Application of PLC and SCADA Based Real-Time Online Counter for Glass Bottle Manufacturing Industry in Bangladesh

Abu Salman Shaikat and Md. Mizanur Rahman and Suraiya Akter and Mehbub Khan
Department of Mechatronics Engineering
World University of Bangladesh
Dhaka, Bangladesh
skt047@gmail.com, m92504@gmail.com, sarmin.suraiya15@gmail.com, m.mehbub.k@gmail.com

Abstract

For industry applications, automation is playing a major role all over the world. Among all automation components, PLC is most reliable technology over the years. In glass bottle manufacturing industry, applications of PLC are mostly substantial. Online counter is not being used in many glass bottle manufacturing industries around the world includes Bangladesh. This paper introduces a real-time counter for glass bottle manufacturing industry, where PLC and SCADA is being used. PLC is used for speed variation with respect to demand in every shift by the use of Variable Frequency Drive (VFD), reset every manual counters in every eight hours, counting the data from sensors in different locations and reject bottles from different inspection machines of glass bottle manufacturing industry, whereas SCADA is used for graphical representation of bottle numbers, number of rejected bottles from machines, number of falling and broken bottles, efficiency of overall system, graphs of efficiency and losses and speed of conveyor can be varied from the SCADA. TIA Portal v14 is used for PLC and WinCC Explorer is used as SCADA in this work. The data's will be shown in one hour and eight hours respectively. With the help of VNC Server and VNC viewer, users can see the data's from anywhere in industry.

Keywords
PLC, SCADA, Real-Time Online Counter, WinCC Explorer, VNC Server, VNC Viewer, Glass bottle manufacturing industry, VFD, Optocoupler..

1. Introduction

In glass bottle manufacturing industry, efficiency calculation is a very vital factor. In every eight hours, one shift is counted. With the help of efficiency in one hour and eight hours, the production of glass bottle is being measured. If the efficiency is low in one hour, then quality control department need to see, where the most of the losses are being occurred and they inform the glass forming department. Then the Glass forming department will take necessary actions, which in turn help the industry to increase the efficiency.

In Bangladesh, none of the glass bottle manufacturing industries use real-time online counter. All the industries have manual counters. So, data inconsistency occurs most of the time, which results data inaccuracy most of the time.

For an instance, glass bottle manufacturing industry 'X' introduces a system, where all the data's of efficiency, bottle numbers and machine rejects are being introduced, which is shown in SCADA window. Moreover, after every eight hours, the data's will reset automatically and this system will reset all the manual counters at the same time. Dhammadip Wasnik et al. and H. Johnston introduced a system, wherein every shift, due to demand rate, speed can change with the help of VFD. SCADA window helps to change the speed.Shivani Arvapally et al.count the bottle numbers using FPGA, whereasEarl E. Swartzlander, Jr introducedparallel counters. For precise detection of materials, a multifunctional counter is introduced by Surve et al. Glass bottle manufacturing industry 'X' counted bottle numbers mostly with photo sensors, which is shown in Figure 1.

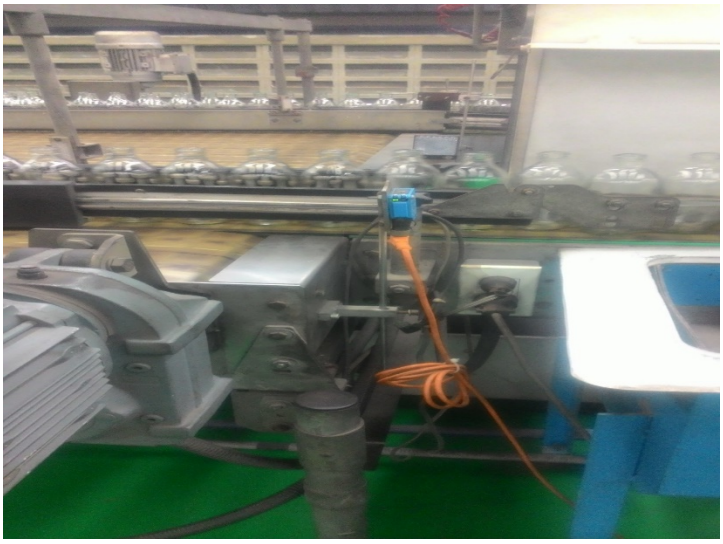


Figure 1: Sensor detects the glass bottles

The total scenario of glass bottle manufacturing industry 'X' is shown in Figure 2. At first, hot end sections are responsible for building the glass bottle presented by Rinchen Geongmit Dorjee. After that, annealing Lehr helps to cool the interior glass in a controlled manner, so that, the glass will not broke down by internal stress. This can be done by spray coating machine, which can be built with PLC. Then Evolution 12 and 5 machines will be responsible for detect the sidewall, finish and base faults in glass bottles and the faulty bottles will swept out by the use of air nozzle. The faulty bottles will repair again after it goes in recycle. OLT AGR, Mettler Toredo and ISM Ranger machines detects problem with bottle thickness, Metal detection and cracks of bottles respectively and faulty bottles will move out from conveyor. OLT AGR A, B and C are three machines, divide in three sublines. Same process happened with Mettler Toredo and ISM Ranger machines.

