International Journal of Scientific Research & Engineering Trends
Volume 11, Issue 3, May-June-2025, ISSN (Online): 2395-566X

# Metal and Non-Metal Sorting by Using Plc

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**Abstract- — The increasing need for automation in industries has led to the development of systems that can improve efficiency, accuracy, and reduce human involvement in repetitive tasks. This project, titled "Sorting of Metal and Non-Metal using PLC," focuses on designing an automated system that can differentiate and sort materials based on their metallic or non-metallic properties. Using a conveyor belt mechanism integrated with an inductive proximity sensor and controlled by a Delta DVP14SS2 PLC, the system detects the material type of objects and sorts them accordingly. The automation process ensures high- speed operation, consistent accuracy, and minimized errors compared to manual sorting. This project demonstrates the practical application of PLCs in industrial automation and material handling, offering a cost-effective and scalable solution suitable for small and medium-scale industries. The system is designed to be modular, allowing future expansion such as adding more sensors or integrating a vision system. It also promotes safety by reducing the need for manual intervention in hazardous working environments. The success of this project highlights the potential of automation to transform traditional material handling processes into more intelligent, reliable, and efficient systems. The implementation of such automated sorting systems can greatly benefit industries like recycling plants, manufacturing units, and quality control departments by streamlining their operations and ensuring greater precision. The integration of PLC technology not only makes the system more flexible and adaptive but also simplifies troubleshooting and future upgrades. Overall, this project sets a strong foundation for the future development of more advanced material classification and handling systems using automation and smart technologies.**

**Keywords: Industrial automation, Material sorting, Metal and non-metal detection, Delta DVP14SS2, Conveyor belt system.**

## INTRODUCTION

Automation has become a significant driving force in modern industrial sectors, enhancing productivity, improving accuracy, and reducing human errors. One crucial area where automation is making a substantial impact is in material handling and sorting. Industries such as recycling plants, manufacturing units, and quality control centers require efficient methods to segregate metallic and non-metallic objects. Traditional manual sorting methods are labor-intensive, slow, inconsistent, and prone to human errors. Therefore, the adoption of automated sorting systems has become essential to meet the demands of higher production rates, improved accuracy, reduced labor costs, enhanced workplace safety, and better quality control. Recognizing this industrial need, the project titled "Sorting of Metal and Non-Metal using PLC (Delta DVP14SS2)" has been undertaken to demonstrate a reliable, efficient, and cost-effective solution for automatic sorting based on material properties.

Industries dealing with bulk material processing face persistent challenges when it comes to the quick and accurate segregation of metals from non-metals. Manual methods not only reduce efficiency but also introduce errors and inconsistencies that can impact product quality and increase operational costs. Hence, there is a pressing requirement for a reliable, fast, and economical automated system capable of differentiating between metallic and non-metallic materials with high precision. The goal of this project is to develop a conveyor-based sorting system controlled by a Delta DVP14SS2 PLC, equipped with appropriate sensors to detect the nature of the material and sort it accordingly.

The primary objectives of this project are to design and fabricate a working model of an automated sorting system, detect and classify objects based on their material properties, control the overall process using the Delta DVP14SS2 PLC, and minimize human intervention during the operation. The system is also designed to be economical and suitable for small to medium-scale industries, while offering scalability for larger operations. Through this project, the real-world applicability of PLC-based control systems in automation is effectively demonstrated.

A Programmable Logic Controller (PLC) is a specialized industrial computer used to control manufacturing processes and machinery. Unlike general-purpose computers, PLCs are built to withstand harsh industrial environments, offering real-time operation, high reliability, modularity, and easy interfacing with field devices. PLCs operate by taking input signals from sensors, processing the logic programmed by the user, and generating appropriate outputs to control actuators and machinery. In this project, the Delta DVP14SS2 PLC is selected due to its compact size, affordability, ease of programming through ladder logic.

The sorting mechanism relies primarily on sensors, specifically inductive proximity sensors, to detect metallic objects. Inductive proximity sensors generate an electromagnetic field and can sense metallic objects without physical contact, making them ideal for automated sorting applications. When an object passes through the conveyor system, the proximity sensor detects whether it is metallic or non-metallic. If the sensor detects the presence of metal, a signal is sent to the PLC, which processes the input and activates a corresponding actuator to direct the metallic object to the designated collection bin. If the object is non- metallic, the absence of a signal triggers an alternative sorting path. Thus, the entire operation is handled automatically and efficiently by the PLC, ensuring a continuous and seamless sorting process.
The overall system comprises several critical components including a conveyor belt mechanism for object movement, an inductive proximity sensor for material detection, the Delta DVP14SS2 PLC for control logic, actuators for physical sorting of objects, power supply units, and a supporting structural frame. All components are integrated systematically to achieve synchronized operation. The entire working principle revolves around detecting an object's material property and appropriately sorting it through programmed automation, ensuring speed, precision, and repeatability.

