2020 IEEE International Conference for Innovation in Technology (INOCON)
Bengaluru, India. Nov 6-8, 2020

PLC and SCADA based Industrial Automated System

Basant Tomar
Department of Electrical Engineering
Delhi Technological University
Delhi-110042, India
basanttomar18@gmail.com

Narendra Kumar
Department of Electrical Engineering
Delhi Technological University
Delhi-110042, India
ndeshwalus@gmail.com

***Abstract*— In every process industry, there is a repetition of the tasks. So, in order to get the better productivity in limited time with lesser error probability, we are incorporating Automation into the process industries. In recent trends of automation like Industry 4.0, manual operations are being replaced with fully or semi auto-controlled, reconfigurable operations by incorporating more advanced technologies. Primitive methods of filling of different types of liquids in a fixed proportion in different containers or bottles involve manual operations. This hampers production rate and sometimes quality of product consistency due to the involvement of human intervention. In this paper, a simulated prototype of SCADA (Supervisory Control and Data Acquisition) and PLC (Programmable Logic Controller) based process of bottle filling in beverage industry is designed to fill the different types of containers with different composition of liquids. The entire simulated operation involves distinct stages of sorting the containers, filling liquids, capping, labelling of different containers and counting the units per batch. The Metallic base and Non-Metallic bottles are sorted by assistance of Inductive Proximity Sensor. During filling stage, the Metallic base bottle is filled with each of the available three different liquids composition equally and the Non-Metallic bottle is filled only with two initial type of liquids composition. In later stages, bottles are labelled separately. Both type of bottles are detected with the help of Photo-electric Retro-reflective type sensors at Filling, Capping and Labelling stages.**

Keywords*— Industry 4.0, Automated Process, PLC (Programmable Logic Controller), Variable Frequency Drive, SCADA (Supervisory Control and Data Acquisition), IPR (Inductive Proximity sensor).

I. INTRODUCTION

Automation entail controlling of any operation with very little or no human intervention. This is the main reason that industries are opting for automated processes which provide flexible and cost-effective operations with competitiveness and efficiency. Traditionally, the industrial processes were conventional and mainly operated manually which made them time consuming and not so cost effective. But with the admittance of automation into industries, all such concerns were rectified. Automation also curtails the probable errors, reoccurring in operations which ultimately results in conservation of energy and resources.

Industry 4.0, the latest scenario in automation, has been developed to offer various leverages like decentralization of process, virtualization, interoperability, real-time data acquisition etc. there is not a unique way of describing or defining Industry 4.0 [1]. It may be perceived as a comprehensive way of combining complex machineries, sensors, actuators and software interlinked in a network for predicting, organizing and utilizing the control outcomes for business processes.

The purpose here is to visualize an automated process industry bottle filling operation in SCADA system and regulation of total operation is carried out by the assistance of PLC. In this operation, an OMRON (NX1P2-9024DT1) PLC is used and ladder logic is developed in OMRON's Sysmac Studio Programming Software. The visualization of the operation is implemented in Wonderware Intouch SCADA software.

PLCs are majorly used in automated process control systems for being simple, easily programmable, less time consuming as compared to implement replace hundreds of hard-wired controllers like relays, timers etc. [2]-[4] and handle multiple inputs and outputs; immune to electrical noises and also provide resistance against vibrations and impacts.

The entire paper is organized into four sections which includes Introduction; Prototype of Automated Beverage Industry Operation; Operation followed by Results and Discussions.

II. PROTOTYPE OF AUTOMATED BAVEREGE INDUSTRY OPERATION

Almost in every beverage industry, filling of different liquids process is the most commonly practiced [5]-[7]. All industries concerned with beverages are designed in order to keep drinks of different material compositions into different container types. The whole container filling and processing is partitioned into following different stages

- Sortation stage: The containers or bottles that are moving over the conveyor belt will be sorted as Metallic base container & Non-Metallic container. The sorting is carried out by the assistance of (IPR) Inductive proximity IME08 sensor. This sensor is capable to sense the metallic things only and ignore all other material type like non-metallic container
- Liquid filling stage: Filling of containers with different materials compositions. Metallic base containers will be having three liquids composition with 33% each but the Non-Metallic containers will be having only two liquid compositions with 33% each. Photo-electric Retro reflective sensor will be used in this stage along with valves.
- Capping Stage: As soon as filling of containers is completed, capping work unit will come into picture to apply caps and tightens them over filled one

978-1-7281-9744-9/20/$31.00 ©2020 IEEE

container. Here also Photo-electric retro reflective sensor will be used.

