International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 09 – Issue 10 || October 2024 || PP. 31-36

Design of a Demo Model of a Product Classification System Based on RFID Combined with PLC

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Abstract: In current practice, product classification systems based on color, height, and RFID tags,... have been widely deployed in industrial zones. However, there are still some limitations due to environmental factors and the ability to handle products with complex shapes or small sizes, especially in demo models at training institutions to help students have an overview of the automatic product classification system. To overcome these limitations, the author team has conducted research, design, and deployment of a product classification model using RFID tags, aiming to improve the ability to recognize and classify products more accurately and efficiently, while also supporting students in their learning process and skill development.
Keywords: Industry 4.0, PLC, RFID, Categorization system, Automation, Industrialization, PTIT

I. INTRODUCTION

Currently, in Vietnam specifically and globally in general, the industrialization sector is increasingly developing, the application of 4.0 technology becomes a crucial factor to enhance productivity and product quality. This is the demand for product classification from businesses that requires high accuracy, flexibility, and reasonable investment costs. One of the technologies being applied today, such as the product sorting system based on color, height, and RFID tags, has been widely deployed in industrial zones. However, these systems still have weaknesses such as being easily affected by environmental conditions such as light, dust, and the ability to handle products with uneven shapes or small sizes. To overcome these limitations, the author's team researched and proposed the design of a demo model for product classification using RFID tags combined with PLC applied in training for students to access the system right at the training facility, helping students to promote their abilities and knowledge to improve the efficiency and accuracy of the systems during the product classification process.

II. OVERVIEW OF PLC AND RFID

a) PLC (Programmable Logic Controller)

PLC, standing for Programmable Logic Controller is extensively utilized in industrial automation systems. In this research, the authors employed the Omron PLC model CP2E-N30DR-A, featuring 18 digital inputs and 12 relay outputs. This PLC is equipped with 2 Ethernet ports for connectivity with other devices through RS-232C, RS-422, and RS-485 communication protocols. The prominent characteristics of the PLC CP2E-N encompass the capability to integrate 24VDC outputs with a current of 30mA and function in temperatures spanning from -20°C to 60°C. The PLC serves a pivotal role in controlling the whole product sorting system, including sensors, motors, solenoid valves, and other devices.

b) RFID (Radio-Frequency Identification)

RFID is a wireless identification technology that uses radio waves to transmit data between the RFID tag and the reader. In a product sorting system, the RFID tag is attached to the box casing containing the product and is read by the GP30 card reader as the tag moves past the reader on the conveyor belt. The RFID tag operates at a frequency of 125KHz, making it suitable for applications such as car parking, motorcycle theft prevention, and product sorting in the industry. The GP30 reader can read tags at a distance of 20 to 30cm, depending on the application, and the distance is set appropriately for each type of application.

III. ASSEMBLY AND CONNECTION OF SYSTEM DEVICES

a) Structure design of the demo system

- **Component Identification of the product classification system using RFID tags**

PLC Module: Using Omron's PLC CP2E-N30DR-A to control the entire system.

24VDC Power Supply: Provides power to electronic devices such as sensors, motors, solenoid valves, and 3-tier tower lights.

12VDC Power Supply: Powers the GP30 card reader.

Single-phase Circuit Breaker: Schneider EZ9D34610 10A 30mA 4.5kA 1P+N circuit breaker to protect the system.

24VDC Intermediate Relay: Used to open and close the main circuit based on signals from the PLC.

RFID Card: Attached to the product container for identification and classification.

GP30 Card Reader: Reads data from the RFID card and transmits it to the PLC.

Omron E3JK-DR12 Sensor: Detects the presence of the product container on the conveyor belt.

3-Tier Tower Light 24V: Indicates the working status of the system (green light - working, yellow light - error, red light - standby).

Air Cylinder CDJ2B10-100Z-B: Controls the pushing of boxes into corresponding containers.

5/2 Solenoid Valve: Controls the air cylinders according to commands from the PLC.

Conveyor Belt: Transports product containers to the required sorting locations.

24V Reduction Motor: Controls the movement of the conveyor belt.

