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Prototype design of automated goods sorting process based on outseal PLC

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Abstract

The production process utilizing automation technology aims to enhance logistical process efficiency, diminish human errors, and elevate precision in item categorization. Accurate simulation of item sorting processes ensures the proper operation of automation systems. In the design of this automatic item sorting system, the Outseal Mega PLC serves as the controller, receiving signals from sensors and limit switches, processing information based on programmed instructions, and directing commands to the actuators. Inputs to the PLC comprise infrared sensors, metal sensors, and limit switches, each transmitting signals according to their designated functions. In the output section, DC motors and servo motors execute mechanical tasks based on PLC commands, with motor activation facilitated by relays. Through testing, it was established that the item sorting process operates in alignment with the designated design. With coordination among sensors, limit switches, and motors linked to the PLC, the system adeptly conducts item sorting with efficiency and accuracy. The prototype's function within the sorting system serves as a production line simulation for item categorization in small-scale industries. Subsequent developmental steps could encompass broader goals and scopes, incorporating measurements, monitoring, control, and analysis of various performance parameters.

Keywords

Prototype design, automated goods, outseal PLC

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Introduction

The development of production processes using automation technology remains a compelling focus within modern industries. The application of this technology aims to enhance logistical process efficiency within the supply chain, minimize human errors, and improve accuracy in categorizing goods [1]. Accurate simulation of goods sorting processes ensures the realization of automated systems that can operate swiftly, a crucial aspect in today's manufacturing industry. The utilization of sensory technology and data processing becomes a pivotal point in designing systems capable of precisely

and rapidly identifying and segregating types of goods [2]. The alignment among technology, logistics, and manufacturing processes stands at the forefront of attention in the development of these innovative solutions, expected to form the basis for increased productivity and efficiency in a competitive industrial environment.

Simulations of automated goods sorting can optimize time, business efficiency, production output, and reduce the number of workers on production lines [3]. Research into goods sorting simulation has showcased control variations involving computers as interfaces with serial communication, PLCs, or microcontrollers [4]. Related studies have explored the design of prototypes for automatic goods sorting machines based on weight determination, utilizing microcontroller-based Arduino controllers. The performance from test results aligned with the initial design with minimal percentage error [5], corroborating similar findings in other relevant research [6–8].

Another facet of production system development involves a product monitoring system utilizing a simulation of an automatic mini conveyor. This aims to address industrial and manufacturing issues like product theft, inefficient supervision, and inadequate workmanship skills. It endeavors to enhance production management systems using an ICT-based platform with monitoring control and data acquisition in manufacturing processes [9]. Development focuses on the design, fabrication, and validation of monitoring and automatic control systems designed to inspect various objects on belt conveyors. The system employs MicroLogix PLCs to control and provide sensor feedback, studying parameters such as position, orientation, filling time, material type, and object type in detail [10].

This paper presents a prototype leveraging the Outseal Mega PLC, a fusion of an Arduino board and shield into a single electronic board. The designed automation simulation of the production process concentrates on detecting metallic and non-metallic items for categorization purposes. The implementation of the designed prototype is expected to contribute to operational efficiency and logistics management in small-scale industries. Through a simulation-based approach, this research aims to design innovative solutions to meet the needs of sorting goods based on metallic and non-metallic characteristics.

Method

System overview

In the design of this prototype for automatic goods sorting process, experimental methods were employed wherein the manipulation of independent variables occurred under controlled conditions while observing their effects on outcome variables. Prior to constructing the prototype, the initial phase of this study involved creating a design diagram, as depicted in Figure 1. This design diagram not only outlined the structure but also delineated the components constituting the simulation model of the small-scale industrial production line. The sorting system employed a conveyor as the item

transporter, integrated with object recognition sensors tasked with detecting metallic and non-metallic items. The control unit selected was the Outseal Mega PLC, built with Arduino-compatible hardware, facilitating cost-effective, user-friendly, and robust automation technology. The electronic scheme of the Outseal PLC was made publicly available for viewing, study, modification, and replication, while still adhering to industry standards [11].

The proposed system's flowchart is illustrated in Figure 2. The sorting system effectively segregates metallic and non-metallic items. The primary components utilized encompass Infrared sensors, Metal sensors Opto Electronics, Outseal Mega PLC sinking type, Power supply Output 12V 10A, Limit switch, Servo motor, and DC motor. In brief, the operation of this prototype sorting system initiates with items placed on the conveyor belt, detected by infrared sensors, with their signals relayed to the PLC. As per the programmed instructions, the infrared sensor signals activate the DC motor, setting the conveyor belt in motion. Upon identifying metallic or non-metallic items via the metal sensors along the conveyor's path, the sensor signals are transmitted to the servo motor by the PLC, rotating the sorting gate, while the limit switch temporarily halts the DC motor.