**Problem Statement**
In industries such as recycling, manufacturing, and quality control, quick and accurate sorting of materials based on their properties is essential to ensure efficiency, reduce operational costs, and maintain high- quality standards. Traditional manual sorting methods are slow, inconsistent, labor-intensive, and prone to human errors, leading to reduced productivity and increased chances of material contamination. Furthermore, manual handling can expose workers to hazardous environments, impacting workplace safety. Therefore, there is a critical need for an automated, reliable, and cost-effective system that can differentiate between metallic and non-metallic objects with high precision and minimal human intervention.

**Need of Project:**
Industries today demand fast, accurate, and reliable sorting of materials to maintain high production quality and efficiency. Manual sorting is slow, error-prone, and labor-intensive, leading to increased costs and inconsistencies. Automated systems using PLCs solve these issues by ensuring consistent and precise operation. Sorting metallic and non-metallic objects quickly enhances workplace safety and product quality. Thus, an automated, economical, and scalable solution is urgently needed.

**Objective:**
The main objectives are to design and build an automated sorting system controlled by a Delta DVP14SS2 PLC. The system must detect and classify objects based on their material properties using sensors. It should minimize human intervention while ensuring reliability and accuracy. The model must be cost-effective for small industries and scalable for larger applications.

## II. LITERATURE SURVEY

| Sr.no. | Title of reasearch paper | Researcher | Methods used | Year |
|---|---|---|---|---|
| 1 | Study of power quality issues in metal sorting IEEE digital library | Sheila H, or Shobha Shankur | Based Metal Sorting | 2002 |
| 2 | National patterns of research output priorities in metal and non metal distribution policy | Mali Uzun | Based on distribution policy | 2 january 2002 |

| | | | | |
|---|---|---|---|---|
| 3 | Programmable logic controller | Bryan, L.A, &Bryan EA | Based on progrimming methods and applications | 2018 |
| 4 | Journal of sensor sorting | Chen, Y, Liu X& Wang.X | Based on sensor based sorting for metal and non-metal | 2019 |

Table 1: Literature Survey

## III. METHODOLOGY

Phase 1: Sensor Selection and Calibration

- **Selection of Proximity Sensor:** An inductive proximity sensor was chosen due to its ability to detect metallic objects without physical contact, ensuring durability and efficiency.
- **Calibration Process:** The sensor was calibrated using test samples of various metal and non-metal objects to establish a reliable detection range and sensitivity.
- **Accuracy Testing:** Calibration was verified by repeatedly testing the sensor's ability to distinguish between metals and non-metals under varying conditions, ensuring repeatability and reliability.
- **Mounting Considerations:** The sensor was strategically mounted above the conveyor belt at an optimal height to ensure that every object passes directly through the detection range.
- **Environmental Adaptation:** Adjustments were made to account for external factors like lighting conditions and electromagnetic interference, optimizing the sensor's performance in the workspace.

**Phase 2: PLC Programming**

- **Input Signal Configuration:** Inputs from the proximity sensor and push buttons were mapped to specific memory locations in the PLC program to ensure clear signal identification.
- **Output Logic Development:** Ladder logic was used to process input signals and trigger outputs, such as activating the sorting arm and controlling the conveyor motor.
- **Incorporation of Timers and Counters:** Timers were used to delay the sorting mechanism to ensure accurate actuation once an object was detected, while counters kept track of the number of sorted items.
- **Safety Interlocks:** The program included fail-safe logic to handle unexpected situations, such as sensor malfunctions or conveyor jams, to ensure smooth operation.
- **Modularity and Scalability:** The PLC logic was designed to allow easy modification or expansion for additional sorting categories or faster conveyor speeds.

**Phase 3: System Integration**

- Mechanical Alignment: The conveyor belt, proximity sensor, and sorting mechanisms were mechanically aligned for smooth and synchronized operation.
- Electrical Wiring: Connections between the proximity sensor, motor drivers, relays, and PLC were carefully executed to ensure a noise-free and reliable system.
- **Integration of Sorting Mechanism:** The sorting arms were connected to motors that were controlled by the PLC outputs, enabling the precise diversion of objects into their respective bins.
- **Component Communication Testing:** Subsystems were tested individually and then integrated, ensuring seamless communication between the PLC and all connected devices.
- **Cable Management:** Proper organization of wires was carried out to minimize electrical noise, avoid wear and tear, and improve the overall system's aesthetic and functionality.

**Phase 4: Testing and Validation**

- **Performance Testing:** The system was subjected to multiple test runs using a variety of metal and non-metal objects to evaluate detection and sorting accuracy.
- **Response Time Evaluation:** The conveyor speed and sorting gate actuation were adjusted to achieve synchronized operation without misplacements or delays.
- **Stress Testing**: The system was run continuously for long durations to evaluate mechanical durability and software reliability.

International Journal of Scientific Research & Engineering Trends
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- **Fine-Tuning:** Based on test results, adjustments were made to the sensor sensitivity, timers, and mechanical components to optimize performance.
- **Final Validation:** The complete system was validated by running it under real-world conditions, ensuring it met all desired objectives and efficiency standards.

