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Design and Development of Automated Sorting System For Warehouse Products

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Abstract: *In modern warehouses, fast and accurate product handling is necessary to meet increasing market demand. Manual sorting of products requires more labour, consumes time, and may create errors during operation. To overcome these issues, an automated sorting system was designed and developed using an Allen-Bradley PLC and an Arduino Uno controller. The proposed system utilises an infrared proximity sensor to detect products moving on a conveyor belt. The PLC controls the conveyor motor and relay module, based on the programmed logic, the Arduino controls the MG996R servo motor to divert product into separate bins. To provide a stable voltage supply to low-voltage components, a buck converter is used. Under certain practical conditions, the complete model was tested, and it showed reliable product detection and smooth sorting operation. The system improves speed, increases sorting accuracy, and reduces manpower. This project is suitable for packaging units, small warehouses, and industrial automation learning purposes.*

Keywords: PLC, Arduino Uno, Servo Motor, Conveyor Belt, Infrared Sensor, Automated Sorting, Warehouse Automation

I. INTRODUCTION

In today's digital world, online shopping has become a part of everyday life, where companies like Amazon, Flipkart, and other e-commerce giants handle millions of orders each day, delivering products across the globe. Every stage of their supply chain, from storage to packaging and dispatch, needs to be quick, reliable, and well-organised to keep up with the growing demand and ensure fast and accurate deliveries. One of the most important stages in this process is product sorting. Traditionally, to identify and place products in the right bins or conveyors, sorting was done manually by workers. As this approach worked for smaller operations, it was not practical for large-scale warehouses where thousands of products move every hour. Manual sorting is slow, prone to human error, and tiring, especially when done continuously. As a result, companies were faced with delays, reduced productivity, and higher chances of mistakes in delivery. Industries are now turning toward automation to solve these issues. Automated sorting systems powered by sensors, actuators, barcode scanners and Programmable Logic Controllers (PLCs) can handle repetitive tasks quickly and with higher accuracy.

A PLC acts as the brain of the system, sorting each product correctly by collecting signals from sensors, processing barcode information, and controlling motors or actuators. In this project, we designed and developed an automated product sorting system using an Allen-Bradley Micrologix 1400 PLC. The system automatically directs each product to the correct bin or conveyor belt according to its destination code, as used by the provided barcode scanner. The process runs with increased speed, reduced errors, minimum human involvement and ensures smooth operation. The system combines both hardware and software elements, including proximity sensors to detect products, motors and conveyors to move products, and actuators or diverters for sorting. Together, these components create a reliable and efficient automation setup that can be applied in real-world warehouses and logistics systems.

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II. LITERATURE REVIEW

The literature review provides an overview of existing research on automated sorting systems used in material handling. Various studies focus on the use of sensors, conveyor systems, PLCs, and identification technologies like barcodes and RFID to improve sorting accuracy and efficiency. This review helps to highlight the need for a reliable and cost-effective automated sorting system by understanding current technology.

Sharma et al. (2020): Studied automated warehouse systems and emphasised that automation significantly reduces manual effort while improving sorting accuracy. Their work showed that sensor-based monitoring and controlled environments help in minimising product damage and increasing operational efficiency.

Patel and Mehta (2019): Developed a PLC-based conveyor sorting system. Their studies show that PLCs provide reliable control over conveyor operations and allow easy modification of sorting logic, making the system flexible for industrial applications.

Kumar (2021): The system's infrared and proximity sensors for object detection in sorting systems. It concluded that proper sensor placement and calibration are essential for achieving efficient and accurate sorting.

Singh and Gupta (2022): Explored barcode and RFID-based identification systems. Their result highlighted that these technologies reduce human errors, improve tracking, and enable real-time product identification in warehouses and logistics.

Deshmukh and Patil (2018): developed the integration of SCADA systems with automation. They concluded that SCADA provides better visualisation, real-time monitoring, and centralised control, improving system reliability.

Verma (2020): Introduced pneumatic actuator-based sorting mechanisms. The result showed that pneumatic systems offer fast response and are suitable for high-speed sorting operations in industries.

Rao (2019): Analysed conveyor belt automation in warehouses. The research emphasised that conveyor systems are the backbone of automated sorting, ensuring continuous material flow and reducing handling time.

Joshi (2021): Entroduced IoT-based smart warehouse systems. The study highlighted that IoT enables remote monitoring, predictive maintenance, and data-driven decision-making, enhancing overall efficiency.

III. METHODS

Hardware Description

I. Programmable Logic Controller

Fig. 1. PLC Unit

MicroLogix 1400 is a compact programmable logic controller developed by Rockwell Automation for industrial automation applications. It is used to control machines, conveyor systems, motors, and automated processes efficiently.

