Automatic Metal Separation Using PLC

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***Abstract*—Automatic metal separation is an essential industrial process used in recycling, manufacturing, packaging, and material handling systems. In many industries, the presence of unwanted metallic objects may cause serious damage to machinery, reduce product quality, and increase safety hazards. Manual sorting is time-consuming, costly, and unreliable due to human errors. Hence, an automated system is necessary to improve accuracy and productivity.**

This paper presents the design and implementation of an Automatic Metal Separation System using a Programmable Logic Controller (PLC). The system consists of a conveyor belt mechanism for transportation of mixed objects, a photoelectric sensor for object detection, and an inductive proximity sensor for metal identification. The PLC continuously monitors sensor inputs and controls the separation mechanism. When a metallic object is detected, the PLC activates a solenoid valve which controls a pneumatic cylinder to push the metal object into a separate bin. Non-metal objects continue moving along the conveyor belt without diversion.

The proposed system provides fast response, reliable separation, and continuous operation.

***Index Terms*—PLC, Conveyor Belt, Inductive Proximity Sensor, Photoelectric Sensor, Pneumatic Cylinder, Solenoid Valve, Industrial Automation.**

I. INTRODUCTION

In today's industrial environment, automation plays a major role in improving efficiency, accuracy, and productivity. Industrial sectors such as recycling plants, packaging industries, ASAfood processing, and manufacturing require the separation of metallic and non-metallic materials. The presence of metallic contaminants in manufacturing lines can lead to machinery damage, increased maintenance cost, and product contamination. A photoelectric sensor is also used to detect the presence of objects on the conveyor belt and synchronize separation timing. The combination of PLC and sensors ensures accurate and efficient separation.

Traditional separation methods mainly depend on manual sorting or simple mechanical processes. Manual separation requires high labor cost and is prone to human errors due to fatigue and lack of precision. Mechanical systems without automation are limited and cannot easily adapt to different material types and sizes. Therefore, an intelligent automated separation system is necessary for continuous and reliable operation.

Programmable Logic Controllers (PLCs) are widely used in industrial automation due to their robust design, reliability, and ability to operate in harsh environments. PLCs can process multiple input signals from sensors and provide output signals to actuators in real-time. In this project, PLC acts as the main controller that receives signals from sensors and activates the sorting mechanism automatically.

The proposed system uses an inductive proximity sensor for metal detection. Inductive sensors work on electromagnetic induction and detect metal objects without physical contact. A photoelectric sensor is also used to detect the presence of objects on the conveyor belt and synchronize separation timing. The combination of PLC and sensors ensures accurate and efficient separation.

II. LITERATURE SURVEY

Automation-based sorting systems have been widely researched in industrial applications. PLC-based sorting systems are considered more reliable compared to relay-based control systems. PLC provides fast execution speed, easy programmability, and flexible modification.

Inductive proximity sensors are commonly used for detecting metallic objects because they operate without

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electrical system's power factor and raise it to a target level.
Studies show that PLC-controlled pneumatic systems offer fast and accurate separation in material handling industries. Conveyor-based sorting is widely used because it supports continuous operation and reduces manual intervention. However, proper synchronization between sensor detection and actuator response is necessary for high accuracy.

III. OBJECTIVE

- To develop an automated metal separation system using PLC.
- To implement inductive proximity sensor for non-contact metal detection.
- To incorporate photoelectric sensor for object presence detection.
- To design PLC ladder logic for real-time decision making.
- To control solenoid valve and pneumatic cylinder for metal separation.
- To improve efficiency, accuracy, and reliability of separation process.
- To reduce manual labor and human error in sorting operations.

IV. METHODOLOGY

Block Diagram

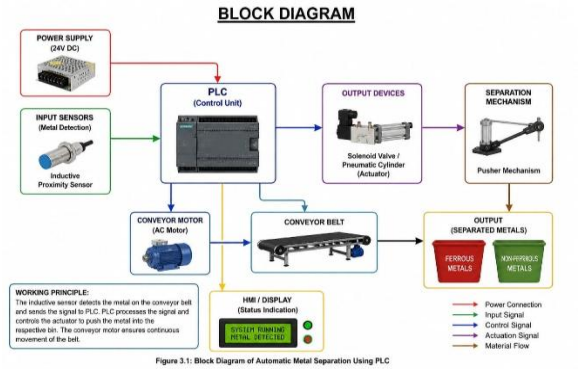


Figure 3.1: Block Diagram of Automatic Metal Separation Using PLC

Block Diagram (Combined Report Explanation)

The block diagram of the Automatic Metal Separation System using PLC represents the complete flow of operation and control. It shows how each component is interconnected to achieve automatic detection and separation of metallic and non-metallic objects. The system is mainly divided into power supply section, sensing section, control section, actuation section, and output collection section.