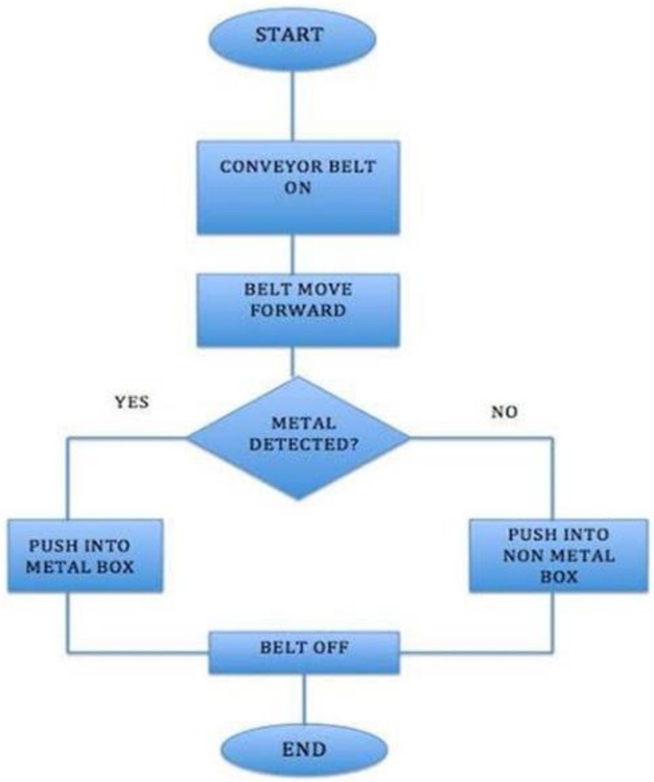


Figure1: Block diagram of the sorting process

The block diagram represents the complete sequential working of the automated metal and non- metal sorting system in a simplified visual format. It begins with the Start block, which symbolizes the initialization of the entire system, meaning that the power is turned on and the PLC is ready to control the operations. Immediately after starting, the Conveyor Belt ON block is executed, where the PLC sends a signal to the conveyor motor to turn it ON. This action activates the conveyor belt and sets it in motion.

As the objects travel along the conveyor belt, the system continuously checks for the presence of metal using the Metal Detected? decision block. This is a critical part of the process where the output of the inductive proximity sensor is constantly monitored by the PLC. If the sensor detects a metallic object (output is high), the flow follows the Yes path, triggering the next block titled Push into Metal Box. In this step, the system activates a mechanical actuator (such as a pushing rod or flap) that physically diverts the metallic object off the main conveyor path into a designated collection box meant exclusively for metals.

If the answer to the metal detection check is No — meaning the object is non-metallic (sensor output remains low) — then the flow follows the other branch towards the Push into Non-Metal Box block. Here again, a separate actuator mechanism or a simple continuation on the conveyor belt ensures that the non-metallic item is guided into a different collection box specifically designated for non-metal objects. This separation ensures that metals and non-metals are accurately sorted without any manual intervention.

After each sorting operation, whether the object is metal or non-metal, the process converges into the Belt OFF block. This block indicates that once an object is successfully sorted into the correct bin, the conveyor belt is stopped temporarily. Stopping the belt allows the system to prepare for the next object or batch of objects. It can also signify the completion of one sorting cycle, depending on how the PLC program is structured.

Finally, the process reaches the End block, which signifies that the sorting cycle for that particular object or batch is complete. The system may either reset to the Start position to process a new object, or it may remain halted based on how the operation is configured, such as awaiting manual restart or automatic continuous loop settings.
This block diagram efficiently captures the core sequence of operations — starting from system initialization, moving objects using a conveyor belt, detecting material type, sorting into correct bins, and then completing the sorting cycle — all under the intelligent control of the PLC and with the assistance of sensor and actuator technologies. It reflects a logical, step-by-step flow ensuring reliable automation, minimal errors, and high sorting efficiency in a simple yet structured manner.

**Highlights of block diagram**
The Start block initializes the PLC and prepares the system to run. Conveyor Belt ON powers the conveyor motor to start moving the belt. In Belt Move Forward, objects travel toward the sensor detection area.

Metal Detected? is a decision-making point based on proximity sensor feedback. If metal is detected (YES), an actuator pushes the object into the Metal Box.

If no metal is detected (NO), the object is guided into the Non-Metal Box. Sorting action uses mechanical actuators like pneumatic pushers or diverters. After sorting, Belt OFF stops the conveyor motor to conclude the operation. The End block marks the completion of one full sorting cycle.

The system demonstrates the effective use of PLC-controlled automation for material segregation.