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The PLC supports digital inputs and outputs, Ethernet communication, and ladder logic programming using RSLogix software. It provides reliable performance, easy maintenance, and flexible communication features, making it suitable for small and medium-scale industrial automation systems.

II. Conveyor System

Fig. 2. Conveyor System

The conveyor system is operated with a 12V DC motor that provides movement for product sorting. This mechanism is used for the transportation of products.

Infrared Proximity Sensor

Fig. 3. IR Proximity Sensor

The Infrared Proximity Sensor operates on a 5V DC supply, and it works on the reflection of infrared light from products. When a product is placed in front of IR sensors, it gives a digital signal to the PLC. This signal controls the conveyor movement and sorts the products. It is used for proper synchronisation of product sorting for different locations.

Web Camera

Fig.4. Web camera

A web camera was used to monitor the conveyor belt and sorting process in real time. It helped in observing product movement and checking the operation of the automated system during testing. The camera also assisted in troubleshooting and improving system accuracy.

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10A12V DC Motor

Fig. 5. 10A12V DC Motor

The 10A 12V DC motor was used to operate the conveyor belt in the automated sorting system. It provided continuous motion for transporting products from one station to another during the sorting process. The motor produced sufficient torque and stable speed for smooth conveyor operation. The conveyor motor was controlled using the PLC and relay module according to the signals received from the infrared sensor.

ARDUINO UNO

Fig. 6. Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P microcontroller. In the proposed system, it was used to control the MG996R servo motor for the product sorting operation. The Arduino received trigger signals from the PLC and generated PWM signals for servo movement. Due to its simple programming structure and easy interfacing capability, Arduino Uno was suitable for implementing the sorting mechanism in the project.

Buck Converter

Fig. 7. Buck Converter

A buck converter is a DC-to-DC step-down voltage regulator. It converts a high input voltage into a lower output voltage. It is used to step down a 12V or 24V supply to 5V required for IR sensors. It ensures a stable supply to sensors for product detection.

Relay 5V

Fig. 8. Relay 5V

The 5V relay module was used as a switching device for controlling electrical loads in the system. It allowed low-voltage control signals from the PLC and Arduino to operate higher-power components safely. In this project, the relay module was mainly used for controlling the conveyor motor and establishing proper interfacing between the control and power circuits. It also provided electrical isolation for safer system operation.

MG996r Servo Motor

Fig. 9. MG996r Servo Motor

The MG996R servo motor was used to divert products into different sorting sections. It is a high-torque servo motor capable of rotating to precise angular positions based on PWM signals received from the Arduino Uno. During operation, the servo motor rotated to a fixed angle to push the detected product into the required collection area and then returned to its initial position. Its fast response and accurate positioning made it suitable for automated sorting applications.

Software Description

1. RSLogix 500 Programming Software

RSLogix 500 is a programming software developed for Allen-Bradley PLCs such as the SLC 500 and MicroLogix series by Rockwell Automation. The software is mainly used to edit, create, and monitor ladder logic programs for industrial automation applications. It helps programmers easily configure PLC instructions and troubleshoot control systems by providing a user-friendly interface. It supports online and offline programming, allowing users to make modifications while the system is running. The software includes data monitoring features for checking inputs, outputs, timers, and counters in real time. It also supports serial and Ethernet connections to communicate with PLCs. RSLogix 500 is widely used in industries such as packaging, material handling, manufacturing and process control. Due to its simple programming environment, efficient troubleshooting tools and reliability, the software is commonly used in automation training and industrial control projects.

2. RS Linux Classic

RSLinx Classic is a communication software for connecting computers with Allen-Bradley PLCs and industrial devices developed by Rockwell Automation. The software acts as a communication interface between PLC hardware and

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programming software such as RSLogix 500 and RSLogix 5000. It supports multiple communication protocols, including RS-232, Ethernet, DF1, and DH-485 networks. RSLinx Classic allows users to monitor, upload and download programs, and troubleshoot industrial control systems efficiently. The diagnostic tools are provided by software for checking communication status and detecting network problems. It also supports real-time data exchange between PLCs and other industrial applications. RSLinx Classic is widely used in process control, factory automation, and machine monitoring systems. It is an important software in industrial automation environments due to its reliable communication features and easy integration with Allen-Bradley devices.

IV. WORKING PRINCIPLE

The Automated Sorting System for Warehouse Products operates by using a PLC on the principle of sequential logic control and real-time sensor feedback, where products are automatically detected, processed, and sorted using a conveyor-based material handling system. The PLC acts as the central controller, decision-making, ensuring precise coordination between sensing and actuation for efficient and reliable sorting. The detailed working principle is described as follows:

System Initialisation:

• PLC performs initialisation and internal memory check.
• All input (sensors) and output devices (actuators, motors) are verified.
• Predefined sorting logic and timing parameters are loaded into the PLC.

