

Performance Analysis of Automated Material Handling and Filling System Using PLC Based Silo Simulator

Mohammed Azam

Supervisor: Prof. J.S. Dhillon
Somany Institute of Technology & Management

Abstract - Industrial automation plays an important role in improving productivity, accuracy, and operational efficiency in modern industries. Material handling and filling systems are widely used in manufacturing plants for automatic transfer and filling of materials with minimum human intervention. This paper presents the performance analysis of an automated material handling and filling system using a PLC based silo simulator. The proposed system uses Programmable Logic Controller (PLC) technology for automatic control of conveyor movement, silo operations, material detection, and filling processes. Sensors and actuators are integrated with the PLC to achieve accurate and reliable automation. Ladder logic programming is used to control the complete operation of the system. The performance of the system is analyzed based on response time, operational accuracy, reliability, and reduction in manual effort. The proposed PLC based automation system improves industrial productivity, reduces human errors, and provides efficient process control for industrial applications. The system is suitable for smart manufacturing and modern industrial automation environments.

Keywords: PLC, Industrial Automation, Material Handling System, Silo Simulator, Ladder Logic, Conveyor Control, Filling System.

1. INTRODUCTION

Industrial automation has become an essential requirement in modern industries for increasing production efficiency, reducing operational cost, and minimizing human effort. Automated material handling and filling systems are commonly used in industries such as food processing, chemical plants, cement industries, pharmaceutical industries, and manufacturing units for efficient transportation and filling of materials.

Traditional material handling systems require continuous human supervision, which may lead to errors, material wastage, and reduced productivity. To overcome these limitations, Programmable Logic Controllers (PLCs) are widely used for industrial automation applications due to their high reliability, flexibility, fast response time, and easy programming capability.

A PLC based silo simulator is an effective system used to automate material handling and filling operations. The system controls conveyor movement, silo gates, sensors, and filling mechanisms automatically through ladder logic programming. Sensors are used to detect the presence of containers and material levels, while the PLC processes input signals and controls output devices accordingly.

In this proposed system, the PLC continuously monitors the operation of the conveyor and filling process to ensure accurate and efficient automation. The use of ladder logic programming simplifies system operation and improves process reliability. The automated system also reduces manual intervention and improves industrial safety.

The main objective of this paper is to analyze the performance of an automated material handling and filling system using a PLC based silo simulator. The study focuses on system operation, response time, automation accuracy, reliability, and industrial applications of PLC based automation systems.