## WORKING

Automation has become a cornerstone of modern industrial systems, providing an efficient, reliable, and cost-effective solution to tasks that were previously labor-intensive and prone to human error. One significant application of automation is the automated sorting of materials, particularly differentiating between metal and non-metal objects. Our project focuses on building an automated system that sorts metal and non-metal items using a conveyor belt, a programmable logic controller (PLC), and sensor technology. The overall objective of this project is to minimize manual labor, increase sorting speed and accuracy, and achieve higher levels of industrial safety and productivity. At the heart of the sorting process lies the fundamental concept of sensing. Sensors are devices that monitor physical conditions and provide real-time feedback to control systems. In this project, an inductive proximity sensor is employed. Inductive proximity sensors operate on the principle of electromagnetic induction. They emit an electromagnetic field from their sensing face. When a metallic object enters this field, eddy currents are induced within the metal, altering the field's characteristics. This disturbance is detected by the sensor, causing it to change its output signal. The beauty of inductive sensors is that they specifically respond to metals and completely ignore non-metallic materials like plastics, wood, or rubber, making them ideal for our metal and non- metal sorting application.

To process the information gathered by the sensor and make logical decisions based on it, a programmable logic controller (PLC) is utilized. A PLC is an industrial digital computer specifically designed for manufacturing and automation tasks. Unlike regular computers, PLCs are built to withstand extreme environmental conditions such as dust, moisture, temperature variations, and electrical noise. They are programmed using ladder logic or other high-level languages, allowing users to control processes in a logical sequence.

In this project, the PLC continuously monitors the output from the proximity sensor. When a metal is detected, the PLC triggers the actuator to direct the object towards the metal collection bin. If no metal is detected, the object is directed towards the non-metal collection bin. This logic ensures accurate and efficient sorting without the need for human intervention.

The mechanical structure of the project is centered around a conveyor belt mechanism. Objects are placed onto the moving conveyor belt, which transports them towards the detection area where the proximity sensor is stationed. The belt itself is driven by a DC motor controlled through a simple motor driver circuit connected to the PLC outputs. When the sensor identifies a metallic object, the PLC activates the sorting mechanism. This could be a mechanical flap or a rotating arm driven by a separate DC motor or actuator, which diverts the metallic item into its designated collection box. In the case of non-metallic items, the conveyor allows them to pass straight through into a separate bin. The entire mechanical structure is carefully designed to ensure a smooth transition of items from conveyor to sorting, without any blockage or mechanical jam.

Electrical integration plays a crucial role in ensuring that the system operates seamlessly. All the components, including sensors, motors, actuators, and the PLC, require proper electrical wiring and a reliable power supply. Sensors are usually connected to the input terminals of the PLC, while motors and actuators are connected through output terminals. Relays are often used to drive motors, providing isolation between the low-voltage control circuitry and high-power devices. Proper grounding, fuse protection, and circuit isolation are implemented to prevent damage to sensitive electronics. Signal integrity is maintained by keeping power cables and signal cables separate to avoid electrical interference.

Programming the PLC forms the brain of the operation. The logic begins with the initialization of input and output variables. The program enters into a continuous loop where it scans the input from the proximity sensor. When the sensor output becomes high, indicating the presence of a metallic object, the program sends an output signal to activate the actuator that diverts the object. Timers are used to ensure the actuator stays activated long enough to sort the object properly before returning to its normal position. If no metal is detected, the actuator remains in its default position, allowing the object to move forward into the non-metal collection area.

The logic also includes provisions for motor start and stop sequences, ensuring that the conveyor runs smoothly during the sorting process and halts safely when required.

Calibration of the sensor is an essential step before running the system. Calibration involves adjusting the sensitivity range of the proximity sensor to ensure it accurately detects metals of varying sizes without false triggering.

International Journal of Scientific Research & Engineering Trends
Volume 11, Issue 3, May-June-2025, ISSN (Online): 2395-566X

This is typically done by adjusting a potentiometer provided on the sensor or through software parameters. During calibration, different metallic and non-metallic objects are tested to fine-tune the sensor's response. Moreover, the mechanical alignment of the conveyor, sensor, and sorting flap is also critical. The sensor must be positioned close enough to detect metals reliably but not so close that it gets damaged by the moving objects.

Testing and validation of the complete system are conducted after sensor calibration, PLC programming, and mechanical integration. The system is first tested in dry runs without any objects to check motor operation, sensor triggering, and actuator responses. Once the basic functionality is verified, objects of different materials are introduced onto the conveyor belt. The system's ability to detect, sort, and move objects into their appropriate bins is observed. Any delays, mechanical issues, or sorting errors are noted and corrected. Testing also includes evaluating the system under continuous operation to ensure that the motors and sensors do not overheat and that the PLC handles long-term operations without faults.

The overall working of the project begins with the user placing different objects onto the conveyor belt. As the conveyor moves, each object passes under the proximity sensor. The sensor checks if the object is metallic. If a metal is detected, the sensor sends a high signal to the PLC. The PLC, after confirming the metal detection, triggers an actuator which physically moves the object off the conveyor into a designated metal collection bin. If the object is non-metallic, the sensor remains inactive, and the PLC allows the conveyor to continue moving the object straight into the non-metal bin. This continuous cycle ensures that all objects are sorted accurately and automatically without any manual intervention.

