A Review Paper on Automatic Metal Separation Using Plc

Prof. Suraj S. Shinde[1], Mr. Pratik Nagesh Shirgave[2], Mr. Sagar Dada Sathe[3]
[1]*Assistant Professor, SMSMPITR AKLUJ(MS)*
[2,3] *B Tech Students, SMSMPITR AKLUJ(MS)*

***Abstract*—Efficient metal separation is a critical process in industries such as recycling, manufacturing, packaging, and material handling. The presence of unwanted metallic particles can damage machinery, compromise product quality, and pose safety hazards. Traditional manual sorting methods are time-consuming, costly, and prone to human error, highlighting the need for an automated solution**

This paper presents the design and implementation of an Automatic Metal Separation System utilizing a Programmable Logic Controller (PLC). The system employs a conveyor belt to transport mixed materials, a photoelectric sensor for object detection, and an inductive proximity sensor for identifying metallic items. The PLC continuously monitors sensor inputs and controls the separation mechanism. Upon detecting a metal object, the PLC actuates a solenoid-controlled pneumatic cylinder, diverting the metal item into a designated collection bin, while non-metal objects continue along the conveyor uninterrupted.

***Index Terms*—Programmable Logic Controller (PLC), Conveyor Belt, Inductive Proximity Sensor, Photoelectric Sensor, Pneumatic Cylinder, Solenoid Valve, Industrial Automation**

I. INTRODUCTION

In today's industrial landscape, automation plays a pivotal role in improving operational efficiency, accuracy, and overall productivity. Sectors such as recycling, manufacturing, food processing, and packaging often require the precise separation of metallic and non-metallic materials. The presence of unintended metal fragments in production lines can lead to equipment damage, increased maintenance costs, and compromised product quality. To address this, a photoelectric sensor is employed to detect objects on the conveyor belt, ensuring precise timing for the separation process. By integrating PLC-based control with these sensing technologies, the system delivers consistent, accurate, and reliable material sorting, minimizing human intervention and operational errors. Automation in material handling has become increasingly vital as industries strive to reduce manual labor, minimize errors, and maintain high production throughput. Traditional methods of metal separation, such as manual inspection or magnetic sorting, are often inefficient and inconsistent, particularly when dealing with mixed or complex waste streams. Implementing automated solutions allows industries to achieve faster processing speeds, greater precision, and improved safety by reducing direct human interaction with potentially hazardous materials.

Modern separation systems leverage a combination of sensors, actuators, and programmable controllers to optimize the sorting process. Inductive proximity sensors are particularly effective for detecting metallic objects, while photoelectric sensors provide reliable detection of items regardless of material type. These sensors feed real-time data to a PLC, which executes logical operations to control actuators such as pneumatic cylinders and solenoid valves. This integration ensures that metal items are accurately diverted to designated bins, while non-metallic materials continue along the production line, significantly enhancing the efficiency and reliability of industrial operations.

II. LITERATURE SURVEY

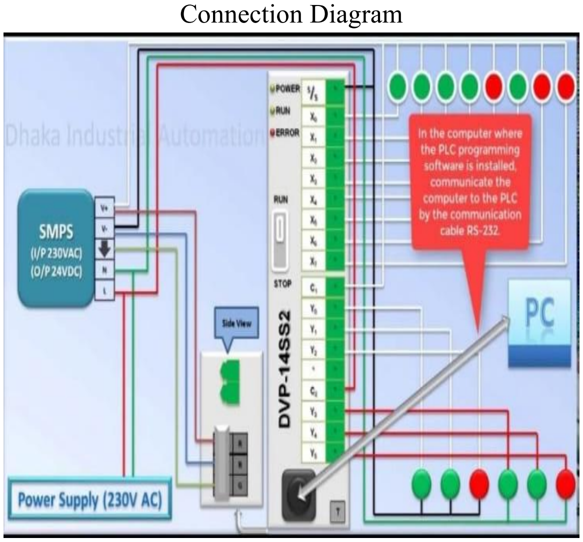
Automation-based sorting solutions have been extensively explored for various industrial applications. Among these, PLC-based sorting systems are preferred over traditional relay-controlled systems due to their higher reliability, faster processing capabilities, ease of programming, and adaptability to system modifications. Inductive proximity sensors are widely employed for detecting metallic objects, as they can sense metals without requiring physical contact, ensuring durability and consistent performance. Studies indicate that PLC-controlled pneumatic systems provide high-speed and precise separation in material handling industries. Conveyor-based sorting systems are widely adopted due to their ability to support continuous operation and minimize manual involvement. However, achieving high sorting accuracy requires proper synchronization between sensor detection and actuator response.

III. OBJECTIVE

The objective of this project is to develop a PLC-based automated metal separation system. The system uses an inductive proximity sensor to detect metallic objects and a photoelectric sensor to sense material presence on the conveyor. A PLC ladder logic program processes sensor inputs in real time, controlling a solenoid valve and pneumatic cylinder to accurately separate metals from non-metallic materials. This automation enhances efficiency, improves sorting accuracy, and reduces manual labor and human error.

