METAL & NONMETAL SORTING CONVEYER BELT

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Abstract: The increasing demand for efficient recycling and waste management has led to the development of automated sorting technologies. Manual separation of metals and nonmetals is time-consuming, error-prone, and often hazardous to workers, creating a need for a reliable automated solution. This project presents the design and implementation of a metal and non-metal sorting conveyor belt system that integrates sensors, microcontrollers, and actuators for real-time classification of materials. The system is designed to detect metallic objects using inductive sensors, while optical or capacitive sensors are employed for identifying nonmetallic materials. Once identified, objects are automatically diverted into separate bins through a conveyor-based mechanism, eliminating human intervention and improving process efficiency. The proposed system not only reduces operational costs but also enhances sorting accuracy and speed, making it highly suitable for industrial automation, recycling plants, and waste management facilities. The project utilizes a programmable control unit for synchronization of the conveyor, sensors, and sorting actuators, ensuring seamless integration of hardware and software. Experimental results demonstrate that the system is capable of achieving consistent performance in distinguishing between metal and nonmetal objects of varying shapes and sizes. Furthermore, the modular design makes the system scalable and adaptable for diverse industrial applications.

Keyword: Metal sorting, Non-metal detection, Conveyor belt system, Microcontroller-based automation, Real-time sorting, Industrial waste management.

I. INTRODUCTION

In the modern industrial era, automation has become a necessity, particularly in applications demanding speed, precision, and safety. One of the most critical operations is the sorting of metallic and non-metallic materials, which is essential in manufacturing, recycling, packaging, and logistics industries. Traditionally, segregation has been performed manually, where workers physically separate items based on their type. While effective in the past, manual methods are slow, error-prone, labor-intensive, and unsafe when handling sharp or hazardous objects. This leads to production delays, safety risks, and higher operational costs.

The real-time challenge lies in handling large volumes of mixed materials with both accuracy and efficiency. In the recycling sector, distinguishing metals such as aluminum, copper, and steel from non-metallic items like plastics, paper, or glass directly impacts recovery efficiency and profitability. In food and pharmaceutical industries, even small metallic contaminants can result in serious health hazards, product recalls, and financial penalties. Likewise, in logistics, conveyor-based parcel sorting systems must process thousands of packages per hour, where errors can cause delays and customer dissatisfaction. Similar demands exist in mining and material processing, where accurate separation of ores and minerals is directly tied to productivity and revenue.

Existing sorting methods often fall short of meeting these requirements. Manual sorting is inefficient, while semi-automated systems are limited by poor adaptability to variations in material size, shape, and environmental

conditions. Machine vision provides accuracy but is costly and requires controlled environments. Sensor-based systems such as inductive or optical sensors perform well in specific cases but lack flexibility for complex mixed streams. To overcome these limitations, modern conveyor-based sorting systems integrate multiple sensing techniques, AI-driven decision-making. By combining metal detectors, inductive sensors, machine vision, and IoT-enabled monitoring, these systems provide real-time adaptability, predictive maintenance, and scalable solutions for high-speed industrial material sorting.

II. LITERATURE SURVEY

Waste material sorting plays a vital role in recycling, industrial automation, and sustainable resource management. Manual sorting is slow, error-prone, and unsuitable for large-scale operations, which has led to the development of automated solutions. Early studies focused on mechanical and conveyor-based systems, such as Arduino-controlled segregation of plastic, metal, and glass [1] and PLC-based conveyor automation [6]. Sensor technologies like color vision, inductive arrays, and optical sensors have been widely applied to detect and classify different materials [7], [8]. High-speed and vision-guided sorting mechanisms have further improved accuracy and throughput [4]. With the growth of artificial intelligence, modern systems employ machine learning and deep learning for more accurate waste classification, as shown in the comparison of SVM and deep learning approaches [2]. Robotics has also been integrated, with color-sorting robots [9] and automatic sorting machines [11], offering improved efficiency and adaptability. Overall, research shows a clear transition from basic mechanical methods to intelligent, AI-driven automated sorting systems, which are more reliable, scalable, and sustainable.
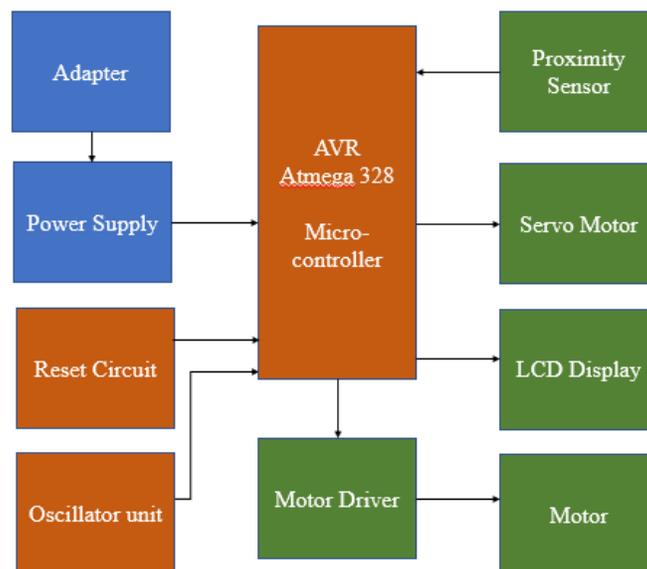
III. PROPOSED SYSTEM

