Review Paper on Industrial Metal Segregation System Using Plc

Gourav G. Deshpande[1], Mr. Gaurav D. Jadhav[2], Mr.Ramchandra G. Pandhare[3], Mr.Ajit S. Nagane[4]
[1]*Assistant Professor, Mechanical Engineering, SMSMPITR AKLUJ (MS)*
[2,3,4]*B Tech Students, Mechanical Engineering, SMSMPITR AKLUJ (MS)*

***Abstract*—Industrial automation has become an essential part of modern manufacturing industries to improve productivity, accuracy, safety, and operational efficiency. One of the important applications of industrial automation is metal segregation using Programmable Logic Controllers (PLC). Industrial metal segregation systems are widely used in recycling industries, food processing plants, packaging industries, automotive industries, and manufacturing sectors for separating metallic and non-metallic objects automatically. This review paper presents a comprehensive study of PLC-based industrial metal segregation systems, including their working principles, sensors, conveyor mechanisms, control strategies, advantages, limitations, and industrial applications. Various research works related to automatic metal sorting and segregation using PLCs, proximity sensors, conveyors, and pneumatic actuators are analyzed. The review also discusses recent technological advancements such as integration of Human Machine Interface (HMI), Internet of Things (IoT), machine vision, and artificial intelligence with PLC systems. The paper concludes that PLC-based segregation systems significantly reduce manual effort, improve accuracy, increase production rate, and provide reliable industrial automation solutions. Future developments may focus on intelligent sorting systems using machine learning and Industry 4.0 technologies.**

***Index Terms*—PLC, Industrial Automation, Metal Segregation, Conveyor Belt, Proximity Sensor, Pneumatic System, Smart Manufacturing, Industry 4.0.**

I. INTRODUCTION

Industrial automation has transformed modern manufacturing industries by replacing manual operations with intelligent control systems. Among various industrial processes, material segregation plays a vital role in maintaining product quality and improving production efficiency. Manual sorting methods are often time-consuming, less accurate, and labor-intensive. Therefore, automated metal segregation systems using PLCs are becoming increasingly popular in industrial environments.

A Programmable Logic Controller (PLC) is a digital industrial computer designed for automation of electromechanical processes. PLCs provide reliable control, fast processing, easy programming, and flexibility in industrial applications. In metal segregation systems, PLCs are used to control conveyors, sensors, motors, and pneumatic actuators for detecting and separating metallic objects from non-metallic materials automatically.

The demand for automated segregation systems has increased significantly in recycling plants, manufacturing industries, food processing industries, pharmaceutical industries, and packaging sectors. These systems improve productivity, reduce human error, and ensure continuous operation with high efficiency. Recent research also focuses on integrating PLCs with IoT, HMI, machine vision, and artificial intelligence for smart industrial automation.

This review paper aims to provide a detailed study of industrial metal segregation systems using PLC technology and discusses different methodologies, sensors, industrial applications, advantages, limitations, and future research directions.

II. OVERVIEW OF PLC-BASED METAL SEGREGATION SYSTEMS

PLC-based metal segregation systems are automated systems designed to identify and separate metal objects from mixed materials. These systems generally consist of the following components:

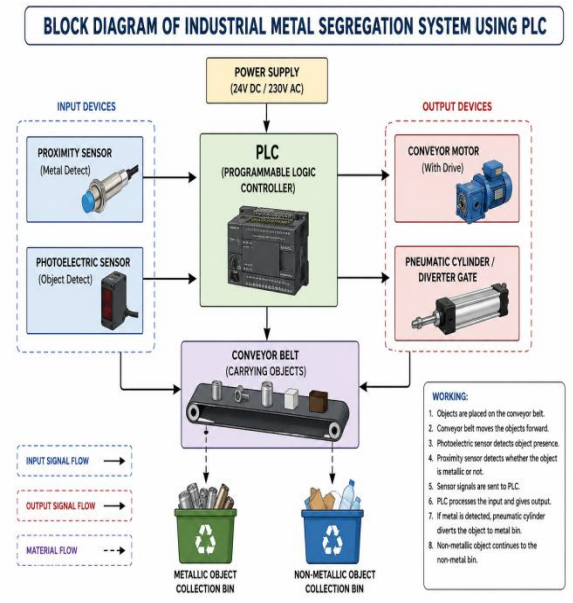
- Conveyor Belt System
- Programmable Logic Controller (PLC)
- Inductive Proximity Sensors
- DC/AC Motors
- Pneumatic Cylinders
- Relays and Contactors
- Human Machine Interface (HMI)
- Power Supply Unit

The conveyor transports objects continuously, while sensors detect metallic materials. The PLC processes sensor signals and controls actuators to segregate metal and non-metal objects into separate bins.

Recent studies show that PLC-based systems provide higher operational efficiency compared to traditional manual sorting systems. Automated systems also reduce production downtime and improve process accuracy.

III. WORKING PRINCIPLE OF INDUSTRIAL METAL SEGREGATION SYSTEM

The working principle of the industrial metal segregation system is based on automatic detection and separation of metallic objects using sensors and PLC logic control.