IV. METHODOLOGY

Connection Diagram



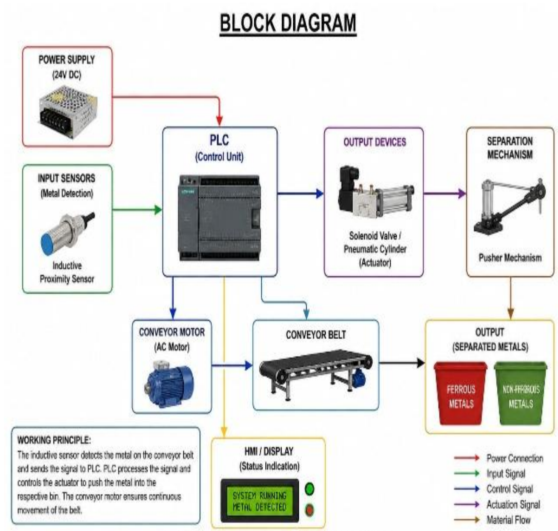


Figure 3.1: Block Diagram of Automatic Metal Separation Using PLC

The PLC-based Automatic Metal Separation System is designed to automatically identify and separate metal and non-metal objects on a conveyor, with all components working together seamlessly. The system consists of five main sections: the power supply unit, sensor detection unit, PLC control unit, pneumatic actuation unit, and final material collection unit. The power supply unit, featuring a 24V DC Switched Mode Power Supply (SMPS), provides a stable and regulated DC voltage necessary for the operation of the PLC, sensors, solenoid valves, and other control components. By converting the standard 230V AC mains supply into 24V DC, it ensures reliable and continuous functioning of the system. The sensor detection unit is responsible for identifying the type of material moving on the conveyor. Sensors detect the presence and characteristics of each object and send corresponding signals to the PLC. Acting as the central control unit, the PLC processes the input signals from the sensors according to the programmed logic. Based on this processing, it generates output signals to control the conveyor motor and the pneumatic actuation unit. The PLC ensures that objects are accurately sorted by activating the pneumatic system at the right moment, allowing precise separation of metal and non-metal materials. The pneumatic actuation unit uses air-driven mechanisms to physically direct the materials into the correct collection channels. It receives signals from the PLC to activate solenoid valves and cylinders, which then push or divert objects as required. Finally, the separated materials are collected in the designated final material collection unit. This ensures that metal and non-metal objects are sorted efficiently and safely, completing the automatic separation process with minimal human intervention.

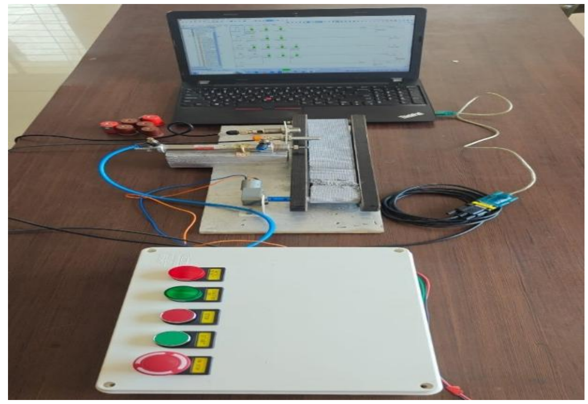
Inductive Proximity Sensor (Metal Detection)
The inductive proximity sensor is responsible for the non-contact detection of metallic objects on the conveyor belt. It operates by generating an electromagnetic field and monitoring any disturbances caused by the presence of a metal object within its sensing range. When a metal item passes through this field, the sensor detects the change and immediately sends a signal to the PLC. The PLC then processes this input and triggers the pneumatic separation mechanism, ensuring that the metal object is accurately diverted from non-metal materials. Solenoid

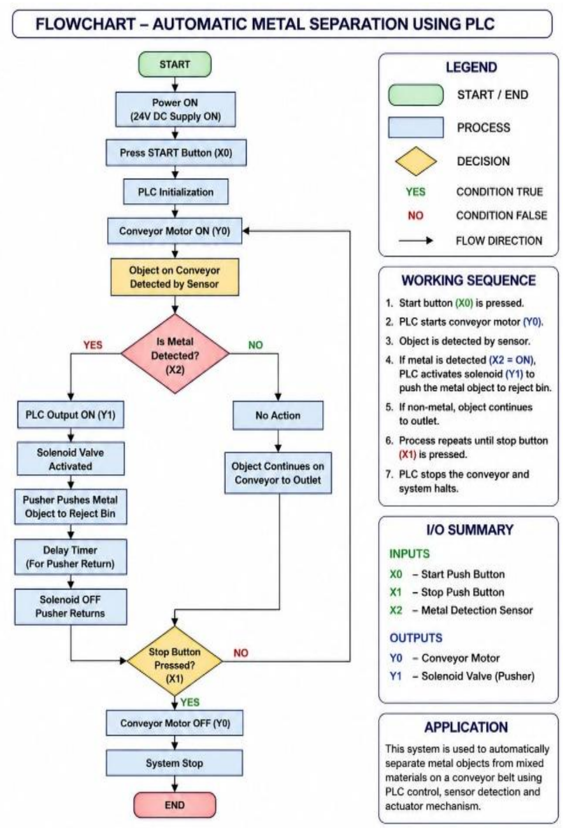
The solenoid valve functions as an electrically operated pneumatic control device, receiving ON/OFF signals from the PLC. When energized by the PLC, the valve opens, allowing compressed air to flow into the pneumatic cylinder. Once the signal is removed, the valve closes, stopping the air supply and releasing any remaining air through the exhaust, which halts the cylinder's motion.