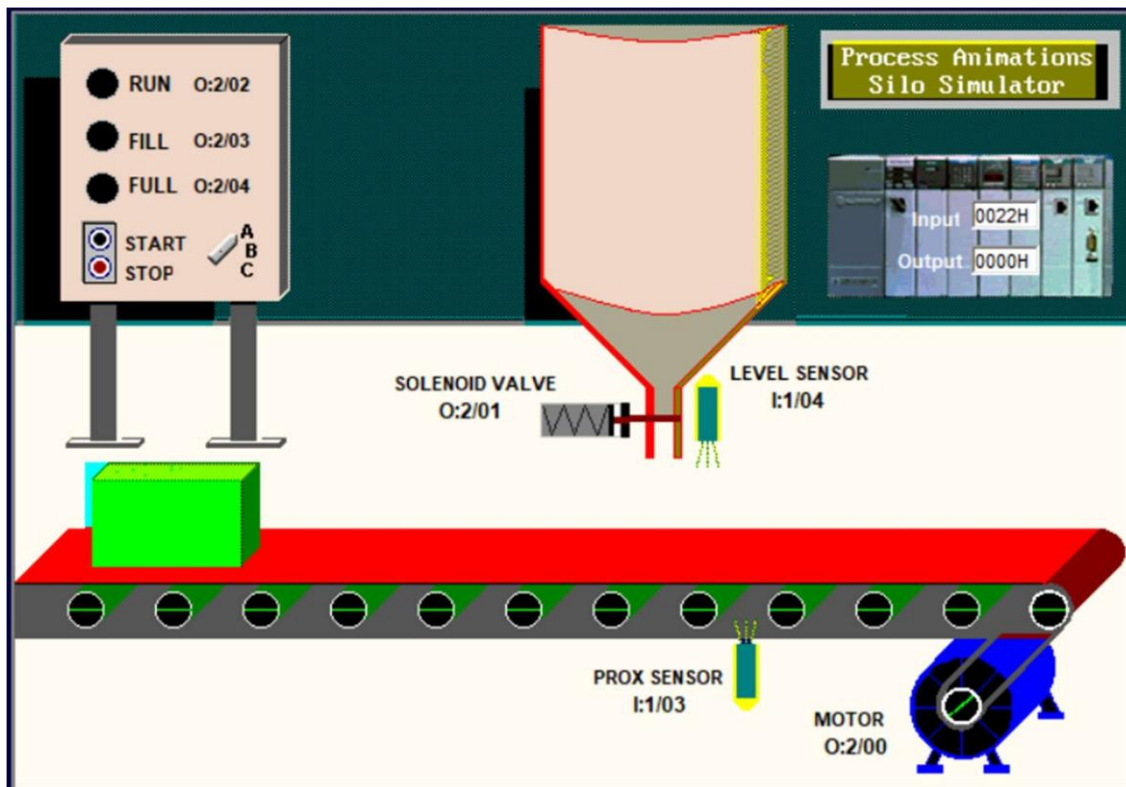


Figure 1: PLC Based Silo Simulator for Automated Material Handling and Filling System

2. LITERATURE REVIEW

Industrial automation using Programmable Logic Controllers (PLCs) has gained significant importance in modern manufacturing industries due to its high reliability, flexibility, and efficient control capabilities. Researchers have developed several automated material handling and filling systems using PLC technology to improve industrial productivity and reduce manual intervention.

Many industries use PLC based conveyor systems for automatic transportation of materials from one process to another. Researchers have shown that automated conveyor systems reduce operational time and increase production efficiency compared to manual systems. PLC

controlled conveyor systems also provide accurate movement control and better synchronization between industrial processes.

Several studies focused on silo automation systems for automatic filling and material storage applications. In these systems, sensors are used to detect the level of material inside containers, while PLCs control solenoid valves, motors, and conveyors automatically. These systems improved filling accuracy and minimized material wastage.

Researchers have also integrated proximity sensors and level sensors with PLC based filling systems for real-time monitoring and control. Sensor feedback allows the PLC to make automatic decisions during the filling process, resulting in improved reliability and safe operation.

A study on PLC and SCADA based automation demonstrated that real-time monitoring and control significantly improved industrial process management. SCADA systems provide graphical visualization, fault detection, and remote monitoring capabilities for automated industries.

Recent industrial automation technologies combine PLC systems with IoT, Human Machine Interface (HMI), and smart sensors for Industry 4.0 applications. These advanced systems improve communication, energy efficiency, and overall system performance.

Based on previous research, PLC based material handling and filling systems are highly effective for industrial automation applications. The proposed PLC based silo simulator system aims to provide reliable automation, accurate filling operation, and improved process efficiency with reduced human effort.