Fig.1: Block diagram

The block diagram of the conveyor-based sorting system illustrates the working of each component and their interconnections. The system is powered by an adapter connected to the power supply unit, which provides regulated voltage to all components. A reset circuit ensures that the AVR Atmega328 microcontroller starts correctly, while the oscillator unit generates the necessary clock pulses for its operation. The Atmega328 acts as the central controller, receiving signals from the proximity sensor to detect objects placed on the conveyor. Once detected, the microcontroller processes the data and decides the sorting action. It then controls the servo motor to divert the object into the appropriate bin based on its classification. The LCD display shows real-time information such as the object type and count. The motor driver, controlled by the microcontroller, powers the conveyor motor to move objects forward on the belt. Together, these components form an automated system that detects, classifies, and sorts materials efficiently with minimal human intervention.
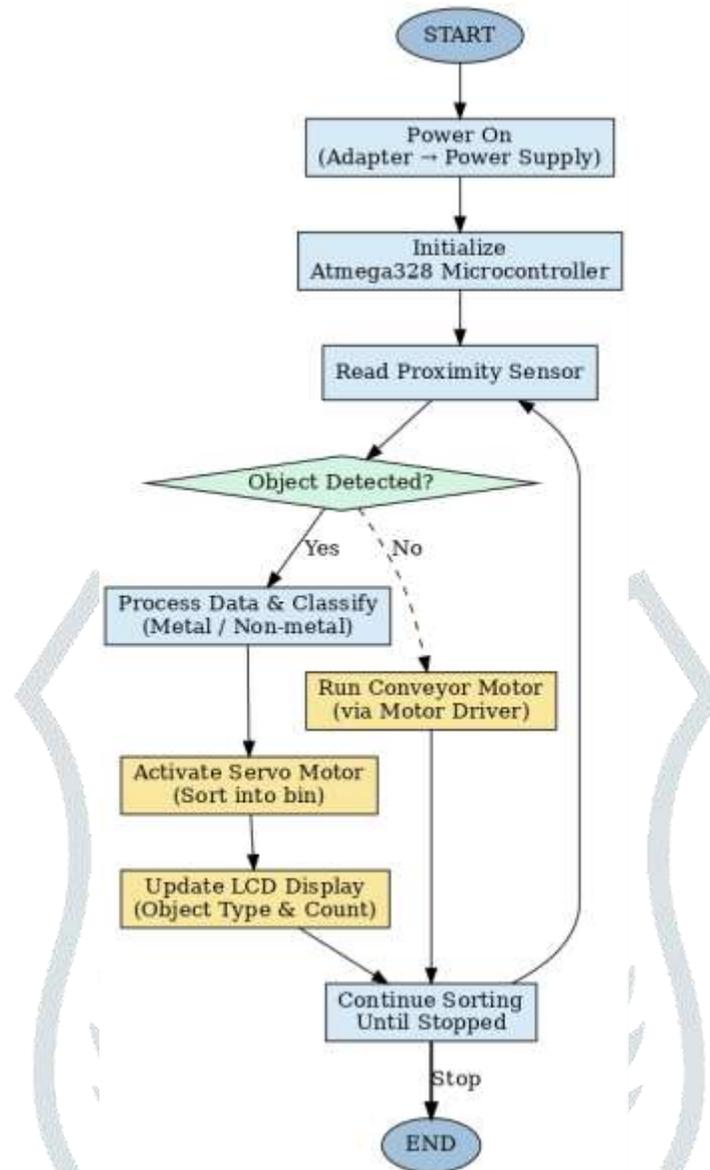
Fig.2: Flowchart

