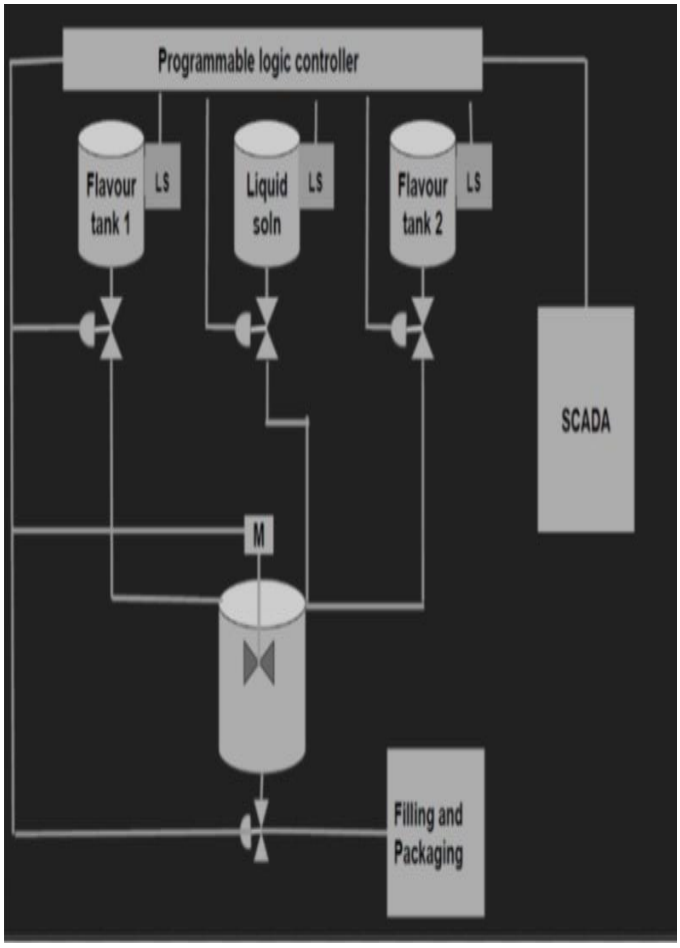

Fig3.1.Block diagram

The proposed system block functions –
Pump & control valve - filling
Motor - Mixing and operating conveyor
Level float switch- maintain levels of mixing and flavour tanks.

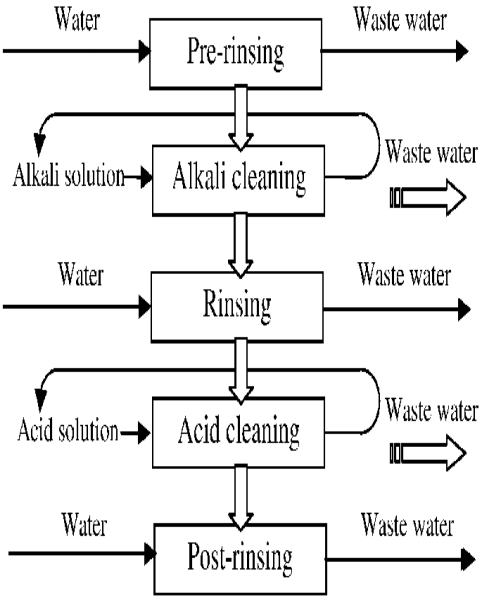

Fig3.2.CIP process

- DEMONSTRATION

PLC & SCADA is the heart of this system.
Fig3.1 shows the block diagram of the process.