- Labelling Stage: Caping of the containers is followed by the labelling work unit. For differentiating containers, we will be using labels of different colors for particular container type. Here also Photo-electric retro reflective sensor will be used for detecting container.
- Counting Stage: Counting process of metallic and non- metallic containers at the end in each and every case.

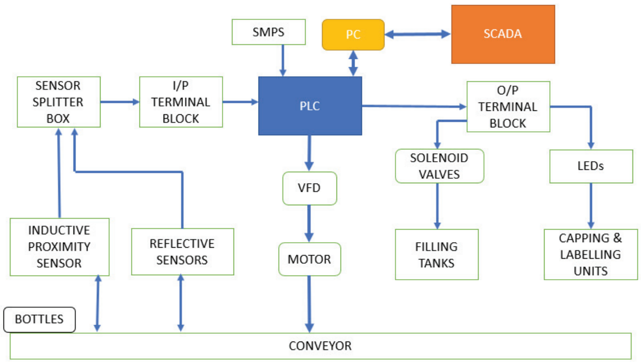


Fig. 1. Framework

The communication between SCADA & PLC is via PC through wired or wireless media. The PLC needs regulated power supply of 24V DC to perform its functions. SMPS (switched mode power supply) provide this required voltage to PLC.

Programmable Logic Controller is the center of the entire process. Input data or signals from input devices like sensors is feed into PLC, input sensor's information is processed, logical operations will be performed over inputs and a desired response is provided for the output connected devices at the output terminal block such as solenoid valves to filling tanks, LEDs to cap & label units, VFD to motor to conveyor belt. Conveyor system motion is governed by a DC motor, which get driven by Drive in order to provide precise and accuracy in motion. Both type of Containers will be sensed by Inductive Proximity sensor IPR and Photo-electric Retro-reflective sensors present over the conveyor. Both type of sensors are linked with a box called sensor splitter, which indicates the status of all sensors. Then infeed signal reaches the PLC input ports or terminals. Output devices are linked with PLC via output ports or terminals. Different type of liquid is poured into both type of containers through valves connected to the filling tanks. Labelling & Capping Units are also controlled with Reflective sensors signal conditioning to the PLC

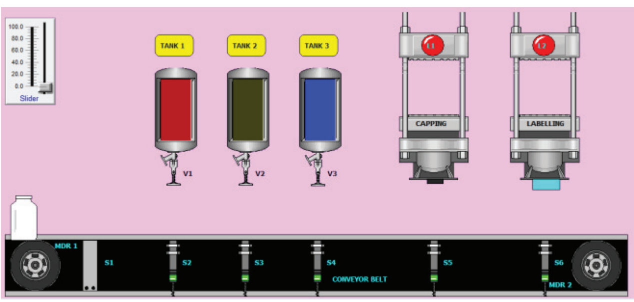


Fig. 2. Process Model in SCADA Wonderware Intouch software

TABLE I. COMPONENTS INVOLVED IN THE OPERATION

Input Components	Output Components	Additional Components
One Inductive Proximity Sensor (S1); Five Photo-electric Retro-reflective type sensors (S2-S6)	Three Valves (V1-V3); Conveyor belt motor; Two LEDS (L1, L2) for capping process unit and labelling process unit.	One PLC unit; Conveyor system; Two motor dependent or driven rollers; Three Tanks for different liquid types; Units for capping Unit for labelling

III. OPERATION

The whole system operation is demonstrated with the help of flow charts discussed below:

In this flow chart functioning of the conveyor belt motor is depicted. Accuracy in the dynamics of the conveyor belt is one of the keenest factors of this operation. The conveyor belt mobility is governed or we can say totally influenced by input signals sent by the sensors (IR sensors and reflective sensors) and output signal send by the Drive. Inductive Proximity Sensor (IPR S1) does not directly influence the stopping and motion of the conveyor belt but whenever either of five Photoelectric Retro Reflective type sensors (S2, S3, S4, S5, S6) senses any of the bottles, metallic base or non-metallic then the conveyor belt motor stops its motion and resumed after a fixed time interval when either of the processes (bottle filling, capping of bottles and labelling of the bottles) is finally done.

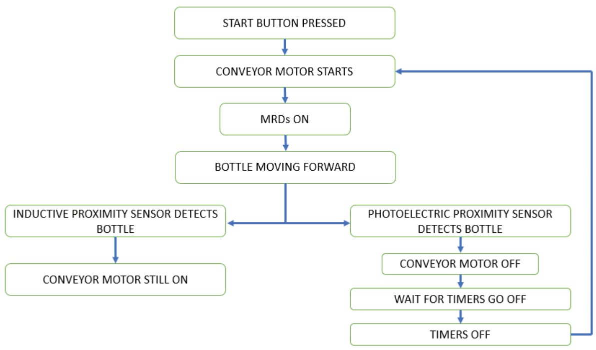


Fig. 3. Conveyor Belt Functioning

In this second flow chart, the entire operation of sorting of containers and filling of each type of containers is depicted. When any type of container is moving on the conveyor belt, then Inductive proximity sensor (IPR S1) will decide the type of the container, whether it is metallic or non-metallic. If the presence of metallic container is there, then the Inductive PR Sensor S1 turns green, else there will be no change in PR sensor in case of non-metallic container. After that, both type of containers moves further and in later stage, they are detected by the Photoelectric retro- reflective type sensor (S2), which results into the opening of solenoid valve (V1) and as a result of this the tank1 starts filling the liquid into the container and this task lasts till the 33% or approximately one-third of the container gets filled. Then timer of the tank1 goes OFF and the motion of the conveyor belt starts again and continues till the next upcoming Photoelectric retro-reflective type sensor (S3) detects the container, which results into the opening of solenoid valve (V2) and as a result of this the tank2 starts filling the liquid into the container and this task lasts till the 66% or approximately two-third of the container gets filled. Then timer of the tank2 goes OFF and motion of the conveyor belt starts again and continues till the next upcoming Photoelectric retro-reflective type sensor (S4) detects the container, which results into the opening of solenoid valve (V3) and as a result of this the tank3 starts filling the liquid into the container and this task lasts till the 99% or approximately full container gets filled. But if the container that was not detected by the IPR S1 then as a action of that the solenoid valve (V3) will not open and as a result the tank 3 will not fill the non-metallic container in this scenario. As a consequence of this, the non-metallic container will be filled by 66% or two-third of the liquid in the entire process.

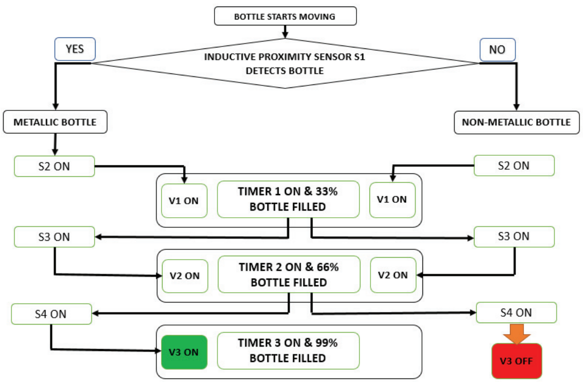


Fig. 4. Sorting and Filling

Next flow chart shows the process of capping of the containers along with the process of labelling of the containers. When Photoelectric retro-reflective sensor (S5) detects any type of the containers then the LED L1 of the unit of capping turns green and capping initiated to put the cap over the containers. During this entire process the conveyor belt motion is stopped. And after the competition of the process the motor resumes again. Now when Photoelectric retro-reflective sensor (S6) detects any type of the containers then the LED L2 of the unit of labelling turns green and labelling initiated to put the labels over the containers. During this entire process the conveyor belt motion is stopped. And after the competition of the process the motor resumes again