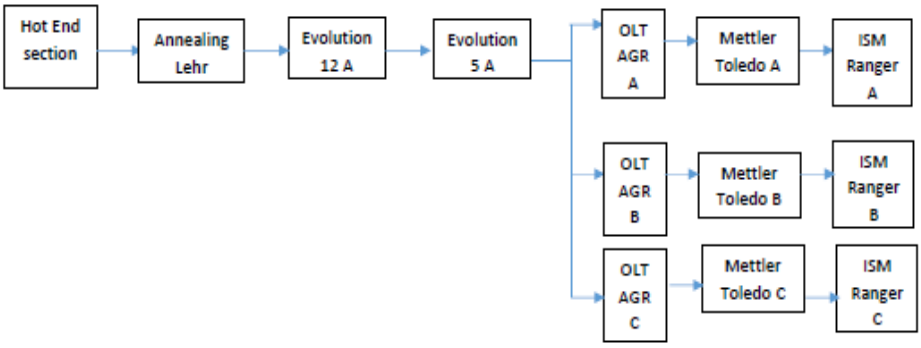


Figure 2: Total Scenario of Glass Bottle Manufacturing Industry 'X'

For glass bottle manufacturing industry 'X', different sensors are used in different positions, which is shown in Figure 3. Photo sensor can't give output to PLC directly without optocoupler, which is introduced by Hongzhen Guo et al. and Julian Henderson.By knowing the exact data of sensor in each location, it's easy to measure the total loss from one side to other. For an example, if the bottle number of Lehr in is 1000 and bottle number of Lehr out is 900, so it's easily recognizable that, reject bottles +falling/broken bottle loss is 100. Hot End (HE) sensor/ Lehr in sensor, Lehr out/ Pre-Evo sensor, OLT A, B, C sensors, Metal A, B, C sensors, ISM A, B, C sensors, Before visual A, B sensors

and Counter A and B sensors is applied to determine the exact data in every positions. Visual loss is counted by the fault in eyes and if the person who is responsible for fault, will detect fault, then he/she throws the bottle for recycle. Accumulated data of Counter A and B is the number of good bottles in line.

Loss of reject bottles can be divided in two parts. One is HE Reject bottles and another is CE Reject bottles.

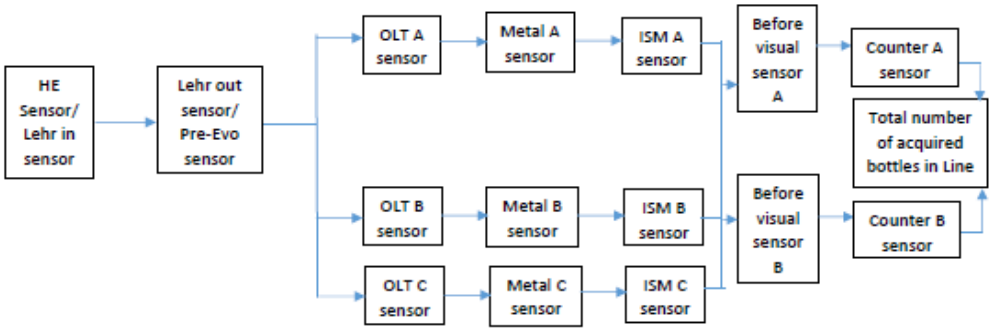


Figure 3: Different sensors of Glass Bottle Manufacturing Industry 'X'

HE reject bottles can subdivided in two parts, which is shown in Figure 4.The total machine loss and Annealing Lehr loss is the parts of HE reject bottles.

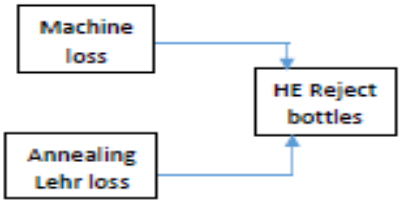


Figure 4: Hot End (HE) reject bottles of Glass Bottle Manufacturing Industry 'X'

CE reject bottles is shown in Figure 5. Evolution 12, Evolution 5, OLT, Metal, ISM and Visual losses are the total rejects of CE bottles.