1. The process starts with the input from the operator i.e by selecting the start button and then by choice of the flavour of beverage (Lime or Orange).
2. After selecting flavour, the valve of the reservoir tank opens and fills the solution into the mixing tank.
3. The valve of the chosen flavour tank opens and the flavour solution is added into the mixing tank.
4. Based on timer instructions, the stirrer in the mixing tank rotates and mixes the solution with the flavour.
5. As the process of filling starts, the container placed on the conveyor is detected when in front of the filling pump by a capacitive proximity sensor.
6. Once the bottle is detected, the conveyor stops and the filling pump starts to fill the bottle based on timer instructions
7. Once the filling is done, the container is moved to a packaging station via conveyor.
8. At the packaging station, the preheated lids are placed on the bottle through a double-acting cylinder.
9. At the end of each batch, cleaning is done by the CIP method as shown in fig3.2.

IV. CONTROL PHILOSOPHY

A. *Programmable logic controller (PLC) -*

The programmable controller operates where the input/output (I/O) system is physically connected to the field devices of the process. Limit switches, pressure transducers, pushbuttons, motor or solenoids are field devices that can be discrete or analogue I/O devices.[2] The I/O interfaces connect the CPU with the information providers and controllable devices.

While operating, the CPU completes three processes- Initially, it reads the input data from the field devices via the input interfaces, thus executing, the control program stored in the memory system and later updates the output devices via the output interfaces.[2][5].This entire process of sequentially reading the inputs, executing the program in memory, and updating the outputs is known as scanning

- PLC & related software
  Here, PLC Allen Bradley MicroLogix1000 Analog. The software to program this PLC is RSLOGIX500 of version-7.30.10(CPR9).
  Allen Bradley MicroLogix1000 Analog model of PLC consists of 11 inputs and 8 outputs.
  MicroLogix1000 micro-PLC can handle a wide variety of big-time applications at 32 I/O or less which is a compact full-size controller.
  Communication is done through RS-232 channel allowing connectivity with personal computer enables program uploading, downloading as well as monitoring using multiple protocols, including DF1 Full-Duplex.

B. *Communication & Monitoring*

- Modern SCADA system –
  SCADA stands for Supervisory Control and Data Acquisition. As the name suggests, it rather focuses on the supervisory level[2]. The software is positioned on top of hardware to which it is interfaced, usually with PLC. The information collected is passed by SCADA, transferring it back to the central site and carry out analysis to control and then display that information on operator screens. The control actions required are then conveyed back to the process.

C. *Demonstration using SCADA –*

This work represents a complete application of automation. The system is controlled according to the programmed PLC and parameters are monitored using SCADA. Fig4.1 shows the SCADA view of the whole process.