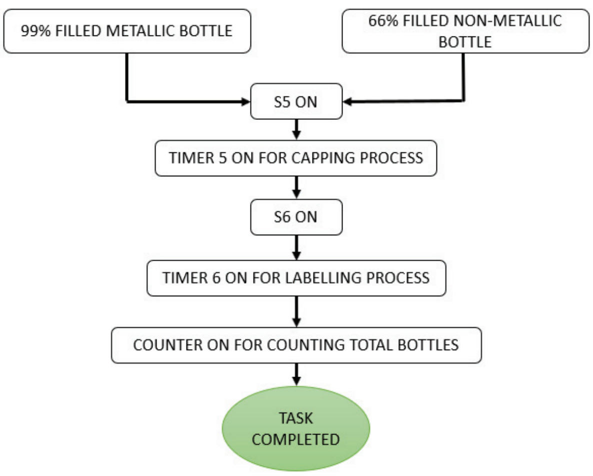


Fig. 5. Capping and Labelling

IV. RESULTS AND DISCUSSION

1. Inductive Proximity (IPR) sensor (S1) is able to identify metallic base bottle and bypass others.

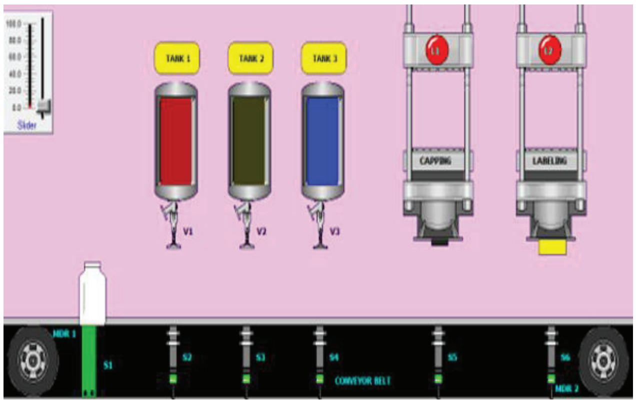


Fig. 6. Sorting

2. (S2) Photo-electric retro-reflective sensor detect both containers, conveyor motor stops, (V1) valve opens and containers got filled one-third.

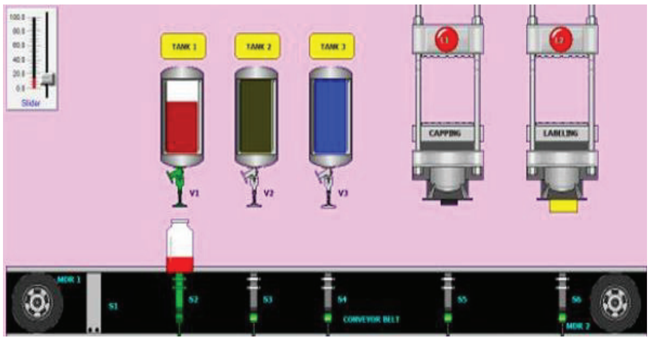


Fig. 7. Tank1 Level

3. (S3) Photo-electric retro-reflective sensor detect both containers, conveyor motor stops, (V2) valve opens and containers got filled two-third.

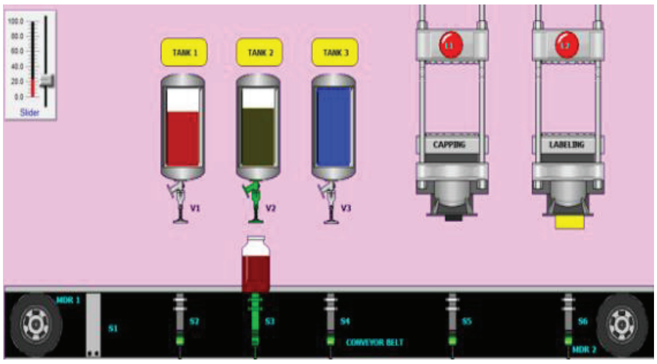


Fig. 8. Tank2 Level

4. (S4) Photo-electric retro-reflective sensor detect both containers, conveyor motor stops but (V2) valve opens only in the case of metallic base container (when S1 is high) and it gets completely filled but in case of non-metallic container, S1 is low, (V2) valve does not open and container remains filled two-third.