Advanced concepts are also embedded into the system. The conveyor speed is carefully controlled to match the sensor's response time. If the belt moves too fast, the sensor might miss detecting small metallic objects; if too slow, it reduces the sorting speed.

The entire system represents a miniature model of real-world industrial sorting processes used in recycling plants, manufacturing units, and material handling industries. In industries, such systems are scaled up with high-speed conveyors, industrial-grade sensors, and large actuators. PLCs used in industry also incorporate Ethernet connectivity, SCADA interfacing, and IoT integration for remote monitoring and control. In our project, while working on a smaller scale, the core principles remain the same and lay the foundation for more advanced industrial automation solutions.

In conclusion, the metal and non-metal sorting system using PLC is a perfect demonstration of how sensing technology, mechanical design, electrical integration, and logical programming work hand- in-hand to achieve a fully automated process. This project not only provides practical exposure to core concepts of industrial automation but also encourages innovation towards developing more efficient, scalable, and intelligent systems for the future of manufacturing and processing industries.

Figure.2: Front View of the Conveyor-Based Sorting System Model

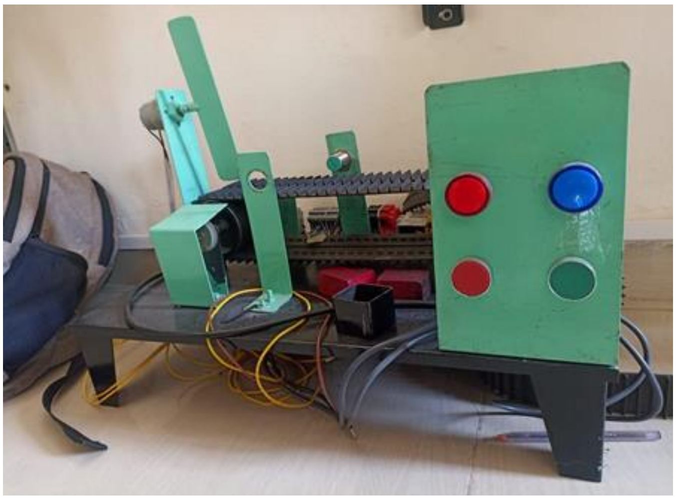

Figure3: Top View of the Conveyor-Based Sorting System Model

## IV. SYSTEM DEVELOPMENT

**Software details**

ISPSoft is a highly accessible programming software application for Delta's programmable logic controllers (PLC). With its modular editing interface, ISPSoft integrates hardware configuration, network configuration, and motion control programming into the same editingplatform. Our current implementation is based upon the software building for the project model. As mentioned initially, we are using ISPSoft 3.03 software for implementing the PLC ladder logic. The logic we have built is compiled error free in the software atmosphere. We have tried using the least number of networks for functioning of each part, at last we acquired a logic of total 18 Networks. Each network corresponds to the functioning of our model. The ladder logic is uploaded on the PLC using Cadyce Cable.

**Hardware detils**

- **Inductive Sensors (e.g., Pepperl+Fuchs, Turck)**
- Model: IND101, IND201
- Input Type: Digital
- **Capacitive Sensors (e.g., Balluff, Sick)**
- Model: BCS101, SICK101
- Input Type: Digital
- **Optical Sensors (e.g., Banner, Keyence)**
- Model: OLS101, KV101
- Input Type: Digital
- **X-ray Fluorescence (XRF) Sensors (e.g., Olympus, Thermo Fisher)**
- Model: XRF101, TFD101
- Input Type: Analog

**SOFTWARE EXECUTION**

Network 1

As the conveyor is run through an electric motor, we have used a single push button on/off ladder logic method to turn on and off the conveyor. The given Ladder Diagram (LD) is designed for setting sensor memory in a conveyor system. When sensor B1 (input %I1.0) is activated, it sets a memory bit (%M1.0, labeled "B1M") and turns ON two outputs (%Q0.1 labeled "1Y2" and %Q0.3 labeled "2Y2"). These outputs are likely controlling parts of the conveyor system, such as motor starters or actuators, to move or sort items. Similarly, when sensor B2 (%I1.1) is triggered, it sets the memory bit %M1.1 ("B2M"), and when sensor B3 (%I1.2) is triggered, it sets memory bit %M1.2 ("B3M"). Setting these memory bits helps the PLC retain the status of the sensors for further logic processing, even if the sensor signal disappears quickly. Overall, this network ensures that the conveyor system responds appropriately when items are detected by different sensors along the conveyor path.

