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Design and Fabrication of PLC Based Automated Object Sorting, Stamping and Storage System

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ABSTRACT

The project focuses on the design and fabrication of a Programmable Logic Controller (PLC) based automated object sorting system integrated with a moving conveyor. The system leverages a combination of color sensor, metallic sensor, and height sensor to accurately identify and categorize objects based on their color, material, and dimensions. The sorted objects are then stamped before being organized and stored using an automated storage system. The photoelectric sensor is attached on the frame of conveyor to detect bright and dark objects as well as height up to the adjustable limit of a slot provided on the mounting.

The inductive proximity sensor detects the metal objects moving on the conveyor. The integration of PLC allows for real-time control and monitoring, enhancing the overall automation process. This project aims to improve sorting accuracy, reduce manual labor, and increase operational efficiency in industrial settings.

Keywords**: Automated sorting, PLC based automation, sensor based automation, PLC based demonstration kit, Object sorting, Color based sorting, PLC programming.**

I. INTRODUCTION

In today's manufacturing environment, automation plays a crucial role in enhancing efficiency, reducing labor costs, and improving overall productivity. The rapid advancement of industrial automation technologies necessitates the development of efficient and reliable object sorting systems. This project aims to design and fabricate an automated object sorting system using a Programmable Logic Controller (PLC) integrated with various sensors, conveyor system, stamping system and a shuttle operated storage system. The system will sort objects based on color (dark/bright), material (metal/non-metal), and height, and subsequently store them using an automated storage system after stamping.

2. LITERATURE SURVEY

Kadiyam Sasidhar et al [1] The completed project is divided into two sections. The first is software that includes ladder logic programming, which is used to program PLCs that methodically regulate the project's entire process based on the sequence of input data. The second component is the hardware, which includes conveyors for moving the items, sensors for detecting the colors of the items (also known as color sensors), an electronic system for sorting the items, and motors to move the conveyor belt.

Apurva Rajmane [2] has done project, which is a basic development and modification of the system that uses the peripheral interface Programmable Logic Control (PLC) as the programming brain to control entire robot movement. The gripper will position the product on to the next stage of production line. The software includes ladder logic programming, SCADA animation and hardware includes pneumatic system, limit switches etc. The benefit of this project is the robot can pick the object using gripper which is simple in construction and also cost effective.

Mr. Nayan J. Tongale et al [3] has designed, built, tested, and run an automated stamping machine powered by pneumatic systems that include an air compressor, directional control valves, and an air service unit. Due to the current trend of stamping issues, small businesses are losing a significant portion of their market share to larger manufacturing companies. The requirement to use easily maintained equipment and make the stamping process economical.

Kavita Shinde et al [4] has developed a stamping system that stamps the logo on a square product as it moves on a conveyor. The system consists of a conveyor belt driven by a Dc gear motor. The conveyor is used to lead the product to the stamping base

Prof. Nilima Bargal et al [5] has developed automated sorting based on height, the objects on the conveyor passes through the guider, it has to pass from front of Height measuring station.

Rohit R. Yadav et al [6] This project consists of two parts, first consisting of software which contains ladder logic programming which is used to program PLC that controls the whole process of the project step by step according to input data sequence. Second is the hardware part which consists of conveyors used to transport the objects.

III. METHODOLOGY

The methodology for the project "design and fabrication of plc-based automated object sorting on a moving conveyor using color sensor, metallic sensor, and height sensor, stamping on objects, and finally storage using automated storage system" involves a series of integrated steps: initially, project planning and requirements analysis are conducted to define system specifications and objectives. This is followed by the design and selection of components, including the conveyor system, sensors (color, metallic, and height), stamping mechanism, and automated storage system. The conveyor system is then built and integrated with the sensors, which are calibrated to ensure precise data acquisition and communication with the PLC. The stamping mechanism is incorporated and controlled by the PLC to mark objects as they are sorted. Finally, an automated storage system is implemented to organize and store the stamped objects efficiently. The entire system undergoes rigorous testing and validation to ensure accuracy, reliability, and seamless operation before deployment.