Step-by-Step Operation:

1. Objects are placed on the conveyor belt.
2. The conveyor moves materials toward the sensing section.
3. An inductive proximity sensor detects metallic objects.
4. The sensor sends signals to the PLC input module.
5. The PLC processes the input signal according to the ladder logic program.
6. The PLC activates the pneumatic actuator or diverter mechanism.
7. Metallic objects are separated into one collection bin while non-metallic objects move to another bin.

The PLC continuously monitors the sensor signals and controls the entire process in real time. Conveyor automation improves sorting speed and minimizes human intervention.

IV. LITERATURE REVIEW

4.1 PLC-Based Metal Sorting System

A study on PLC-based metal sorting systems discussed the use of conveyor belts, inductive sensors, and pneumatic cylinders for automatic segregation of metallic objects. The researchers observed that PLC-based automation improved efficiency by approximately 43% compared to conventional sorting methods.

4.2 Automatic Metal Separation Using PLC

Researchers developed an automatic metal separation system using PLC and conveyor mechanisms for separating different metal sizes. The system provided improved flexibility, reduced manual work, and enhanced industrial productivity.

4.3 Conveyor-Based Metal Sorting System

Another research work implemented a conveyor-based metal sorting machine using Omron PLC and proximity sensors. The system successfully detected metallic and non-metallic materials using photoelectric and inductive sensors.

4.4 PLC-Based Automatic Sorting System

A mini-scale PLC-based sorting system was developed using double-acting pneumatic cylinders and conveyor belts. The system demonstrated improved sorting speed and reduced industrial labor requirements.

4.5 Automatic Sorting Conveyor Belt Using PLC
Research on automatic sorting conveyor systems focused on height-based object segregation using photoelectric sensors and PLC programming. The study concluded that PLC automation improves industrial accuracy and productivity.

4.6 PLC-Based Color Sorting with Metal Detection
Researchers integrated color sensors and metal detectors with PLC systems for multi-parameter sorting applications. The system could identify object color and metallic properties simultaneously, improving industrial flexibility.

V. SENSORS USED IN METAL SEGREGATION SYSTEMS

5.1 Inductive Proximity Sensor
Inductive proximity sensors are commonly used for detecting metallic objects without physical contact. These sensors generate electromagnetic fields and detect disturbances caused by metal objects.
Advantages:
- Fast response time
- Non-contact operation
- High reliability
- Long operational life

5.2 Photoelectric Sensor
Photoelectric sensors detect objects using light beams. These sensors are mainly used for object counting and position detection on conveyor systems.

5.3 Capacitive Sensors
Capacitive sensors can detect both metallic and non-metallic materials based on dielectric properties.

5.4 Color Sensors
Color sensors are used in advanced sorting systems for identifying object colors along with metal detection.

VI. PLC PROGRAMMING TECHNIQUES

PLC programming is mainly performed using Ladder Logic Diagram (LLD), Function Block Diagram (FBD), and Structured Text (ST). Among these methods, ladder logic is the most widely used technique in industrial automation due to its simplicity and ease of troubleshooting.
PLC Programming Functions:
- Conveyor motor control
- Sensor signal processing
- Timer and counter operations
- Pneumatic actuator control
- Alarm and safety control
- Sequential operation management

PLC programming enables real-time industrial automation and ensures reliable operation under harsh industrial environments.

VII. ADVANTAGES OF PLC-BASED METAL SEGREGATION SYSTEMS

Advantages	Description
High Accuracy	Accurate detection and segregation of materials
Reduced Labor Cost	Minimizes manual intervention
Increased Productivity	Faster sorting operation
Reliability	Stable industrial operation
Flexibility	Easy modification of control logic
Safety	Reduced human exposure to hazardous conditions
Continuous Operation	Suitable for 24/7 industrial use

PLC systems also offer easy maintenance and fault diagnosis compared to conventional relay-based systems.

VIII. LIMITATIONS OF EXISTING SYSTEMS

Despite several advantages, existing PLC-based segregation systems still face certain limitations:
- Difficulty in detecting mixed composite materials
- Sensor sensitivity issues
- Limited adaptability to complex industrial environments
- Higher initial installation cost
- Requirement of skilled programming personnel

Advanced technologies such as artificial intelligence and machine vision are being explored to overcome these limitations.

IX. RECENT TRENDS AND FUTURE SCOPE

Modern industrial automation systems are moving toward Industry 4.0 technologies. Recent developments in metal segregation systems include:

- IoT-enabled PLC systems
- Wireless industrial monitoring
- SCADA integration
- Artificial Intelligence-based sorting
- Machine vision systems
- Cloud-based industrial monitoring
- Smart predictive maintenance systems

Future research may focus on intelligent self-learning segregation systems capable of identifying complex materials with higher precision and efficiency. Integration of deep learning algorithms with PLC systems can further improve industrial automation capabilities.

X. CONCLUSION

Industrial metal segregation systems using PLC technology play an important role in modern industrial automation. These systems improve operational efficiency, reduce labor dependency, enhance product quality, and provide reliable material segregation. PLC-based systems offer flexible programming, high-speed processing, and real-time industrial control, making them suitable for various industrial applications such as recycling, manufacturing, food processing, and packaging industries.

The review of existing literature indicates that automated segregation systems provide better performance than conventional manual methods. The integration of advanced technologies such as IoT, machine vision, and artificial intelligence further enhances system intelligence and industrial productivity. Future industrial automation systems are expected to become smarter, more efficient, and fully integrated with Industry 4.0 concepts.

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