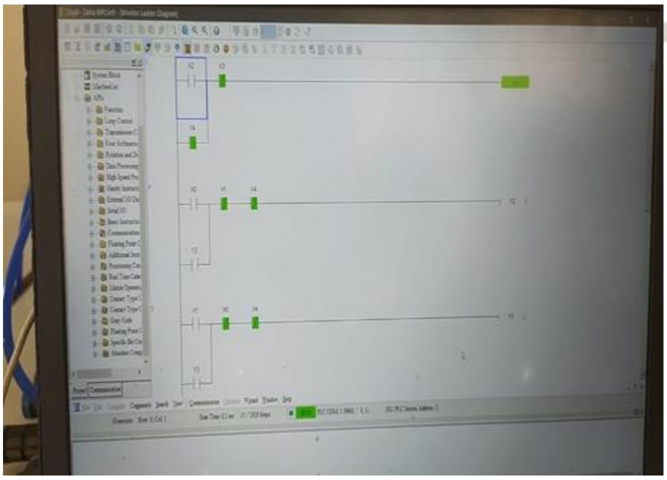

Figure4: Conveyor ON/OFF

Network 2

The Ladder Diagram (LD) shown is designed to set sensor memory for a conveyor control system. When the sensor B1 (input %I1.0) detects an object, it activates and sets a memory bit (%M1.0 labeled "B1M") and simultaneously turns ON two outputs (%Q0.1 "1Y2" and %Q0.3 "2Y2"), likely used for starting conveyor motors or other actuators. Similarly, when sensor B2 (%I1.1) is triggered, it sets the memory bit %M1.1 ("B2M"), and when sensor B3 (%I1.2) is triggered, it sets memory bit %M1.2 ("B3M"). These memory bits are used to store the state of the sensors even if the actual physical input turns OFF quickly. This logic ensures the conveyor system properly tracks and processes items detected by the sensors along the line.

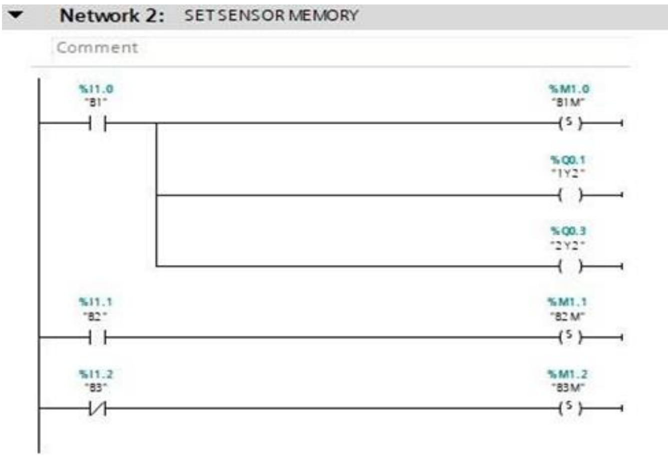


Figure5: Set Sensor Memory

Network 3

It is the main sorting program that decides which object will be sorted at what station. Using this ladder logic program, we have

sorted all three materials i.e. plastic, metal, and wood in their respective collectors The Ladder Diagram (LD) in Network 3 is designed for a sorting program in a conveyor system using memory bits and timers. The first two rungs control outputs %Q0.0 ("1Y1") and %Q0.2 ("2Y1") based on the status of memory bits %M1.0 ("B1M"), %M1.1 ("B2M"), and %M1.2 ("B3M"). If all three memory bits are set, %Q0.0 and %Q0.2 are energized, likely activating sorting devices or conveyors. In the lower part of the network, two ON-delay timers (TON) are used. The first timer (%DB1) is triggered by input %I0.5 ("1B1") and, after a preset time of 5 seconds, it turns ON output %Q0.1 ("1Y2"). Similarly, the second timer (%DB2) is triggered by input
%I0.7 ("2B1") and after the same preset time, it turns ON output %Q0.3 ("2Y2"). These timers are used to delay actions to ensure proper timing and coordination in the sorting operation, preventing immediate switching and allowing smoother material handling on the conveyor.

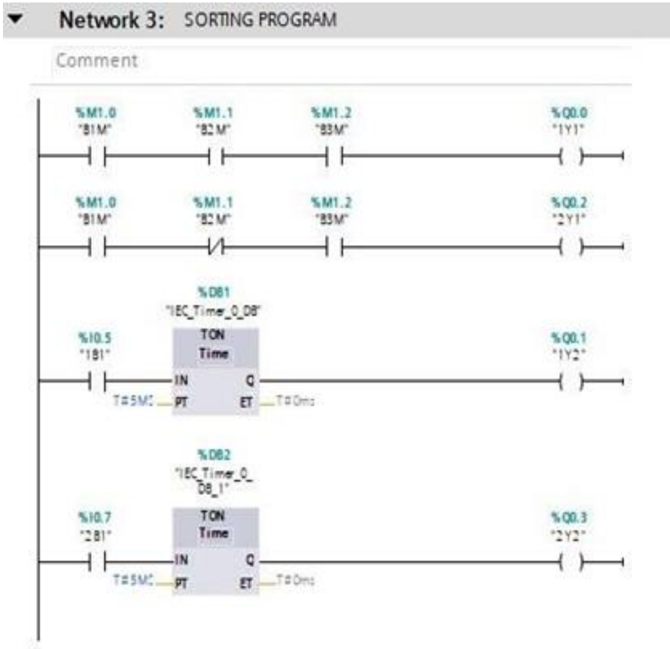


Figure6: Sorting Program

**Lamp And Switches**

A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive proximity sensor or photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor always requires a metal target.[citation needed]

Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between the sensor and the sensed object.