3.1 Work Outline details

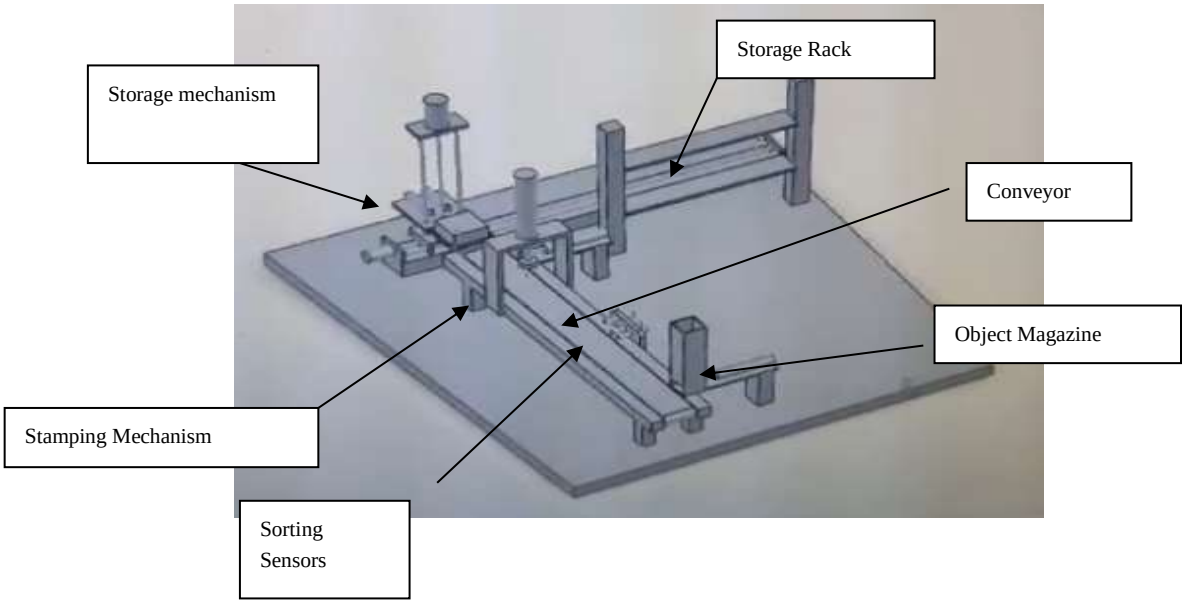

Figure 1: Conceptual Model

This project consists of following major systems

Object Magazine with Pushing Mechanism: Initially the objects can be placed directly on the conveyor belt manually or it can be stored in the object magazine and pushed by pneumatic cylinder automatically one after the other. The object in the bottom will be pushed by pneumatic cylinder through the opening provided. Then the objects will be arranged again due to gravity making a way for the next object to be pushed towards the conveyor belt.

Conveyor System: In this project work the conveyor structure is made with aluminum profile. The pulleys at each end are provided. The pulleys are 3D printed and firmly placed on bearings. One pulley is driven with the help of DC motor. The pulleys are wrapped around to form a loop with a wide endless belt.

Object Sorting System: An object sorting system on a moving conveyor uses a combination of sensors Inductive sensors and photoelectric sensors to sort items based on height, material type, and color.

- **Inductive Sensor for Metal/Non-Metal Sensing:** The inductive sensor generates an electromagnetic field and detects changes when a metal object passes through it. This sensor differentiates between metal and non-metal objects, allowing the system to sort them accordingly.
- **Photoelectric Sensor for Color Sensing:** The photoelectric sensor uses a light source and a photo detector to measure the reflected light from an object. By analyzing the intensity and wavelength of the reflected light, it determines the color of the object, enabling the system to sort items based on color.

Stamping Mechanism: Once objects are sorted, they proceed to the stamping station. The control system, informed by the sensor data, activates a stamping device such as a pneumatic actuator with a stamp head. The stamp head contain ink, engravings, or branding marks.

Automated Storage System: An automated storage system for objects coming off a conveyor uses a DC motor to control the movement and organization of items into designated storage areas.The system's control unit, which is programmed with specific storage criteria, directs the DC motor to position the shuttle to the appropriate storage location. The pneumatic mechanism then places the items into the correct bin or shelf.

Object Rejection System: When a sensor identifies an item that needs to be rejected, it sends a signal to a control system, which in turn directs the conveyor towards the rejection bin. The conveyor moves the item to be rejected directly, which pushes the item off the conveyor into a designated rejection area or bin.