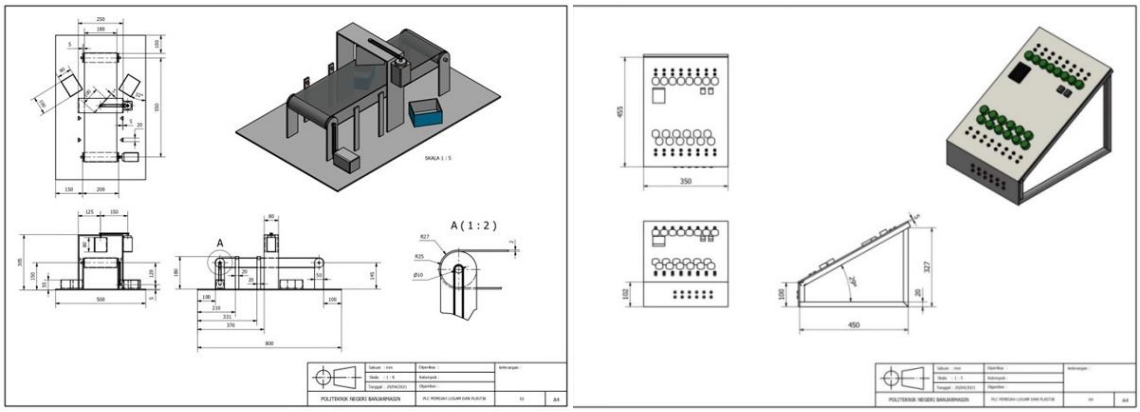

Figure 1. The design of automated goods sorting

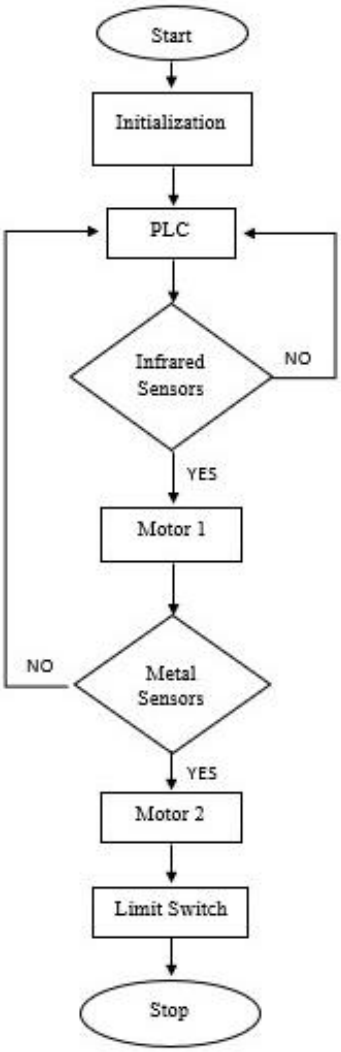

Figure 2. Control flow of the proposed system

Block Diagram Description

The block diagram depicted in Figure 3 illustrates the functioning concept of this automated sorting system. This diagram delineates the flow of information and actions within the system. Serving as the controller is the Outseal Mega PLC, which receives signals from sensors and limit switches, processes information based on the programmed instructions, and transmits commands to the actuators. Inputs to the PLC comprise infrared sensors, metal sensors, and limit switches, each sending signals in accordance with their respective functions. In the output section, there are DC motors and servo motors that execute commands from the PLC in mechanical form, with motor activation aided by relays. Through the coordination among the infrared sensors, metal sensors, limit switches, DC motors, and servo motors linked to the PLC, the system is capable of efficiently and accurately sorting items [12].