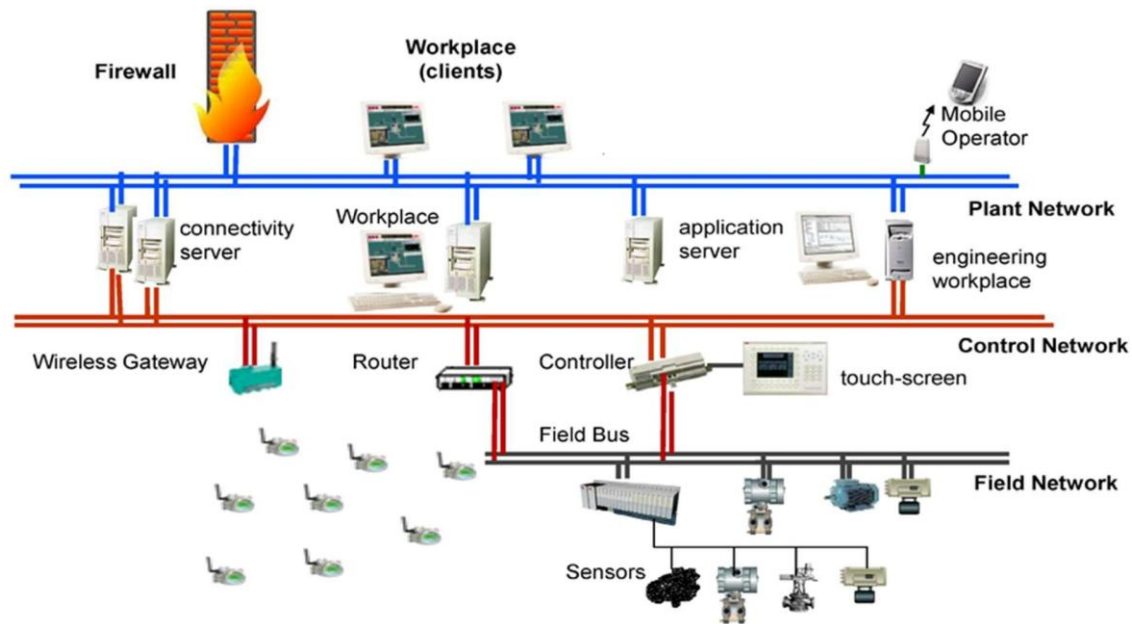


Figure 2: Typical Industrial Automation Network Architecture showing Field, Control, and Plant levels.

3. COMPONENTS USED IN THE SYSTEM

The proposed PLC based silo simulator system uses various industrial automation components for automatic material handling and filling operations. These components improve system reliability, operational accuracy, and industrial efficiency.

3.1 Allen Bradley MicroLogix 1000 PLC

Allen-Bradley MicroLogix 1000 PLC is used as the main controller of the system. The PLC receives input signals from sensors and controls the conveyor motor, solenoid valve, and other output devices according to the ladder logic program.

The MicroLogix 1000 PLC provides reliable performance, fast processing, and easy programming for industrial automation applications.

3.2 Delta HMI

Delta HMI is used as the Human Machine Interface (HMI) for monitoring and controlling the automation process. The HMI displays system status, conveyor operation, filling condition, and control parameters in real time.

A 4-inch Delta DOPSoft HMI is used in this system for operator interaction and process visualization.

3.3 Delta VFD E-Series

Delta VFD-E Series Variable Frequency Drive (VFD) is used to control the speed of the conveyor motor. The VFD improves motor efficiency, reduces power consumption, and provides smooth motor operation during the material handling process.

3.4 Proximity Sensor

The proximity sensor is used to detect the presence of containers at the filling station. The sensor sends input signals to the PLC for automatic process control.

3.5 Solenoid Valve

The solenoid valve controls the flow of material from the silo tank into the container during the filling operation. The PLC automatically activates and deactivates the valve according to the filling condition.

3.6 Conveyor Motor

The conveyor motor is used for automatic movement of containers in the material handling system.

3.7 Push Buttons

Start and stop push buttons are used for manual operation and emergency control of the automation system.

4. PROPOSED METHODOLOGY

The proposed system is designed to automate the material handling and filling process using a PLC based silo simulator. The system consists of a conveyor belt, silo tank, proximity sensor, level sensor, solenoid valve, motor, and Programmable Logic Controller (PLC). The complete operation is controlled automatically through ladder logic programming.

Initially, the conveyor motor starts when the start push button is pressed. The conveyor belt carries the container toward the filling station located below the silo tank. A proximity sensor is used to detect the presence of the container at the filling position.

When the container reaches the filling station, the proximity sensor sends a signal to the PLC. The PLC immediately stops the conveyor motor and activates the solenoid valve connected to the silo outlet. Material from the silo starts filling into the container automatically.