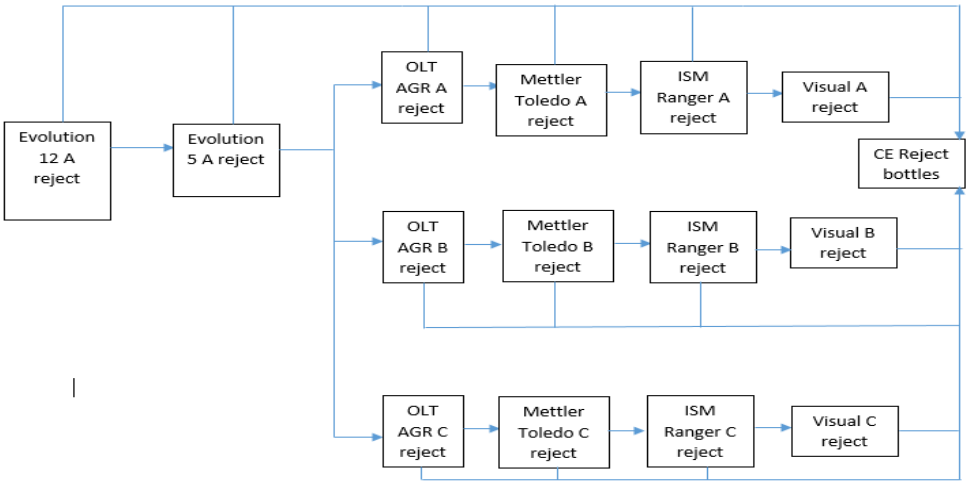


Figure 5: Cold End (CE) reject bottles of Glass Bottle Manufacturing Industry 'X'

Table I shows the difference between majority of existing system and new system. Previously, counter and reject numbers need to write from counters and machines. However, new system is presenting data's in automatic way. Loss in percent and efficiency counted manually before, whereas it's automatic in new system. Because of one people need to write data from different counters and machines, so he/she can't write in same time, which makes data inconsistency before. But data is exact for new system as it's coming automatically in every hour and in eight hours. Figure in Table I shows the difference between previous and new system.

Table 1: Majority of existing system vs new system

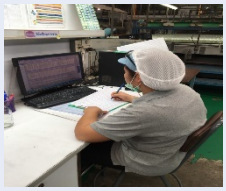
	Existing system	**New system**
Counter	Write manual	Automatic
Number of reject	Write manual	Automatic
Loss% and Efficiency	Count by calculator	Automatic
Data consistency	No	Yes
Reset Counter	Manual	Automatic
		

Figure 6 represents the counter used in glass bottle industry 'X'. After every eight hours, the counters will reset automatically with the help of PLC and it will maintain the same number that will show in SCADA window after every hour and eight hours. Introducing manual counters is important for the time of emergency or maintenance.

Figure 6. Counter of Glass Bottle Manufacturing Industry 'X'

Moreover, with the help of VNC software, anyone can see the data's by knowing the exact IP address and password.

2. Methodology

The block diagram of real-time online counter is shown in Figure 7. PLC is connected with PC via LAN, where PC displays the data's by WinCC Explorer (SCADA). All sensors and reject bottles from machines is connected as PLC input. However, speed of conveyor belt can be changed by daily demand rate, which is connected with PLC as PLC output. Furthermore, reset of manual counters also done by PLC output after every 8 hours. By the use of IP address, VNC software will help to monitor the data from anywhere in industry. VNC server creates IP address and password and VNC viewer helps to view the data's by using the exact IP address and password.