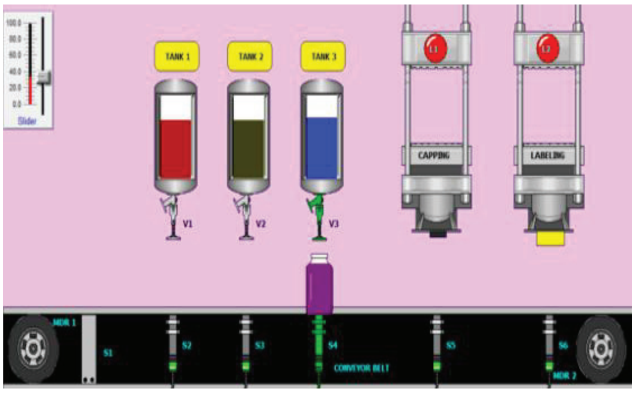


Fig. 9. Tank3 Level (Metallic Base Bottle)

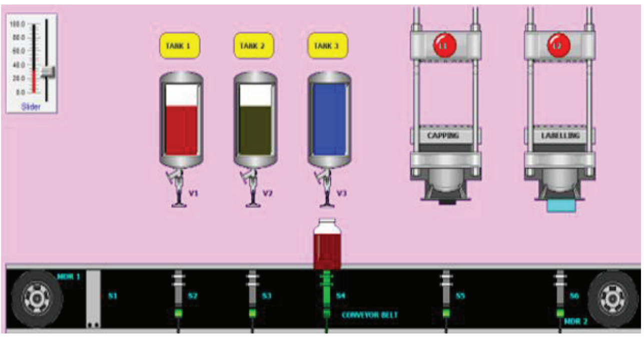


Fig. 10. Tank3 Level (Non-Metallic Bottle)

5. (S5) Photo-electric retro-reflective sensor detect both containers, conveyor motor stops, (L1) LED turns green and capping unit applies cap to both containers.

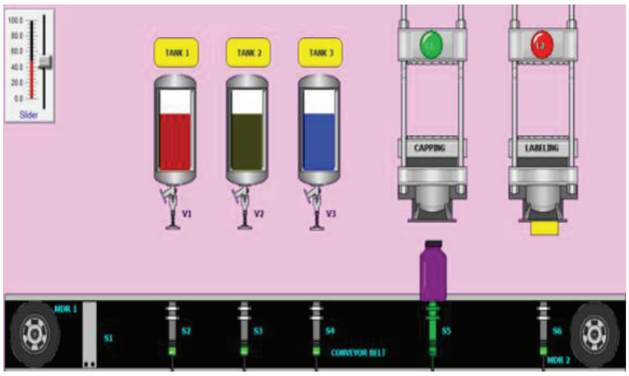


Fig. 11. Capping (Metallic Base Bottle)

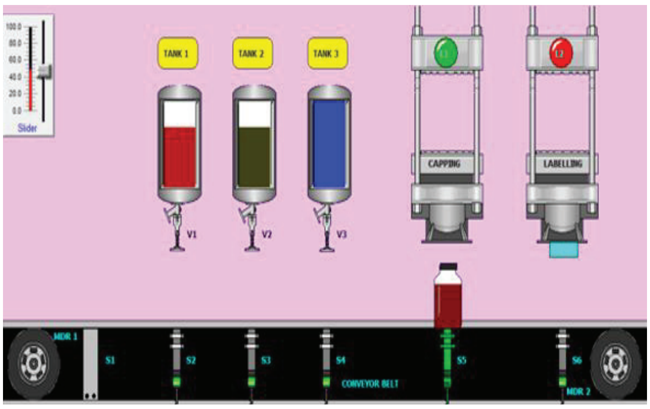


Fig. 12. Capping (Non-Metallic Bottle)

6. (S6) Photo-electric retro-reflective sensor detect both containers, conveyor motor stops, (L2) LED turns green and labelling unit applies cap to both containers but with different colors.