A level sensor is used to monitor the filling level of the container. Once the container becomes full, the level sensor sends feedback to the PLC. The PLC then closes the solenoid valve and restarts the conveyor motor to move the filled container away from the filling station.

The entire process operates automatically without continuous human intervention. The use of PLC technology improves system reliability, operational accuracy, and industrial safety. Ladder logic programming simplifies system control and enables fast response during operation.

The proposed methodology reduces material wastage, minimizes manual effort, and improves production efficiency in industrial applications.

Working Steps of the System

1. Start push button activates the PLC system.
2. Conveyor motor starts moving the container.
3. Proximity sensor detects the container position.
4. Conveyor stops automatically at filling station.
5. Solenoid valve opens for material filling.
6. Level sensor detects the full container condition.

7. Solenoid valve closes automatically.
8. Conveyor motor restarts to move the filled container.

5. LADDER LOGIC PROGRAMMING

The PLC based silo simulator system is programmed using ladder logic programming for automatic control of the material handling and filling process. Ladder logic is one of the most commonly used PLC programming methods in industrial automation because of its simple structure and easy implementation.

The ladder logic program controls the operation of the conveyor motor, proximity sensor, level sensor, and solenoid valve. Initially, the start push button activates the PLC system and starts the conveyor motor. The conveyor moves the container toward the filling station.

When the container reaches the filling area, the proximity sensor detects its presence and sends an input signal to the PLC. The PLC then stops the conveyor motor and activates the solenoid valve for material filling.

The level sensor continuously monitors the filling level of the container. Once the container becomes full, the level sensor sends feedback to the PLC controller. The PLC immediately closes the solenoid valve and restarts the conveyor motor to move the filled container away from the filling station. The ladder logic program ensures accurate automation, smooth operation, and reliable industrial process control. The use of PLC programming reduces manual intervention and improves operational efficiency of the system.