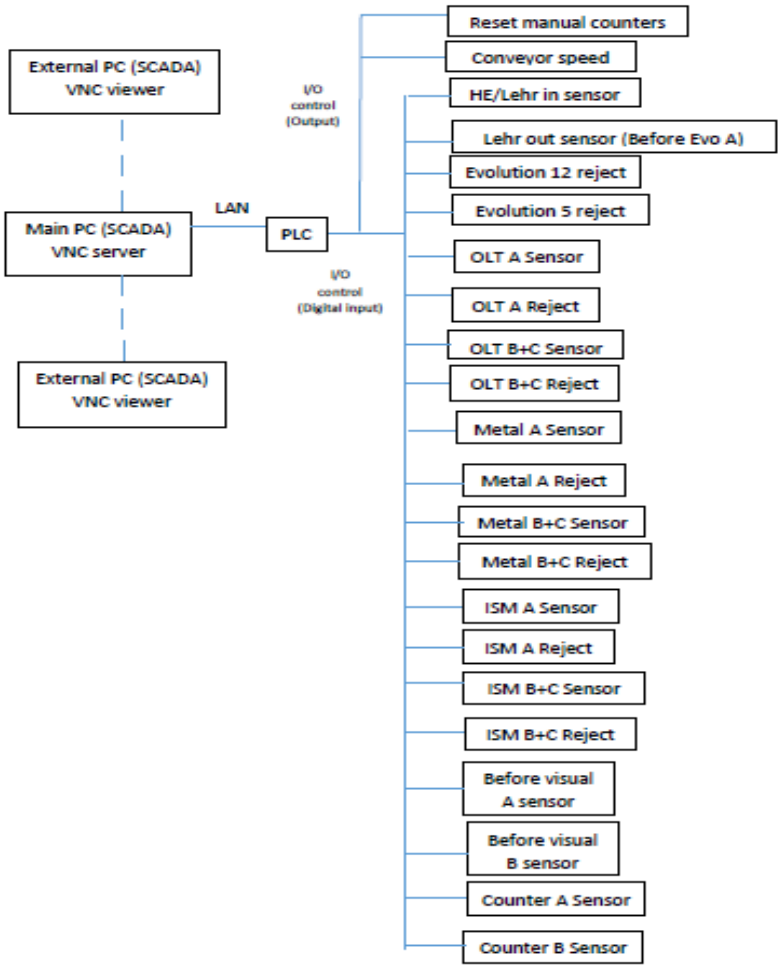


Figure 7: Block diagram

The electrical design is shown in Figure 8(a)-(f). Figure 8(a) shows the connection between sensors with PLC. Output of sensor should be 24V as PLC detects 24V only. Sensor connects with Optocoupler as it gives a light beam and optocoupler connects with PLC input. PLC input gives data only when optocoupler gives the signal. Hot end (HE), Before Evo A, Metal A, Metal B, Before Visual A, Before Visual B, Counter A and Counter B sensors are connected with PLC input via optocoupler.

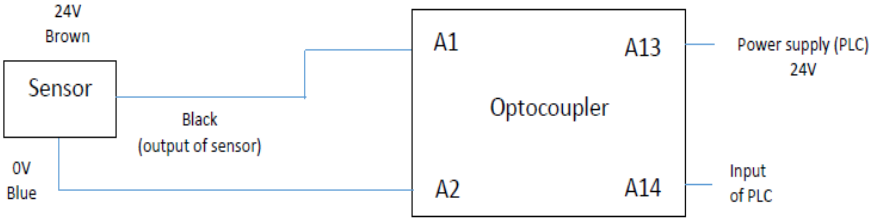


Figure 8(a): Electrical Design of sensors connected with PLC input

Figure 8(b) represents the connection between ISM machine infeed (A and B) with PLC. Infeed is getting 24V input signal from build-in sensors. Infeed connects with Optocoupler as it gives a light beam and optocoupler connects with PLC input. PLC input gives data only when optocoupler gives the signal.

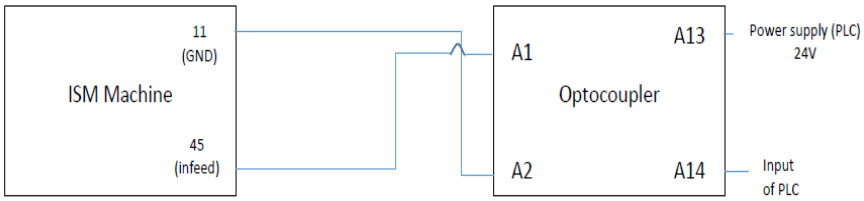


Figure 8(b): Electrical Design of ISM A and B infeed connected with PLC input

Figure 8(c), (d) and (e) represents the connection between Evolution 5 reject, Evolution 12 reject and OLT machine reject with PLC. Reject data of machines connect with optocoupler and optocoupler connects with PLC input. PLC input gives data only when optocoupler gives the signal.

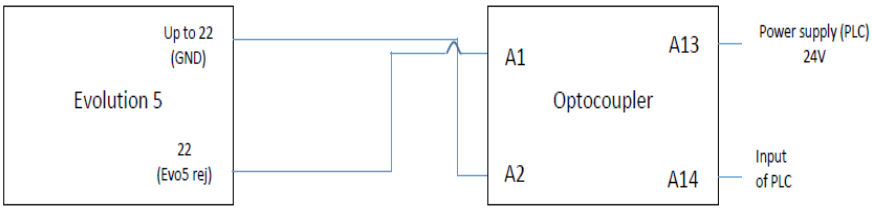


Figure 8(c):Electrical Design of Evolution 5 reject connected with PLC input

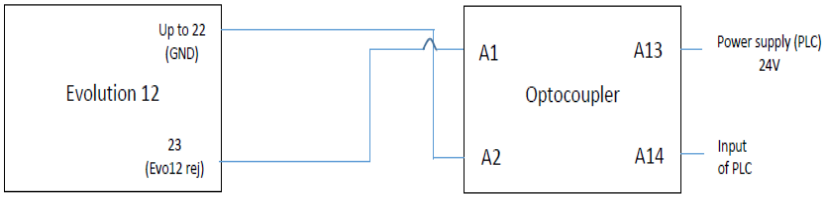


Figure 8(d):Electrical Design of Evolution 12 reject connected with PLC input

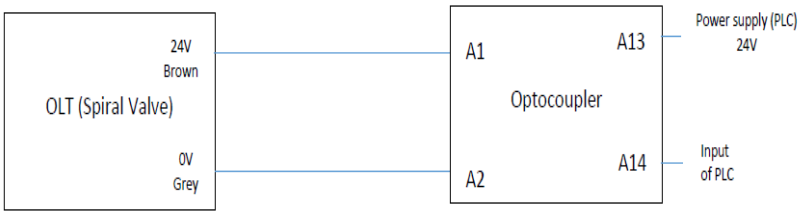


Figure 8(e):Electrical Design of OLT reject connected with PLC input

Figure 8(f) represents the connection between Metal detector reject with PLC. Reject data connect with relays as the input signal is 220 V. Relays help to provide 24 V as its output is connected with PLC input via optocoupler. PLC input gives data only when optocoupler gives the signal.