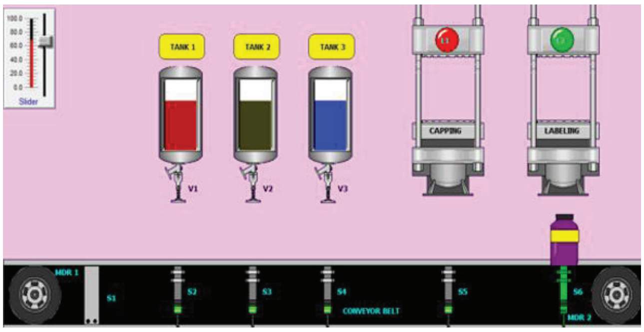


Fig. 13. Labelling (Metallic Base Bottle)

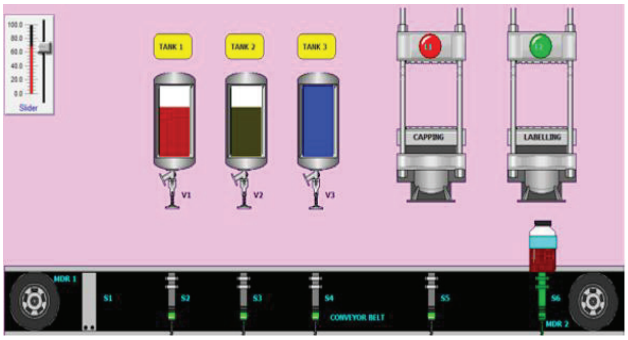
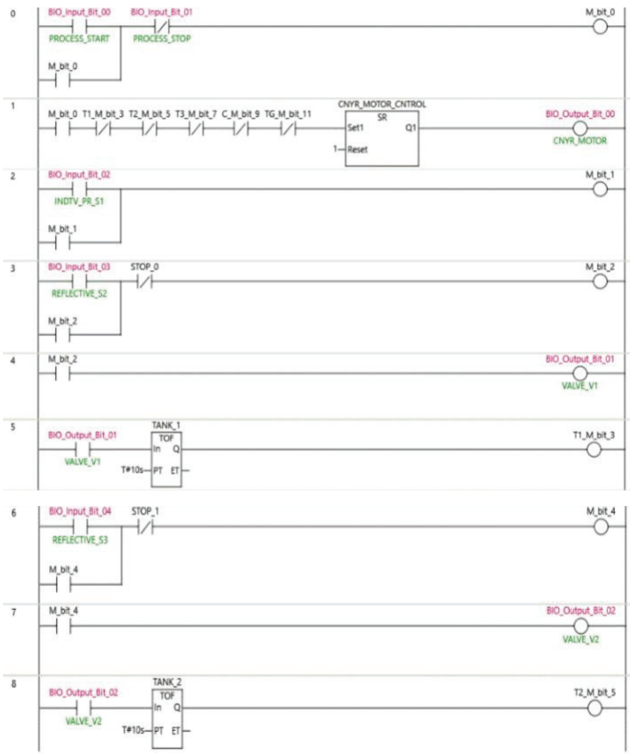


Fig. 14. Labelling (Non-Metallic bottle)