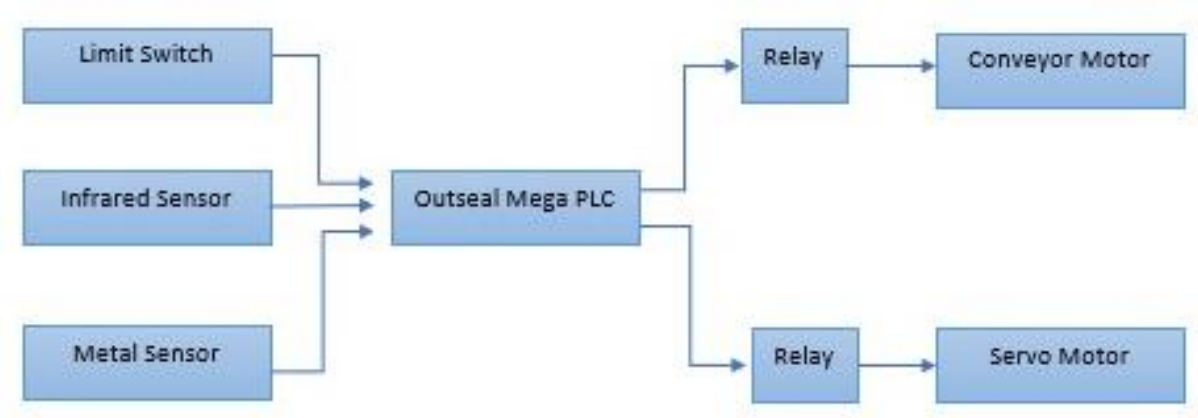

Figure 3. Block diagram of proposed system

Result and Discussion

Based on the testing conducted on the prototype, it was observed that the automated goods sorting process based on Outseal Mega PLC can operate in accordance with the designed specifications. The function of this sorting system prototype serves as a production line simulation for item categorization processes implemented in small-scale industries. Numerous simulations have been developed for production system enhancement using PLCs, all tailored to simulate characteristics specific to the unique working conditions of individual locations [13][14]. The types and specifications of PLCs available in the market for industrial scales have generally been tested across multiple production sites, making the procurement of components relatively expensive. In the case of the prototype design for the sorting process outlined in this paper, an Outseal PLC integrating a Programmable Logic Controller (PLC) and Human Machine Interface (HMI) was utilized. The Outseal product is cost-effective compared to other PLC types as it is designed with Arduino compatibility. The programming for the automated sorting system was carried out using the Outseal studio application, based on ladder diagrams as depicted in Figure 4.