Proximity sensors are also used in machine vibration monitoring to measure the variation in distance between a shaft and its support bearing. This is common in large steam turbines, compressors, and motors that use sleeve-type bearings

Figure7: Lamp and Switches

**DC Motors**

A DC motor is a rotational electrical machines that changes over direct flow electrical energy into mechanical energy. The most well-known sorts depend on the powers delivered by magnetic fields. About a wide range of DC engines have some inward component to intermittently alter the course of current stream in part of the engine.

DC engines were the principal type broadly utilized, since they could be fueled from existing direct-current lighting power distribution system. A DC motor's speed can be controlled over a wide range, utilizing either a variable supply voltage or by changing the quality of current in its field windings. Little DC engines are utilized in instruments, toys, and apparatuses. The all inclusive engine can work on direct current however is a lightweight brushed engine utilized for convenient power instruments and machines. Bigger DC engines are utilized in impetus of electric vehicles, lift and raises, or in drives for steel moving plants.

Figure 8: DC Motor

**PLC**

Delta Electronics is a well-known global manufacturer of industrial automation products, and its Programmable Logic Controllers (PLCs) are widely recognized for reliability, flexibility, and cost- effectiveness. In your project, you are using the Delta DVP14SS2 model, which belongs to the DVP-SS2 series, designed for small and medium automation tasks.

The Delta DVP14SS2 PLC is a compact, high-speed, and cost-efficient controller ideal for applications requiring precise control and quick response. It supports basic sequential control, timer, counter, data processing, and communication operations. It is especially popular in simple material handling, sorting, and machinery control systems.

Key Features of Delta DVP14SS2 PLC:

- Model: DVP14SS2
- Type: Compact, Basic Sequential Control PLC
- Input/Output:

**Digital Inputs**

**Digital Outputs (Relay or Transistor types depending on model)**

- **High-Speed Processing:** Basic instruction execution speed is around 0.35 µs per instruction, allowing for fast response times.
- **Programming Language:** Ladder Diagram (LD), supporting intuitive control logic development.
- **Program Capacity:** 8k steps.
- **Data Register Capacity:** 5k words.
- **Communication:**

Built-in RS-232 and RS-485 ports

Supports MODBUS ASCII/RTU protocols, making communication with HMIs, drives, and sensors easy.

- **Expansion Capability:**
- Supports additional expansion modules for digital and analog inputs/outputs if needed.
- **Memory:** Non-volatile memory ensures that programs are retained even after power loss.
- **Power Supply**: Typically operates with a 24V DC power input.
- **Compact Size**: Suitable for installation in small panels or machine-mounted enclosures.
- **Reliability:** Built to withstand industrial environments including moderate temperature variations, dust, and vibration.


Figure9: Delta PLC ( DVP14SS2)

**Conveyor Belt**

A conveyor belt is a mechanical system consisting of a continuous moving belt that transports objects from one place to another. In your project, the conveyor belt plays a crucial role in moving the materials (metallic and non-metallic objects) through the sensing and sorting area. It acts as the backbone of the automated material handling system by providing a controlled and consistent motion for proper object detection and sorting.

The use of a conveyor belt ensures the objects move at a regulated speed, allowing sensors and the PLC system to detect and sort materials accurately without human intervention.

Key Features of the Conveyor Belt:

- **Material:**

Typically made of rubber, PVC, or PU for small models.

The frame is usually aluminum or mild steel for lightweight and durability.

- **Motion Type:**

Continuous, unidirectional movement driven by a DC motor or gear motor.
Speed can be controlled using motor drivers or external control circuits.

- **Motor:**

12V DC motor (common in small projects) or geared motor for higher torque and controlled speed.
Optional: Use of variable speed control for adjusting the belt speed as needed.

- **Length and Width:**

Designed according to object size; typical dimensions for small projects are 500mm– 1000mm in length and 100mm–300mm in width.

- **Power Source:**
- Runs on 12V or 24V DC (common for project models).

**Rollers:**
Cylindrical rollers fitted at both ends to rotate the belt smoothly.
Supported by bearings for minimal friction.
**Speed:**
Typically set between 0.1–0.5 meters/second in small systems to allow proper sensing and sorting.

- **Support System:**

Rigid base frame made of metal or hard plastic to support the belt tension and motor assembly.