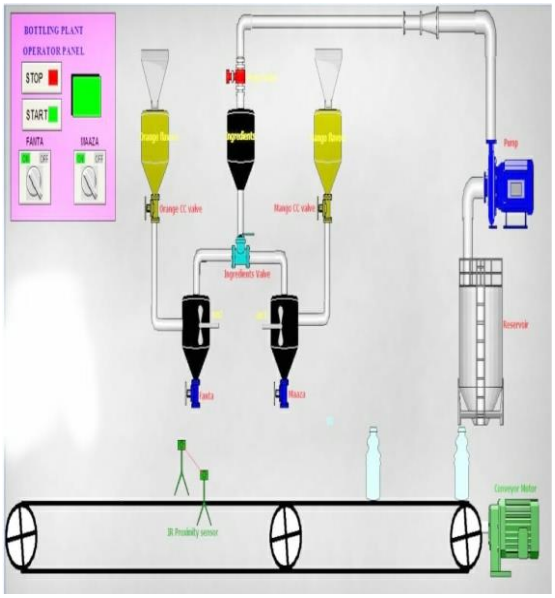

Fig. 4.1.Process monitoring SCADA screen

Fig.4.1 shows monitoring process of a uniquely design for the preparation of beverage-drinks using purified water, flavour powder, liquid concentrate.[2] In the process when we switch ON (START) then the liquid concentrate starts to fill its respective tank. The pumps help to fill the water tank from the reservoir. By the automatic opening of the water valve, the water pass to the two mixing tank for a given time which was already programmed as per the tank volume and our requirement. The valve of beverage tank opens leading the concentrated liquid for the beverages to pass to their respective mixing tanks for a given amount of time. The ratio of two different liquids will be decided as per the required mixed liquid that we needed in the container. A timer is set to the programmed for the valves opening and closing as per the volume of the tank. A stirrer motor is fitted to mix the liquids in the mixing tank when the mixing of the water and the concentrated liquid completed then the stirrer motor stop. Then in the next process, the conveyor motor starts and the filling containers come right below to the outlet valve of the desired flavour tank valve.[5] The position of the container is detected at the exert point by a Proximity sensor at that time conveyor motor stops and the filling process starts for a given amount of time. Later, filling stops and conveyor motor starts allowing the container to go to the packaging unit by a conveyor belt. All valves controlled by timers in the program. This process continues till mixing tank is empty until the batch is complete to undergo CIP. Then the whole process starts again.

V. LADDER LOGIC

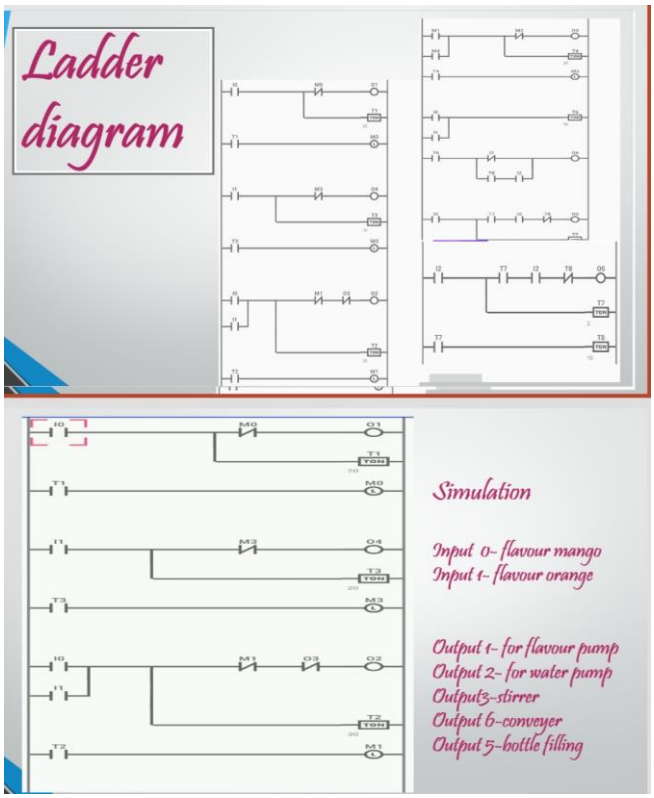

Fig.5.1.Ladder diagram

- LADDER EXPLANATION

In a bottling plant, there are two sections - Filling and packaging.
For the operation of the plant, there will be 2 buttons. The two buttons represent the START and STOP.
The START button will start the whole system and the STOP button will stop the entire system. Initially, the flavour pump and solution pump turns ON for a fraction of seconds and then switch OFF to turn ON the stirrer motor the conveyor belt. All the valves are timer operated valves. The proximity sensor will sense the container as it passes on the conveyer belt and holds the conveyor for seconds to complete the process of filling which future resumes onto the packaging unit completing a batch process.

CONCLUSION

This project allows small scale beverage preparation and bottling plants to introduce automation with PLC and SCADA with least human interaction and utmost accuracy and precision. Also, the system has been proved working without wastage or spilling out of the liquid. The setup for an automated plant using PLC and SCADA involves high initial cost but it offers myriad advantages that overcome this cost. It leads to a high production rate, using minimum men power, saving the operational time of the plant. An additional feature of the proposed system is the use of SCADA that enables control and monitors the system even through a remote location. Hence, with this concept error detection is possible.
In mere future, this advanced technology will lead to greater efficiency of beverage production at all stages.

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