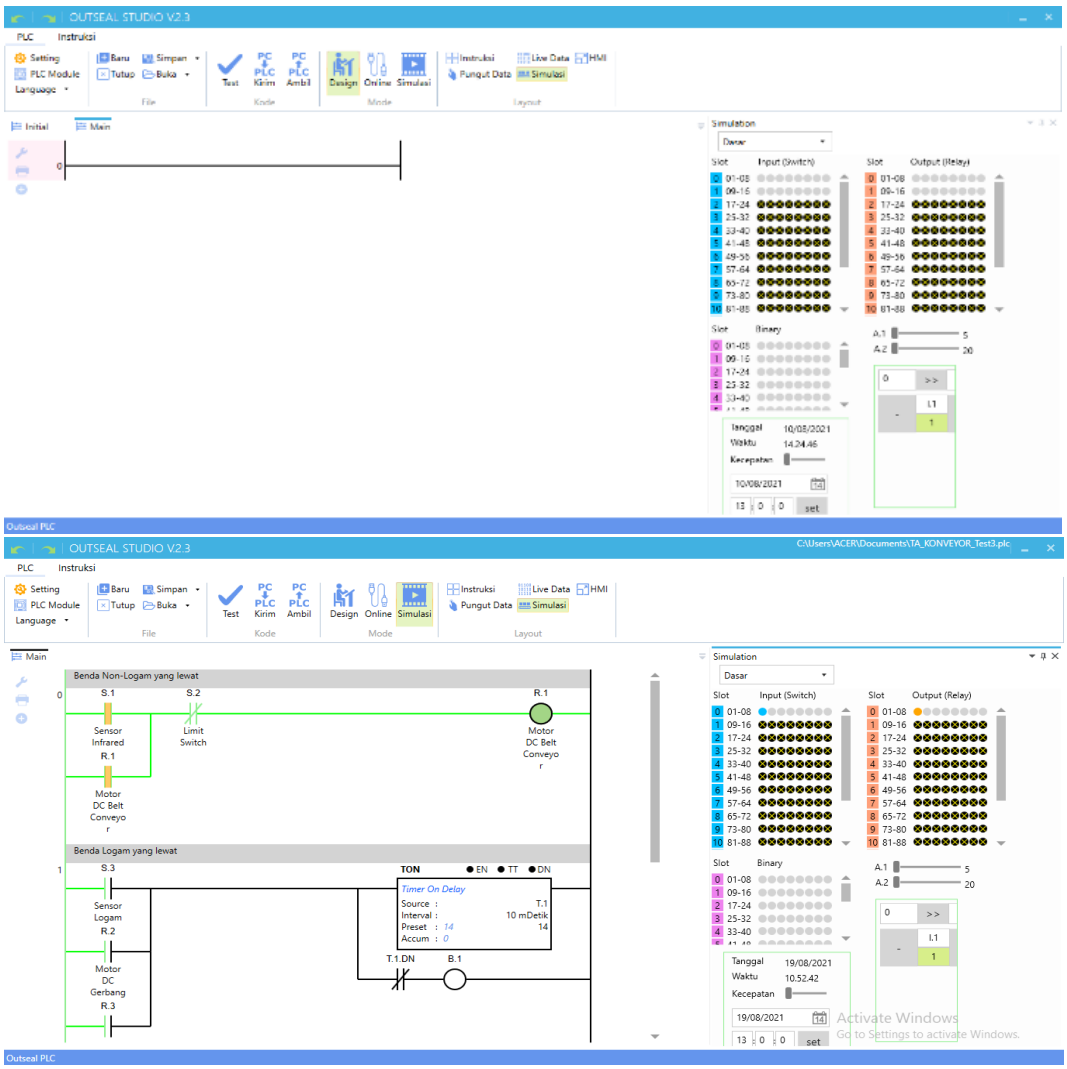

Figure 4. Ladder diagram

The prototype testing involved the use of iron material for metallic items and plastic/glass for non-metallic items, as shown in Figure 5. Assuming a production line scenario, items were placed on the conveyor belt, with an infrared sensor installed at one end to detect the presence of an object (Figure 6a). Upon detecting an item on the conveyor path, information from the sensor was relayed to the PLC as the system controller (Figure 6b). Subsequently, the PLC activated motor 1, a DC motor propelling the conveyor belt to move the item along its path. Positioned midway along the path was a metal sensor that discerned the type of item passing in front of it (Figure 6c). If the item was identified as metallic, the sensor's signal was transmitted to the PLC, which processed the received information and directed it to motor 2, a servo motor situated above a sorting gate. The gate's movement steered the item towards a containment box on the left side of the conveyor belt. When the item landed in the containment box, it triggered a limit switch positioned beneath the box, temporarily halting motor 1 and the conveyor operation (Figure 6d). In case another item was placed at the end of the conveyor belt, the motor would restart the conveyor's motion, initiating another round of item type detection. If the item was non-metallic, the gate would remain stationary,

defaulting the item's direction towards a containment box on the right side of the conveyor belt.

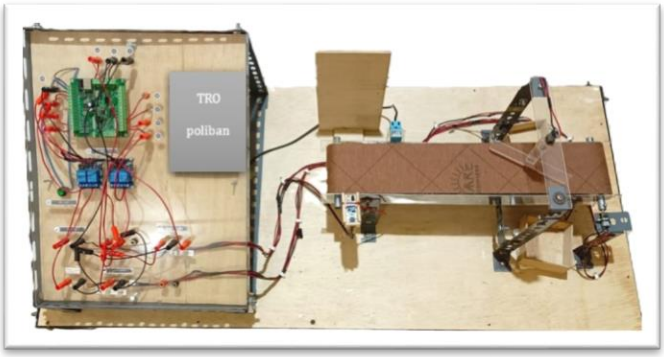

Figure 5. Prototype of automated goods sorting

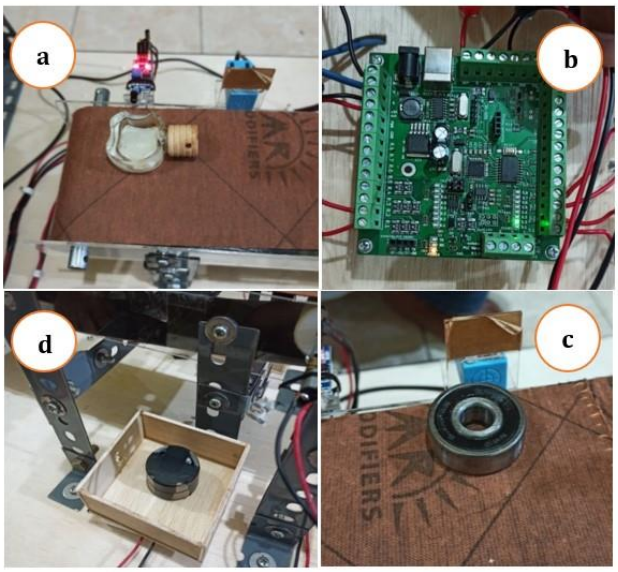

Figure 6. The parts and components of the prototype sorting system

Based on the performance results from the simulation of the automated goods sorting prototype, it was observed that all system components operated in accordance with the designed functions and the programmed inputs embedded within the PLC. The PLC's performance as a controller was also found to be adequate for operation on a larger scale within small-scale industries. The subsequent development steps utilizing the Outseal PLC could aim for a broader scope and purpose, encompassing measurements, monitoring, control, or analysis of various performance parameters associated with this automated goods sorting prototype process.

Conclusion

Based on the design and simulation testing results of the automated goods sorting prototype, it can be concluded that the designed automated goods sorting system utilizing a belt conveyor and controlled by the Outseal PLC has successfully demonstrated its performance in simulation testing. With inputs from the infrared sensor detecting item presence, the metal sensor distinguishing between metallic and

non-metallic types, and the limit switch in the item containment bin, the system effectively manages the conveyor belt movement and sorting gate to separate items based on their types. The testing on the prototype has validated the alignment between the planned design and the actual performance of the system, indicating its potential for effective use in automated goods sorting processes.

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