Pneumatic-Cylinder
The pneumatic cylinder serves as the primary mechanical component for material separation. Upon activation of the solenoid valve, the cylinder extends to push the detected metal object away from the conveyor path and into the designated metal collection area. After completing this action, the cylinder retracts automatically to its initial position, ready to handle the next object efficiently.

Collection Bins (Metal and Non-Metal)
The sorted materials are directed into two separate collection bins. The metal bin receives all metallic objects diverted by the pneumatic cylinder, while non-metallic objects continue along the conveyor undisturbed and are deposited into the non-metal bin. This ensures an organized and efficient separation process with minimal manual intervention.

V. TESTING SETUP





VI. FLOWCHART OVERVIEW

The flowchart illustrates the step-by-step working of an automatic metal separation system using a PLC. It highlights the logical sequence from system start-up to the sorting of metal and non-metal objects, including decision points and actuator actions.
The automatic metal separation system operates under PLC control to sort metal and non-metal objects on a

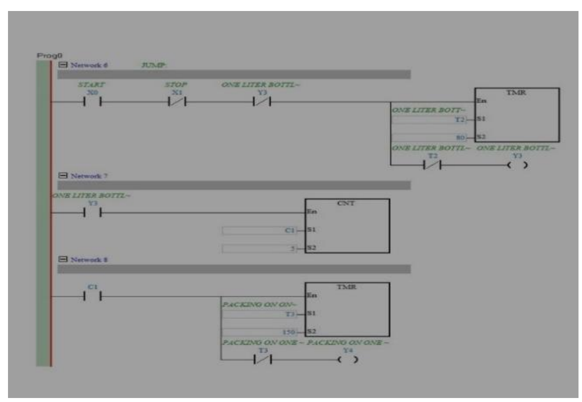
conveyor. The process begins when the 24V DC supply is turned on and the START push button (X0) is pressed, initializing the PLC and activating the conveyor motor (Y0). As objects move along the belt, sensors detect their presence and check for metallic content (X2). If a metal object is detected, the PLC triggers the solenoid valve (Y1), causing the pneumatic pusher to divert the metal into a designated reject bin, after which the pusher returns to its original position. Non-metal objects continue along the conveyor to the non-metal collection bin without interruption. This sequence repeats automatically until the STOP push button (X1) is pressed, at which point the PLC turns off the conveyor motor and halts the system. This setup ensures efficient, accurate, and fully automated separation of materials with minimal human intervention. The solenoid valve triggering logic is functioning accurately as per the program. The indicator lamp outputs are working as expected. Automatic Metal Separation using PLC is an industrial automation project developed to enhance the efficiency of material sorting in sectors such as recycling, The image depicts a PLC program written in ladder logic. It appears to be part of an automated system for handling objects, likely a filling or packing process, based on the identifiers like FALF LITER BOTTLE and PACKING ON FAL. The program is divided into multiple networks, each representing a functional segment of the process.

Review 1

- Strengths:
  - Modular network design makes it easy to troubleshoot and understand.
  - Proper use of timers and counters to control sequential operations.
  - Clear use of inputs/outputs with logical naming conventions.
- Possible Improvements:
  - Comments could be more descriptive to explain the purpose of each timer and counter.
  - Input/output names could be standardized for clarity (Y1, Y2 could reference specific actuators).
  - Safety interlocks (like emergency stop or sensor checks) could be explicitly added if not present.

Review 2

- Strengths:
  - Clear use of timers and counters for batch processing.
  - Modular networks make it easier to troubleshoot and maintain.
  - Logical sequencing ensures automation without manual intervention.
- Possible Improvements:
  - Add comments describing the purpose of each timer and counter for clarity.
  - Consistent naming conventions for inputs and outputs would improve readability.
  - Safety interlocks for emergency stops or miscounts could be explicitly implemented.



VII. CONCLUSION

The PLC-based Automatic Metal Separation System was successfully developed and tested. The system effectively separates metallic and non-metallic materials by using an inductive proximity sensor for metal detection and a pneumatic mechanism for separation. The PLC provides precise control,

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