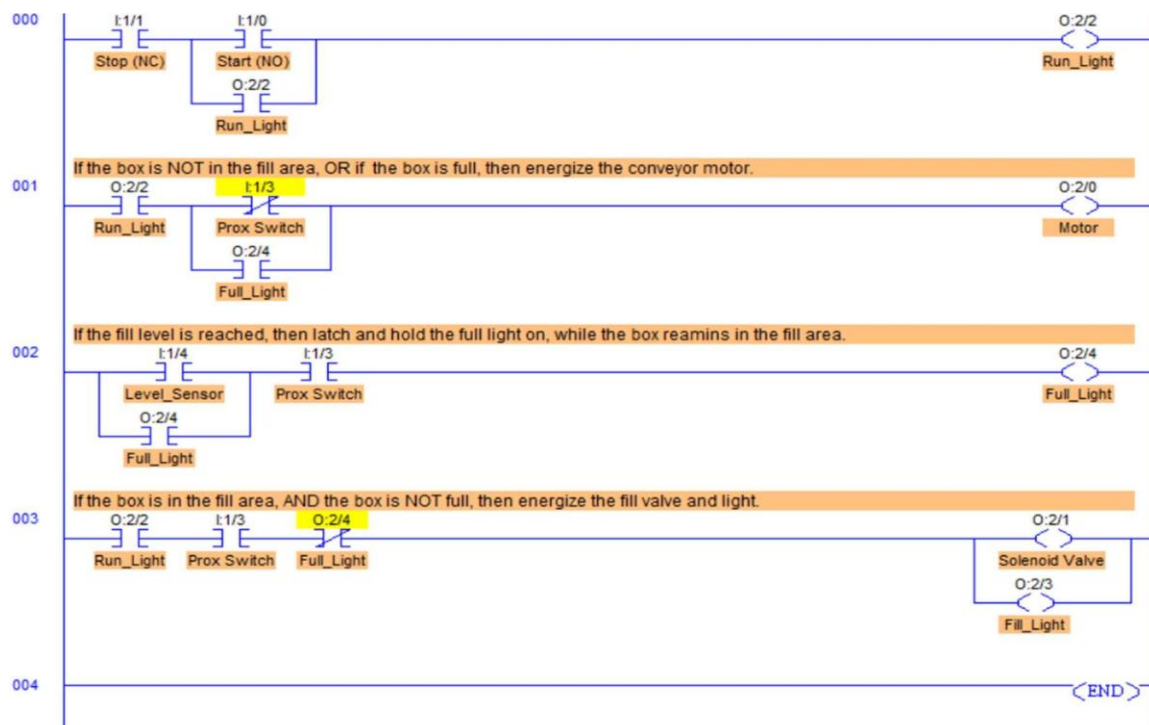


Figure 3: Ladder Logic Program for PLC Based Silo Simulator .

6. RESULT AND DISCUSSION

The PLC based material handling and filling system using silo simulator was successfully implemented and tested under different operating conditions. The automation system performed all operations accurately according to the programmed ladder logic.

During system operation, the conveyor motor automatically transported the container to the filling station. The proximity sensor detected the presence of the container and sent signals to the PLC controller. After detection, the PLC stopped the conveyor motor and activated the solenoid valve for the filling operation.

The level sensor continuously monitored the filling level inside the container. When the container reached the required level, the sensor provided feedback to the PLC, which automatically closed the solenoid valve and restarted the conveyor motor.

The system demonstrated reliable automation with fast response time and accurate material handling operation. The use of PLC technology reduced manual intervention and improved operational efficiency. The HMI interface also provided real-time monitoring and easy control of the complete process.

The Delta VFD E-Series provided smooth speed control of the conveyor motor and improved overall system performance. The ladder logic program operated efficiently without any major operational error during testing.

The proposed automation system is suitable for industrial material handling and filling applications where accuracy, reliability, and productivity are important requirements.

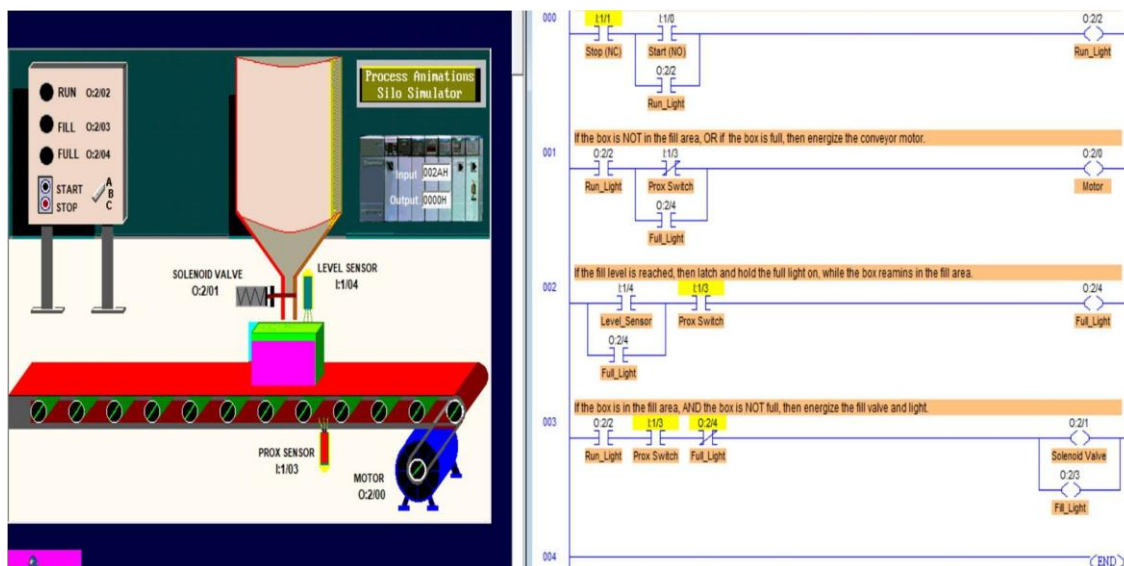


Figure 4: Running Condition of PLC Based Material Handling and Filling System Using Silo Simulator.