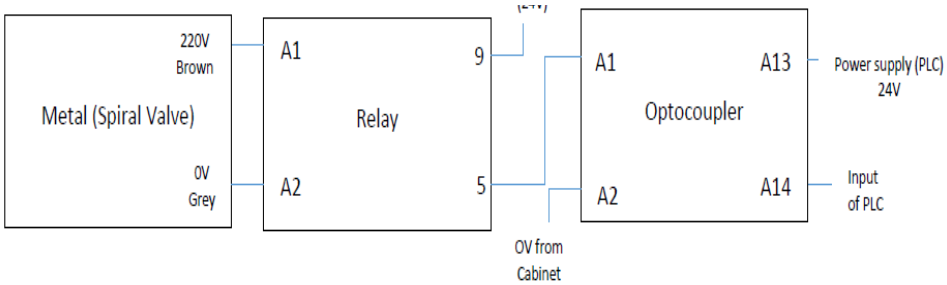


Figure 8(f):Electrical Design of Metal Detector reject connected with PLC input

Figure 8(g) represents the connection between motor inputs with PLC. Output of PLC is connected to motor via VFD (Variable Frequency Drive), which controls the speed of motor with the help of SCADA.

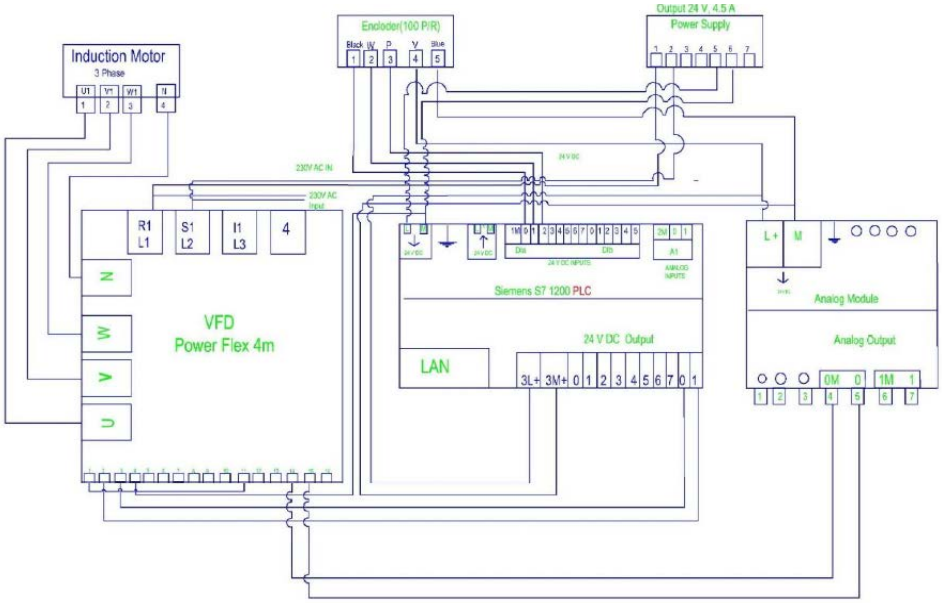


Figure 8(g):Electrical Design of Speed variation of Conveyor belt connected with PLC output

Figure 8(h) represents the connection between the manual counters with PLC. Output of PLC is connected to reset button of counters via relay, which resets after every eight hours.

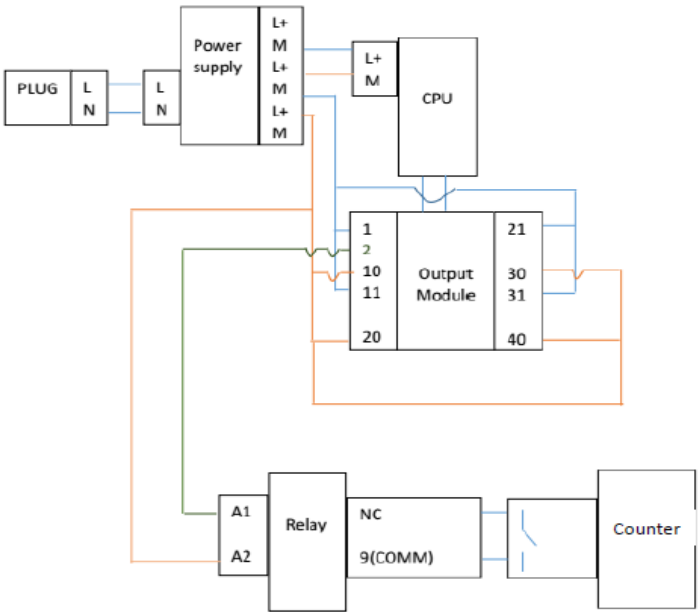


Figure 8(h):Electrical Design of reset of Manual counters connected with PLC output

Figure 8: Electrical Design

The flow chart of real-time online counter is shown in Figure 9. PLC collect data's from sensors and machines. Moreover, SCADA is displaying data's and controls the speed of conveyor belt with respect to demand of each day.