Product Detection:

• Products are fed onto the conveyor system.
• IR/Proximity sensors detect object presence and position.
• Sensor signals are transmitted to the PLC input module in real time.

Data Processing and Decision Making:

• PLC scans inputs continuously using a cyclic scan operation.
• Input conditions are evaluated using a ladder logic program.
• Product is classified based on predefined criteria (type/size/category).
• The output decision is generated for the corresponding sorting mechanism.

Sorting Operation (Actuation):

• Conveyor positions the product at the sorting point.
• PLC activates output devices via relay modules.
• Actuators (DC motor/pneumatic cylinder/servo) perform diversion.
• Product is accurately directed into the assigned bin.

Synchronisation and Continuous Flow:

• Timing coordination is maintained between conveyor motion and actuator response.
• PLC ensures no overlap or mis-sorting of products.
• System resets automatically after each sorting cycle.

Final System Operation:

• Continuous, real-time sorting of multiple products.
•Due to sensor feedback and PLC control, it provides high accuracy.
• Increased system reliability and Reduced human intervention.

V. WORKING OF THE MODEL

The developed model provides an automated sorting system using a conveyor belt and PLC-based control. The setup consists of a moving conveyor belt mounted on a frame, along with multiple sensors and sorting mechanisms placed at specific positions. The operation begins when a product is placed on the conveyor belt, and it starts moving along the belt driven by a motor. The installed sensors detect the presence of the object as the product passes through the sensing zone. PLC receives the signal from the sensors. The system decides how the product should be sorted based on the programmed logic in the PLC. At different points along the conveyor, small mechanical diverters are activated. These are controlled outputs that physically push or guide the product into different bins. Each sorting position corresponds to a specific category. When the product reaches the sorting position, the respective actuator is triggered, and the product is diverted accordingly. The product continues moving forward if no condition is met. The wiring setup connects sensors and actuators to the control unit, ensuring proper signal transmission and operation. The entire process runs continuously, allowing automatic sorting of multiple products. This working model demonstrates basic industrial automation concepts such as sensing, PLC decision-making, and actuation, providing an efficient and low-cost solution for warehouse product sorting.

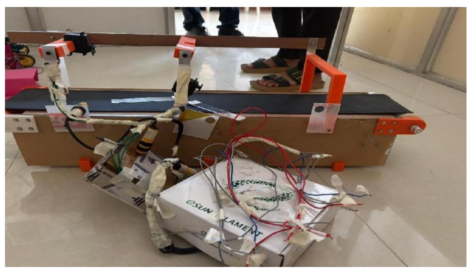

Fig. 9. Working Model

VI. RESULT

The PLC-based automated warehouse sorting system was successfully implemented and tested under different operating conditions. Signals received from the infrared proximity sensor ensured smooth movement of products throughout the sorting process, and the conveyor belt system responded properly to the signal. The IR sensor detected products when they reached the sensing area and sent the signal to the Allen-Bradley PLC. The PLC then controlled the conveyor operation and triggered the Arduino Uno for sorting action.

The MG996R servo motor diverted the products into the required collection area, and the motor operated correctly during testing without major errors. The servo motor returned to its initial position after completion of the sorting operation, and the conveyor resumed movement automatically, maintaining continuous system operation. The buck converter and relay module provided stable power distribution to the control components and helped the system operate reliably.

The system maintained proper synchronisation between the PLC, Arduino, sensor, conveyor motor, and servo motor during repeated trials. The average sorting time for each product was approximately 4 to 6 seconds, depending on conveyor speed and product position. When the sensor alignment was maintained properly, product detection accuracy was good. The conveyor mechanism operated smoothly without interruption or vibration during testing.

The developed system improved sorting efficiency and reduced manual effort compared to manual handling methods. Overall, the project demonstrated reliable automation performance and showed that PLC and Arduino integration can be effectively used for small warehouse product sorting applications.

VII. CONCLUSION

The automated sorting system for warehouse products was successfully designed and developed using an Allen-Bradley PLC and Arduino Uno. The project demonstrated how industrial automation can improve product handling efficiency, reduce manual work, and increase sorting accuracy in warehouse operations. The infrared proximity sensor effectively detected products moving on the conveyor belt, while the PLC controlled the conveyor sequence and overall system operation. The Arduino controlled the MG996R servo motor to divert products into the required section smoothly and accurately.

The developed model operated reliably during testing and showed proper coordination between sensors, conveyor movement, relay control, and servo action. The integration of PLC and Arduino provided both industrial reliability and flexible control at a low cost. Compared to manual sorting methods, the proposed system reduced operational delay and improved consistency in product segregation.

This project proves that simple automation components can be combined to create an efficient warehouse sorting solution suitable for small industries, educational laboratories, and industrial training purposes. The system can be further enhanced with advanced sensors, SCADA monitoring, barcode scanning, and IoT technology for large-scale industrial applications.

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