1. Power Supply (24V DC SMPS)
The 24V DC SMPS (Switched Mode Power Supply) provides regulated DC voltage required for the PLC, sensors, solenoid valve, and control circuits. It converts the 230V AC supply into 24V DC, ensuring safe and stable operation.

2. PLC Controller
The Programmable Logic Controller (PLC) is the main control unit of the system. It receives signals from sensors, processes them according to ladder logic programming, and generates output commands for controlling the conveyor motor and pneumatic separation mechanism. The PLC ensures accurate decision-making and timing control.

3. Conveyor Motor Drive
The conveyor motor drive consists of a DC geared motor with conveyor belt system. It is responsible for transporting the mixed materials (metal and non-metal) through the sensing area. The motor is controlled by the PLC through relay output.

4. Photoelectric Sensor (Object Detection)
The photoelectric sensor detects the presence of any object moving on the conveyor belt. When an object enters the sensing range, the sensor sends a signal to the PLC. This helps the PLC to identify that an object is approaching the metal detection area and ensures synchronization of the sorting process.

5. Inductive Proximity Sensor (Metal Detection)
The inductive proximity sensor is used for detecting metallic objects. It works on electromagnetic induction principle. When a metal object comes close to the sensor, it generates an output signal which is sent to the PLC. Non-metal objects do not activate this sensor.

6. Solenoid Valve

The solenoid valve is an electrically controlled pneumatic valve. It receives an ON/OFF command from the PLC. When energized, it allows compressed air to flow into the pneumatic cylinder. When de-energized, it stops the airflow and releases air through the exhaust port.

7. Pneumatic Cylinder (Actuator)

The pneumatic cylinder acts as the mechanical separation device. When the solenoid valve is activated, the cylinder extends and pushes the detected metal object away from the conveyor belt into a separate bin. After separation, the cylinder retracts back automatically for the next operation.

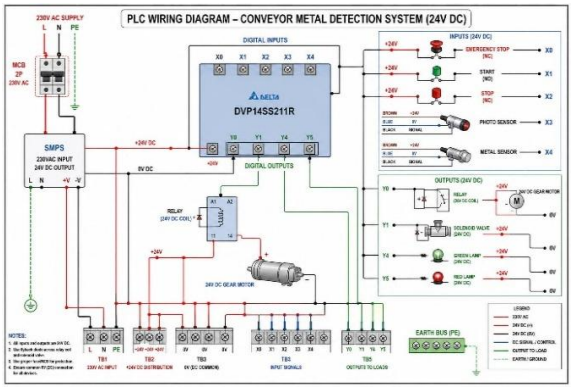
8. Collection Bins (Metal and Non-metal)

Finally, the separated objects are collected into two different bins:

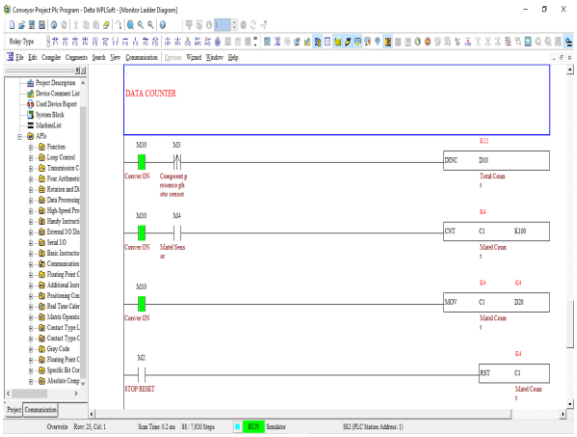
- Metal Bin: Metallic objects pushed out by pneumatic cylinder are collected here.
- Non-metal Bin: Non-metal objects continue straight on the conveyor and are collected separately.