The data's being updated in every 1 hour and 8 hours. After 8 hours, new session will start and manual and online counters will start counting from zero again.

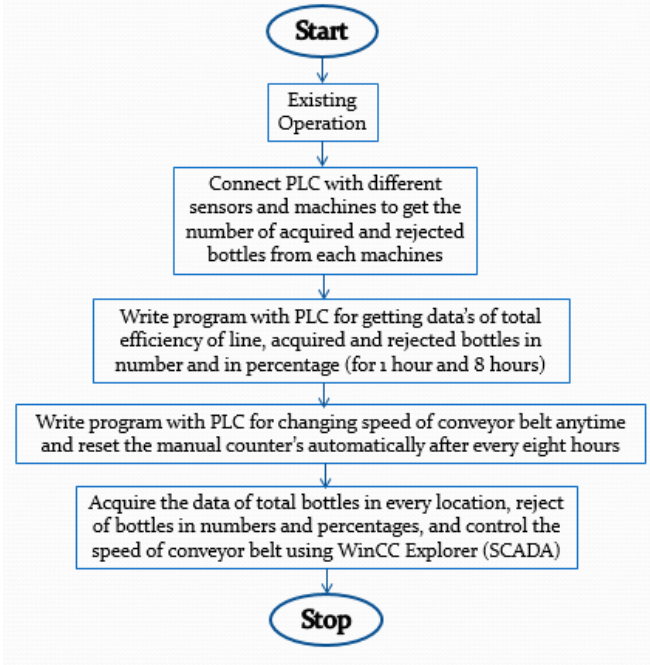


Figure 9: Flow Chart of Real-time Online Counter

3. Results and Discussion

In this work, we use PLC 315-2DP and WinCC Explorer as SCADA software. The real-time online counter shows in Figure 10 by SCADA. The data's of speed, Hot End (HE)/Lehr in counter, Lehr out/Pre-evo Counter, OLT A counter, OLT B counter, Metal A counter, Metal B counter, ISM A counter, ISM B counter, Before Visual A, Before Visual B, Counter A, Counter B and total efficiency in percentage is shown in SCADA window of "Counter(L11)". The data's are updated in every hour.

SCADA window "Loss in 1 hour (HE)" represents the data's of total Hot End (HE) loss in number and percentage, Machine loss in number and percentages and Lehr loss in number and in percentage. All data's will update in every one hour.

Third window of SCADA "Loss in 1 hour (CE)" shows the data's of total Cold End (CE) loss, Evolution 12 reject, Evolution 5 reject, OLT A reject, OLT B reject, Metal A reject, Metal B reject, ISM A reject, ISM B reject and total visual reject in number and in percentages, which updates in every hour.

Last window of SCADA "Loss in 8 hours" represents the percentages of total efficiency, HE loss, Machine loss, Lehr loss, CE loss, Evolution 12 reject, Evolution 5 reject, OLT A reject, OLT B reject, Metal A reject, Metal B reject, ISM A reject, ISM B reject and visual rejects in every eight hours.

Speed can change from the SCADA window, which is shown in right side of Figure 10. By clicking graph, the SCADA window of Figure 11 will appear. The efficiency of 1 hour and 8 hours will appear at graph of "Efficiency", whereas "Loss in 1 hour" graph will represent graph of HE loss and CE loss in every hour.

Moreover, by clicking Speed in right side of Figure 9, SCADA window of Figure 12 will appear. At first, setting the speed of 300 rpm will introduce input speed to become 300 rpm. But for output speed, at first, speed rises because of overshoot before it gets the set value. After that, the output speed will be constant at 300 rpm until the set value will change.