The flowchart depicts the operation of an automated object sorting system using an Atmega328 microcontroller. The process begins with powering on the system, supplying electricity to the microcontroller and connected components. The Atmega328 is then initialized, setting up the necessary configurations for sensor readings and motor control. The system continuously reads input from a proximity sensor to detect the presence of an object. When an object is detected, the system processes the data to classify it as either metal or non-metal. Based on this classification, the servo motor is activated to sort the object into the appropriate bin. Simultaneously, the LCD display is updated to show the type of object and maintain a count of items sorted. If no object is detected, the conveyor motor is run to move objects along the sorting line, and the system continuously loops back to read the proximity sensor, ensuring uninterrupted sorting. This cycle continues until the system is manually stopped, at which point the process ends. The flowchart efficiently outlines the sequential and conditional steps involved in automated object detection, classification, sorting, and display updating in a real-time sorting mechanism.

IV. RESULT & DISCUSSION

The working principle of the metal and non-metal sorting conveyor belt is based on the integration of sensors, a microcontroller, and an automated conveyor mechanism. When the system is powered on, the conveyor belt begins to move and carries materials one by one towards the sensing unit. As an object reaches the sensor section, an inductive proximity sensor detects the presence of metallic objects by responding to changes in its electromagnetic field. If the object is metallic, the sensor generates an electrical signal that is transmitted to the microcontroller for

processing. For non-metallic materials, such as plastic or wood, the inductive sensor does not respond, and instead, an optical or capacitive sensor is used to confirm their presence. The microcontroller continuously monitors the inputs from these sensors and determines the category of the object in real time.
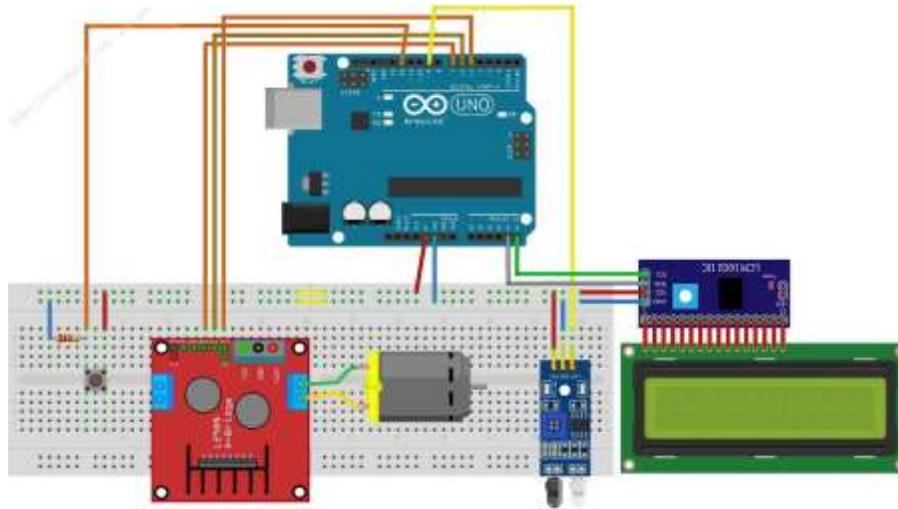

Fig.3: Circuit diagram

Based on the decision, the controller activates a sorting mechanism such as a pneumatic actuator, solenoid, or servo motor, which pushes or diverts the object into the designated bin. The conveyor system ensures continuous material flow, allowing objects to be classified without manual intervention. The synchronization between conveyor speed and sensor response is critical to avoid errors, which is managed by programming control logic into the microcontroller. The entire process is automated, enabling faster sorting, consistent accuracy, and reduced human involvement in hazardous or labor-intensive environments. Additionally, the modular nature of the system allows it to be scaled up for larger industrial applications or integrated with advanced technologies such as IoT monitoring, data logging, or machine vision for improved functionality.

V. CONCLUSION

The study highlights the importance of developing automated sorting systems to address the inefficiencies of manual classification of metal and non-metal objects. Existing research demonstrates progress using vision systems, electrostatic separation, and basic automation techniques, but these solutions often face challenges in cost, complexity, or limited adaptability. In this work, the focus is on a microcontroller-based conveyor belt system, which provides a low-cost, flexible, and efficient solution for real-time material segregation. By integrating simple sensors with microcontroller control, the system ensures accurate, continuous, and safe sorting without relying on complex or expensive PLC architectures. This approach supports industrial needs by reducing human intervention, improving speed, and promoting effective recycling. Future work can extend this system by incorporating IoT-based monitoring and AI for enhanced decision-making.

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