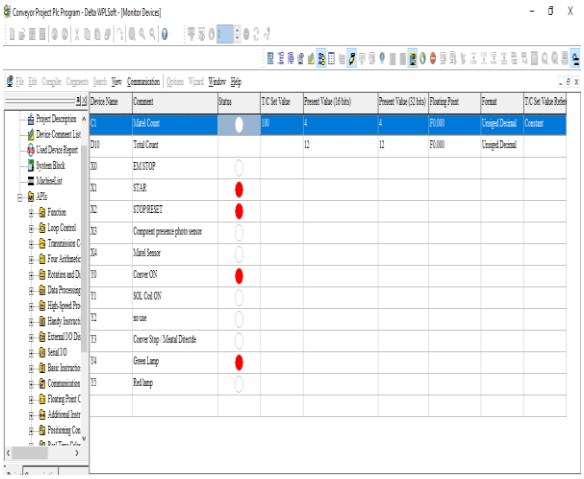
In summary, the conveyor transports objects to the detection zone. The photoelectric sensor confirms object presence, while the inductive sensor identifies whether it is metal. The PLC processes these signals and activates the solenoid valve and pneumatic cylinder to separate metal objects into a metal bin. Non-metal objects pass directly into the non-metal bin. Thus, the entire system achieves automatic and continuous metal separation with high efficiency and accuracy.

V. CIRCUIT DIAGRAM



VI. RESULT





RESULT (From Above PLC Ladder Diagram Output)

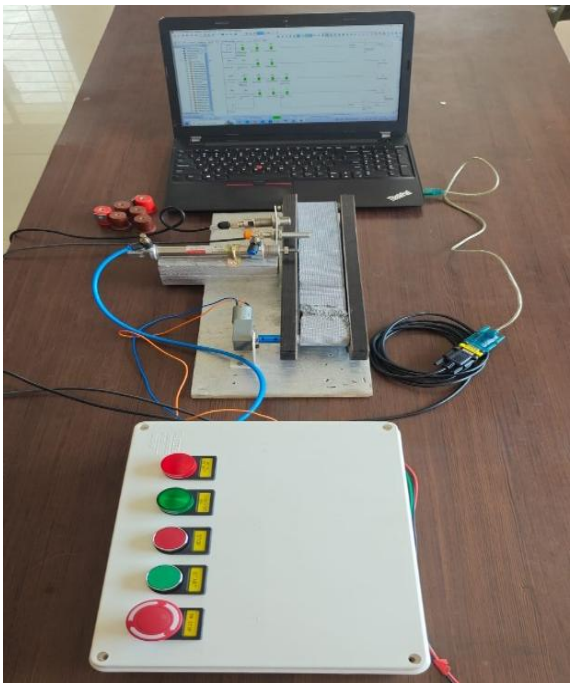
The above image shows the Delta WPLSoft PLC ladder logic in RUN mode, indicating that the program is successfully executed and the system is operating properly.

Observed Output Result:

- The PLC is in RUN condition, which confirms that the ladder program is uploaded and working.
- The Green Lamp Output (Y4) is ON, indicating that the system/conveyor operation is in running condition.
- The Red Lamp Output (Y5) is also shown active in the ladder logic, which indicates metal detection or fault indication as per programmed condition.
- The Solenoid Coil Output (Y1) is being controlled through the metal sensor logic, meaning when metal is detected, the solenoid valve gets activated for separation.
- Timer functions (T0 / T2) are used for delay

operation, ensuring proper timing between detection and actuation.

From the ladder logic monitoring, it is confirmed that: Conveyor motor logic is working Sensor input detection is properly processed Solenoid valve activation logic is correct Indicator lamp outputs are functioning Timers are working for delay and synchronization



Automatic Metal Separation using PLC is an industrial automation project designed to improve the efficiency of sorting processes in industries such as recycling, manufacturing, and waste management. The main purpose of this system is to automatically detect and separate metallic objects from non-metallic materials, thereby reducing manual labor, improving accuracy, and increasing productivity.

In this proposed system, a conveyor belt is used to carry mixed objects (metal and non-metal). A photoelectric sensor is used to detect the presence of an object on the conveyor belt, while an inductive proximity sensor is used to identify whether the object is metallic or not. The sensor signals are continuously monitored by the Programmable Logic Controller (PLC), which acts as the central control unit of the system.When a metal object is detected by the inductive sensor, the PLC immediately activates the solenoid valve. This solenoid valve controls a pneumatic cylinder which extends and pushes the metal object into a separate metal collection bin. After separation, the pneumatic cylinder retracts automatically and the system becomes ready for the next object. If the object is non-metallic, the inductive sensor does not generate a signal, so the PLC does not activate the pneumatic system, and the object continues moving on the conveyor belt into a different bin.

VII. CONCLUSION

The Automatic Metal Separation using PLC system was successfully designed and implemented. The system provides efficient separation of metallic and non-metallic objects using inductive sensor detection and pneumatic actuation. The PLC ensures accurate control and reliable continuous operation. This automation reduces human intervention, improves productivity, and enhances safety. The proposed design is modular and can be used in recycling, manufacturing, and industrial material handling processes.

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