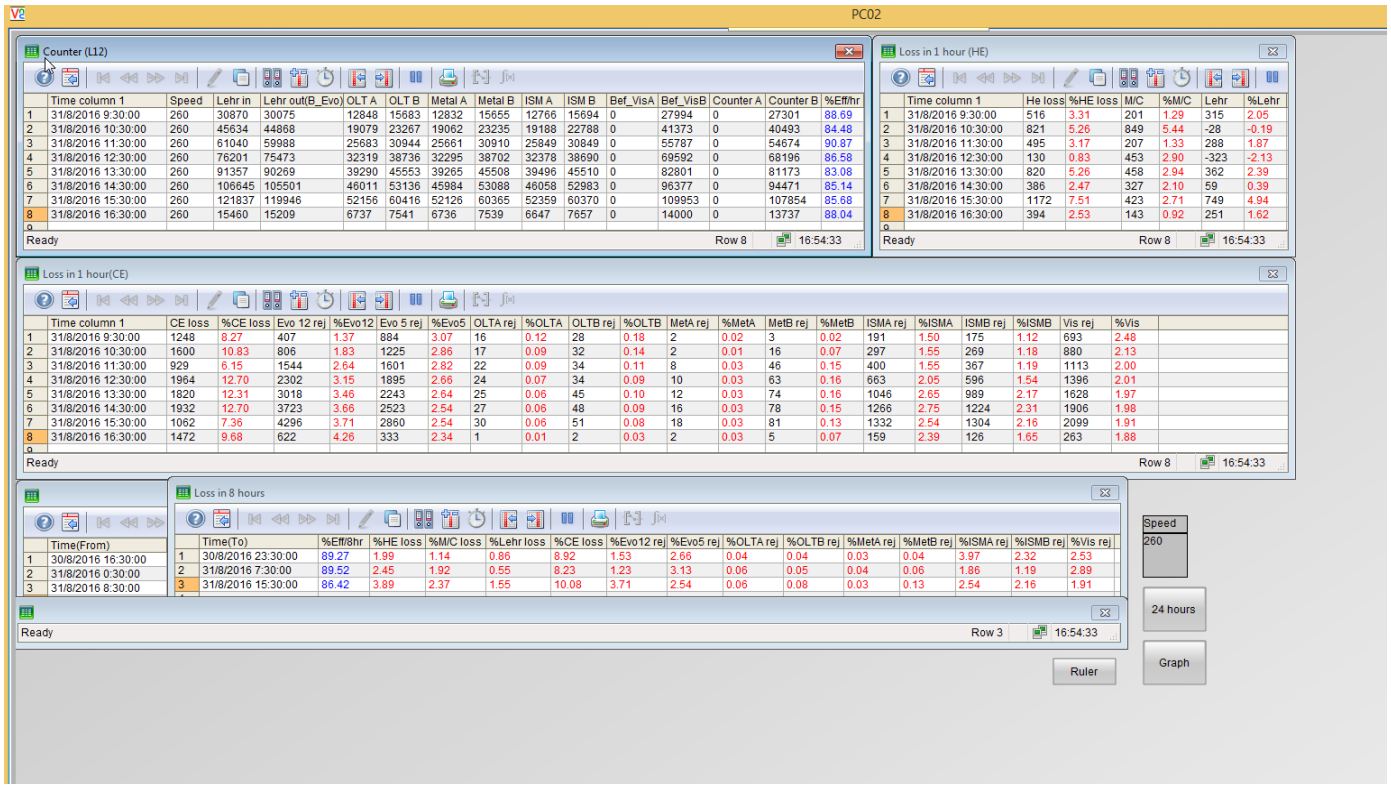


Figure 10: SCADA of Real-time Online Counter

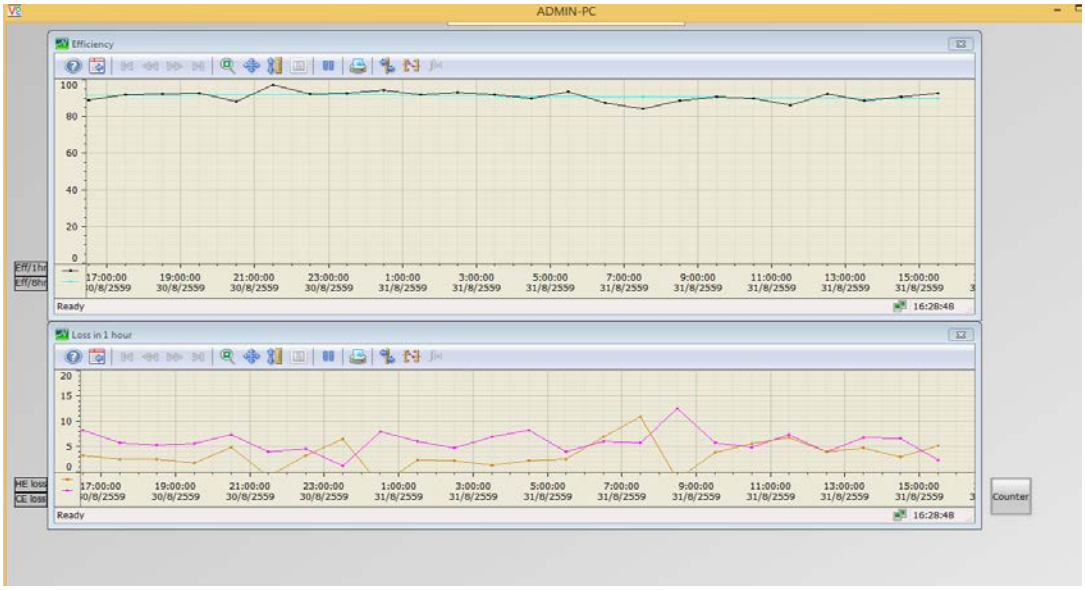


Figure 11: Graph of Real-time Online Counter

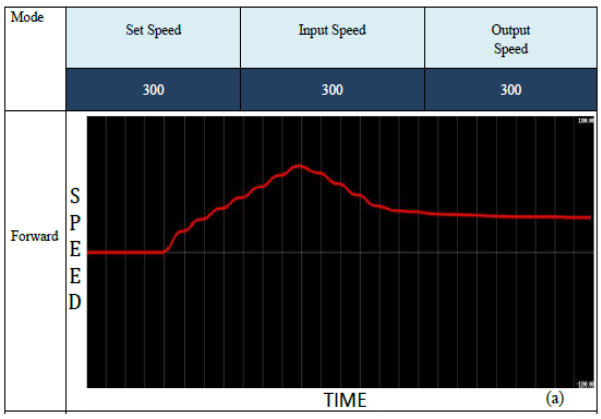


Figure 12: Input and output speed of VFD

4. Conclusion

This work is done successfully in Glass Bottle Manufacturing Industry 'X'. Different data's of sensors and rejects are being carried out in this system. This system proves as an efficient system due to the exact number of data's and multitasking purposes such as reset manual counters automatically and speed variation by the use of VFD.

References

Shivani Arvapallyet al., FPGA Implementation of Industry Automated Bottle Counter, International Conference on Electronics, Communication and Aerospace Technology, ICECA, April 2017.

Dhammadip Wasnik et al., Speed Control of Induction Motor using Variable Frequency Drives and PLC" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 6, Issue 6, 2017.

Earl E. Swartzlander, Jr., "A Review of Large Parallel Counter Designs", IEEE Computer Society Annual Symposium on VLSI Emerging Trends in VLSI Systems Design (ISVLSI'04), 2004.

Surveet al., PLC Based Automatic Railway Gate Controller and Obstacle Detector, *International Journal of Latest Trends in Engineering and Technology*, 2010.

Hongzhen Guoet al., A 1ew Multifunctional Counter", 8th International Conference on Intelligent Human-Machine Systems and Cybernetics, 2016.

H. Johnston, and B. G. Rax, "Proton Damage in Linear and Digital Optocouplers", 1999 RADECS Conference; published in IEEE Trans. Nucl. Sci., 47(3), 675, 2000.

Rinchen Geongmit Dorjee, "Monitoring and Control of a Variable Frequency Drive Using PLC and SCADA" International Journal on Recent and Innovation Trends in Computing and Communication, Volume: 2, Issue: 10, 2014.

Julian Henderson, "The Raw Materials of Early Glass Production", Oxford Journal of Archeology, 1985.

SIEMENS, Industry Journal, 2009.

R. Colbaugh et al., "Identification of SCADA systems: case studies", 38th IEEE Conference on Decision and Control (Cat. No. 99CH36304), December 1999.