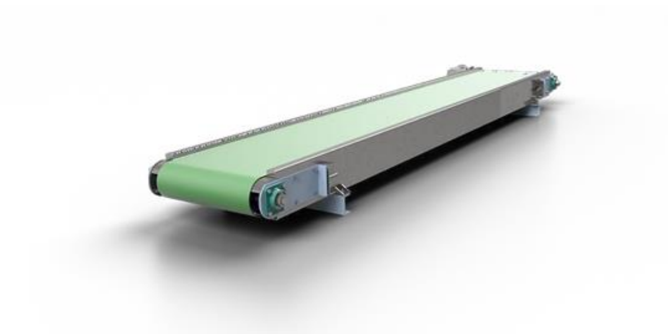

Figure10: Conveyor Belt

## V. ADVANTAGES & LIMITATION

**Advantages**

- **High Speed:** The system sorts objects much faster than manual methods, increasing overall throughput.
- **Improved Accuracy:** Sensors and PLC logic ensure precise sorting with minimal errors.
- **Reduced Labor Cost:** Automation eliminates the need for manual sorting, saving labor expenses.
- **Continuous Operation:** The system can run for long hours without fatigue or efficiency loss.
- **Compact Design:** The setup is space-saving, making it suitable for small and medium industries.
- **Low Maintenance:** Simple components and clear wiring make maintenance easy and cost-effective.
- Enhanced Safety: Reduces human exposure to moving machinery and potential injuries.
- Consistency: Every object is sorted according to the same programmed standards, ensuring uniform quality.
- Energy Efficient: Uses less power compared to fully manual operations and larger automated systems.
- **Scalability:** Can be upgraded with additional features like vision sensors or larger conveyors for bigger applications.


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- **Compact Design:** The setup is space-saving, making it suitable for small and medium industries.
- **Low Maintenance:** Simple components and clear wiring make maintenance easy and cost-effective.

- **Enhanced Safety:** Reduces human exposure to moving machinery and potential injuries.
- **Consistency:** Every object is sorted according to the same programmed standards, ensuring uniform quality.
- **Energy Efficient:** Uses less power compared to fully manual operations and larger automated systems.
- **Scalability**: Can be upgraded with additional features like vision sensors or larger conveyors for bigger applications.

**Limitations**

- **Limited Material Detection:** Only metallic and non-metallic differentiation is possible; complex material types cannot be identified.
- **Fixed Sorting Criteria:** The system cannot adapt to new materials without reprogramming.
- **Sensor Sensitivity:** Inductive sensors may not detect very small or low-metal content objectsaccurately.
- **Mechanical Wear**: Conveyor belts and moving parts may suffer wear and require regular maintenance.
- **Limited Load Capacity:** The model may not handle very heavy or large-sized objects.
- **No Shape or Size Sorting:** The system only sorts based on material, not on object dimensionsor shapes.
- Manual Loading Required: Objects must still be placed manually on the conveyor unless fully automated.

- **Space Limitation:** Scaling up for industrial use needs more space and stronger construction.
- **Environmental Sensitivity**: Dust, moisture, and vibrations can affect sensor performance.
- **Initial Setup Cost:** Although economical for small setups, full industrial versions can be costly to build initially.

**Cost Estimation**

| Sr.No | Component | Price of Component in Rs. |
|---|---|---|
| 1. | PIC | 4,000 |
| 2. | Dc Motor | 1,900x2=3,800 |
| 3. | Proximity sensor | 326x2=652 |
| 4. | Metal Frame | 1000 |
| 5. | Connecting Wire | 100 |
| 6. | Lap and switches | 2600 |
| 7. | Conveyor Belt | 1200 |
| | Total | 13,325 |

## VI. CONCLUSION

The project titled "Sorting of Metal and Non-Metal Using PLC" was undertaken with the primary aim of designing and developing an automated sorting system capable of differentiating objects based on their material properties. The use of the Delta DVP14SS2 Programmable Logic Controller (PLC) and inductive proximity sensors provided an efficient, reliable, and scalable solution to one of the critical needs of various industries – the quick and accurate segregation of metallic and non- metallic materials. This project successfully demonstrated the significant advantages that automation brings to industrial applications, including increased productivity, improved accuracy, reduced labor costs, enhanced workplace safety, and consistent product quality.

Throughout the development and implementation of this project, a deep understanding of PLC programming, sensor integration, conveyor design, and system synchronization was achieved. The conveyor mechanism combined with precise sensor detection and PLC logic enabled the system to sort materials seamlessly with minimal human intervention. This reflects real-world industrial practices where automation plays a pivotal role in maintaining continuous and efficient operations. Despite its success, the system has its limitations, such as the inability to sort based on size, shape, or non-metallic subcategories, and potential challenges posed by environmental conditions affecting sensor performance. However, these limitations present opportunities for future enhancements, such as integrating vision systems, multiple sensor types, and SCADA integration for centralized monitoring and control. The project also offers a strong foundation for further scaling the system to handle larger and more diverse types of materials, incorporating artificial intelligence for smarter sorting, and improving the robustness of the design for industrial-grade applications.

In conclusion, the project not only meets its intended objectives but also highlights the broader potential of PLC-based automation systems in addressing modern industrial challenges. It showcases how even relatively simple automation technologies can greatly enhance operational efficiency, accuracy, and cost-effectiveness.

This project experience has also been instrumental in strengthening practical skills related to automation technology, system design, programming, and industrial equipment handling, preparing the team for future contributions to the field of industrial automation and smart manufacturing.

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