7. ADVANTAGES OF PROPOSED SYSTEM

The proposed PLC based material handling and filling system provides several advantages in industrial automation applications.

- Reduced human effort and manual operation
- Accurate and reliable filling process
- Fast response time and smooth operation
- Improved industrial productivity
- Reduced material wastage
- Easy monitoring and control using HMI
- Energy efficient motor operation using VFD
- Increased operational safety
- Flexible and easy PLC programming
- Low maintenance requirement

The use of PLC, HMI, and VFD technologies improves the overall efficiency and reliability of the industrial automation system.

8. CONCLUSION

This paper presented the performance analysis of an automated material handling and filling system using a PLC based silo simulator. The system successfully automated conveyor movement, material filling operation, and sensor-based process control using ladder logic programming.

The Allen Bradley MicroLogix 1000 PLC effectively controlled the conveyor motor, solenoid valve, proximity sensor, and level sensor during the automation process. The Delta HMI provided real-time monitoring and easy operation of the system, while the Delta VFD E-Series ensured smooth motor speed control and efficient operation.

The proposed system reduced manual intervention, improved filling accuracy, increased operational reliability, and enhanced industrial productivity. The ladder logic program performed efficiently during system testing and provided stable automation performance.

The developed PLC based automation system can be effectively used in modern industrial applications such as material handling plants, packaging industries, and automated filling systems. Future improvements may include integration with SCADA, IoT, and smart industrial monitoring systems for Industry 4.0 applications.

9. FUTURE SCOPE

The proposed PLC based material handling and filling system can be further improved using advanced industrial automation technologies. Future enhancements may include integration of SCADA systems for real-time monitoring and centralized process control.

The system can also be integrated with Internet of Things (IoT) technology for remote monitoring and wireless industrial communication. Advanced Human Machine Interface (HMI) systems can be used for better visualization and process management.

Artificial Intelligence (AI) and machine learning techniques may be implemented for predictive maintenance and intelligent process optimization. Wireless sensors and cloud-based monitoring systems can further improve industrial efficiency and data

management.

The proposed automation system can also be expanded for large-scale industrial applications such as smart manufacturing plants, packaging industries, and Industry 4.0 based automation systems.

REFERENCES

- [1] J. S. Dhillon, "Secure Data in Wireless Sensor Network By Using DES," *International Journal of Wireless & Mobile Network (IJWMN)*, vol. 3, No. 3, June 2011.
- [2] S. Kumar and R. Singh, "Automated Material Handling Systems in Industry 4.0," *Technical Journal of Automation*, 2025.
- [3] F. D. Petruzella, *Programmable Logic Controllers*, McGraw Hill Education, 2017.
- [4] John W. Webb and Ronald A. Reis, *Programmable Logic Controllers: Principles and Applications*, Prentice Hall, 2015.
- [5] Rockwell Automation, *Allen Bradley MicroLogix 1000 PLC User Manual*, 2023.
- [6] Delta Electronics, *Delta HMI DOPSoft User Manual*, 2022.
- [7] Delta Electronics, *Delta VFD-E Series Technical Manual*, 2022.
- [8] A. Kumar and P. Singh, "PLC Based Industrial Material Handling System," *International Journal of Engineering Research and Technology (IJERT)*, vol. 9, no. 5, pp. 102–108, 2021.
- [9] R. Sharma and S. Gupta, "Automation of Conveyor and Filling System Using PLC," *International Research Journal of Engineering and Technology (IRJET)*, vol. 8, no. 3, pp. 1450–1456, 2021.
- [10] M. Patel, "Performance Analysis of PLC Based Silo Automation System," *International Journal of Advanced Industrial Engineering*, vol. 6, no. 2, pp. 55–61, 2020.
- [11] P. Bolton, *Programmable Logic Controllers*, Elsevier Publication, 2019.
- [12] S. Rao, "Industrial Automation Using PLC and SCADA," *International Journal of Industrial Automation and Control Engineering*, vol. 5, no. 1, pp. 25–31, 2022.