Shashank G et al.," Implementation of SCADA in industries using wireless technologies", International Conference on Industrial Instrumentation and Control (ICIC), 2015.

Tom Bartman and Kevin Carson, " Securing communications for SCADA and critical industrial systems", 69th Annual Conference for Protective Relay Engineers (CPRE), April 2016.

Biographies

Abu Salman Shaikatis a Lecturer in Department of Mechatronics Engineering at the World University of Bangladesh, Dhaka, Bangladesh. He earned his B.Sc. in Electrical and Electronics Engineering from Ahsanullah University of Science and Technology, M.Eng.degree in Mechatronics Engineering from Asian Institute of Technology. He worked at Bangkok Glass Public Company Limited as a Production Engineer, AIT Extension, IT and Engineering Unit as a Service Provider and Dowla Consultants and Engineering Limited as an Electrical Design Engineer. His research interest includes Automation, Robotics, Artificial Intelligence, Product Design and Development, Control System, Image Processing and Deep Learning.

Md. Mizanur Rahman is chartered Energy Engineer who is now working as an Associate Professor under World University of Bangladesh. He also worked as a Research Assistant, a Research Engineer, and a consultant in the Renewable Energy Technology in Asia (RETs in Asia) project at KUET and AIT until 2004, December. After that, he moved as a Program Support Specialist under a NGO named BRAC Bangladesh. He was joined as Assistant Manager in the Rural Power Company Ltd (RPCL) in February 2006 and continued until July 2007. He started PhD on Natural Draft Chimney at Universiti Malaysia Sabah from July 2007. He was worked as a lecturer in the TAS institute of Oil and Gas from July 2009 and continue until August 2012 then moved Universiti Malaysia Sabah as Senior Lecturer.

Suraiya Akteris currentlystudying in Department of Mechatronics Engineering at World University of Bangladesh.

Mehbub Khanis currentlyworking with Confidence Power Limited as Trainee Engineer. He studied in Department of Mechatronics Engineering at World University of Bangladesh.