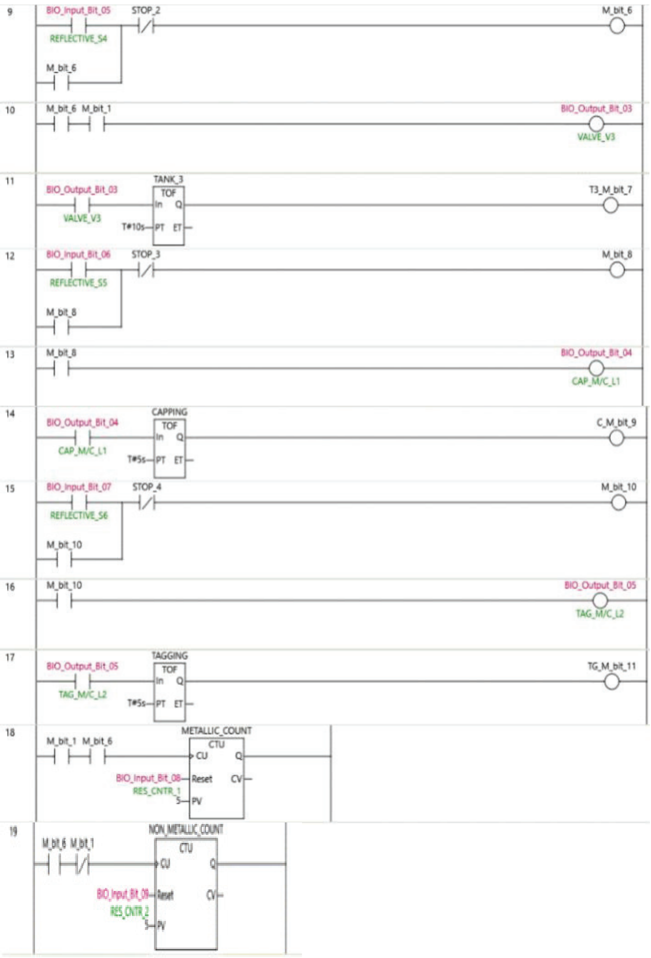
APPENDICES

Appendix A:



Appendix B:

Continued…



REFERENCES

[1] Kahiomba Sonia Kiangala and Zenghui Wang (2019), "An Industry 4.0 approach to develop auto parameter configuration of a bottling process in a small to medium scale industry using PLC and SCADA", Procedia Manufacturing Volume 35, 2019, Pages 725-730

[2] Htet Htet Aung, Thae Thae Ei Aung (2019), "Simulation and Implementation of PLC based for Nonstop Filling Process using PLCSIM and HMI", International Journal of Creative and Innovative Research in All Studies, Volume 2, Issue 3

[3] Zar Kyi Win, Tin Tin New (2019), "PLC Based Automatic Bottle Filling and Capping System", International Journal of Trend in Scientific Research and Development (IJTSRD), Volume 3 Issue 6, October 2019

[4] E. R. Alphonsus & M. O. Abdullah (2016), "A review on the applications of programmable logic controllers (PLCs)", Renewable and Sustainable Energy Reviews, 60, 1185–1205

[5] N. Nadgauda, Senthil Arumugam Muthukumaraswamy, S. U. Prabha (2020), "Smart Automated Processes for Bottle-Filling Industry Using PLC-SCADA System", Chapter in Intelligent Manufacturing and Energy Sustainability, pp.693-702

[6] S. V. Viraktamath, A. S. Umarfarooq, Vinayakgouda Yallappagoudar and Abhilash P. Hasankar (2020), "Implementation of Automated Bottle Filling System Using PLC", Chapter in Inventive Communication and Computational Technologies, pp.33-41

[7] K. Chakraborty, M.G. Choudhury, S. Dasc and S. Paul (2020), "Development of PLC-SCADA based control strategy for water storage in a tank for a semi-automated plant", Published by IOP Publishing for Sissa Medialab, Journal of Instrumentation, Volume 15, April 2020

[8] Nadgauda, N., & Muthukumaraswamy, S. A. (2019), "Design and Development of Industrial Automated System using PLC-SCADA", 2019 IEEE 10th GCC Conference & Exhibition (GCC).

[9] Mini Sreejeth and Shilpa Chouhan (2016), "PLC based Automated Liquid Mixing and Bottle Filling System", 1st IEEE International Conference on Power Electronics. Intelligent Control and Energy Systems (ICPEICES-2016)