3.2 Details of Fabrication:

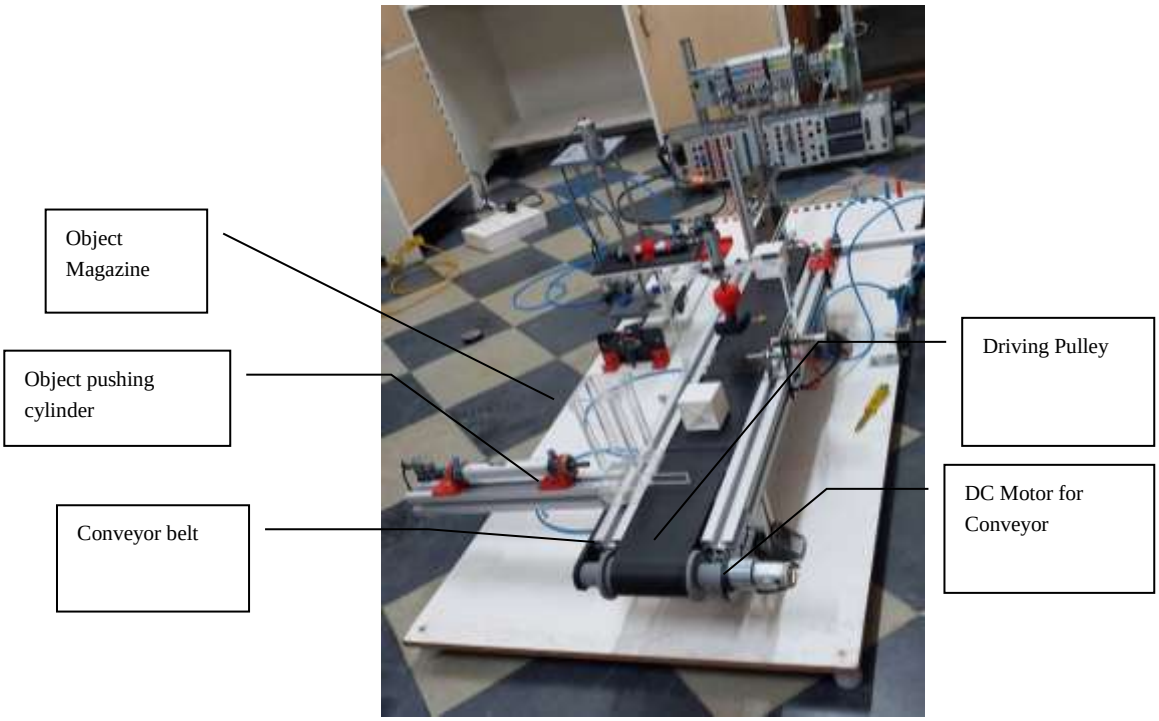

Figure 2: Prototype Model

4. RESULTS AND DISCUSSION

Sensor Accuracy Testing

- Inductive Proximity Sensor (Metal Detection): After multiple trials, the sensor showed a 100% detection rate for metal objects and correctly ignored non-metallic items within the range of 5mm.
- Photoelectric Sensor (Color and Height Detection): The sensor successfully detected an object within a range of 100mm. Minor inaccuracies were noted in extreme light variations, indicating a need for optimal lighting in the setup.

Sorting Mechanism Testing

- Out of 20 test runs, 18 objects were correctly sorted, yielding a sorting accuracy of 90%.
- It took 8 sec for objects come from magazine towards sensors.
- The conveyor stopped below the stamping mechanism, after stamping it took 9 sec to reach unload cylinder.
- Common Issues Observed: Occasionally, lighter objects would shift position on the conveyor due to the conveyor speed, affecting sensor readings.

Stamping Process Testing

- The stamping mechanism was triggered when objects met all criteria. In trials, 9 out of 10 stamped objects had clear, well-positioned marks, with a 10% error rate attributed to positioning misalignment.
- Position Calibration: Additional calibration of the conveyor stopping mechanism and guiding attachments were added to reduce positioning errors during stamping.

Shuttle-Operated Storage System Testing

- The unloading cylinder positions the object on the shuttle with variations. The guides were added to reduce the positioning errors.
- Out of 20 test runs, all objects were placed correctly, showing 100% storage accuracy and a fast response time within 25 seconds per object.
- 4 objects were stored on 2 racks one after the other. Slight variations in positioning on rack were observed due to vibrations of lead screw and nut.
- The use of sensor at each storage location would further improve the storage accuracy.

CONCLUSION

The PLC-based automated object sorting, stamping, and storage system proved effective in achieving reliable, accurate, and efficient object classification. The combination of inductive proximity and photoelectric sensors successfully identified objects on a moving conveyor based on material (metal/non-metal), color (light/dark), and height (within the adjustable limit) using the PLC program. The stamping mechanism functioned as intended, with only minor calibration needs, and the shuttle-operated storage system efficiently organized sorted items on the storage racks. Overall, the project demonstrates the capability of automated systems to improve productivity and precision in sorting applications, with potential for further optimization and scalability.

The project can be used as a low cost demonstration kit/model by students to practice PLC programming by giving many criteria for object sorting, stamping and storage. Also, demonstration kit combines the applications of sensors, mechanical system and pneumatic systems.

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