Start and Stop Buttons: Start and stop the sorting system.

Fig 1. CP2E - N PLC Module

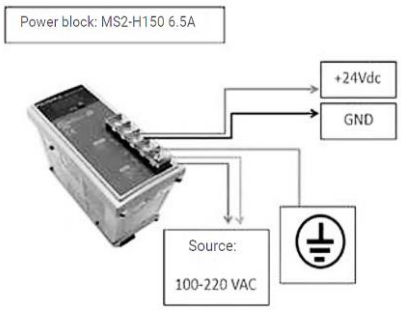

Fig 2. Power Blocks 24 vdc

Fig 3. GP30 Card Reader

Fig 4. Three-tier 24vdc tower light

Fig 5. Pneumatic cylinder

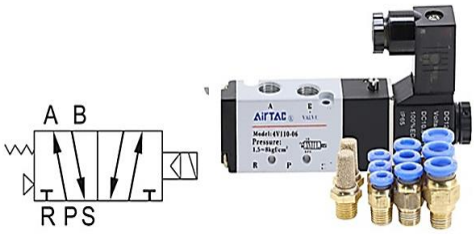

Fig 6. Structure of 5/2 solenoid valve

b) Structure of the demo system

The product classification system includes a 80cm long conveyor belt with a width of 7.5cm, installed on a 20x20 shaped aluminum frame. The product containers with RFID tags will move on the conveyor belt. The sensor at the head of the conveyor detects the presence of the container and sends a signal to the PLC to control the motor operation. When the container passes through the GP30 card reader, the RFID card data will

be sent back to the PLC to determine the corresponding container. Depending on the RFID card code, the PLC will control the air cylinders and solenoid valves to push the container into the appropriate bin.

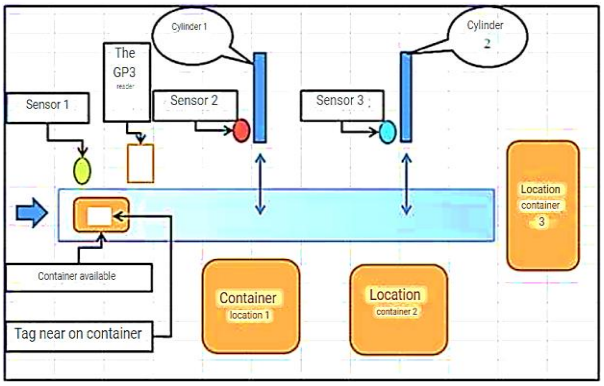

Fig 7. General schematic of the system

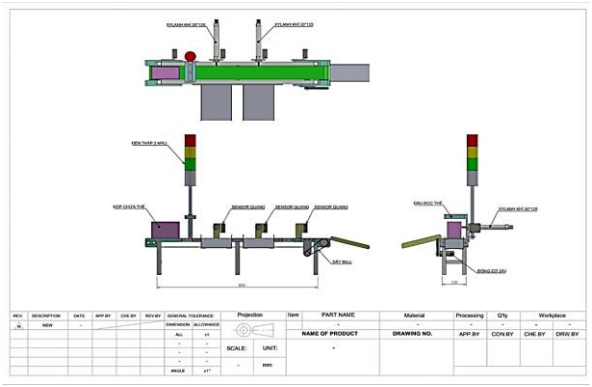

Fig 8. Design blueprint of the model

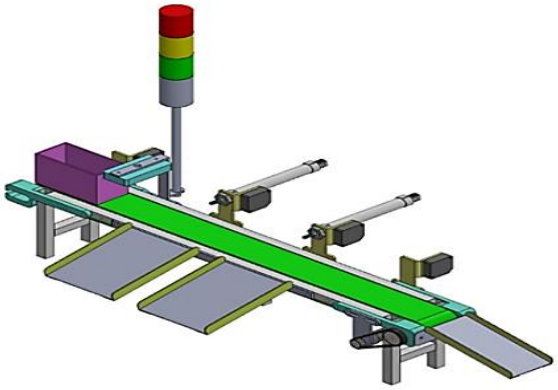

Fig 9. Simulation of the box being placed in the drop-off position

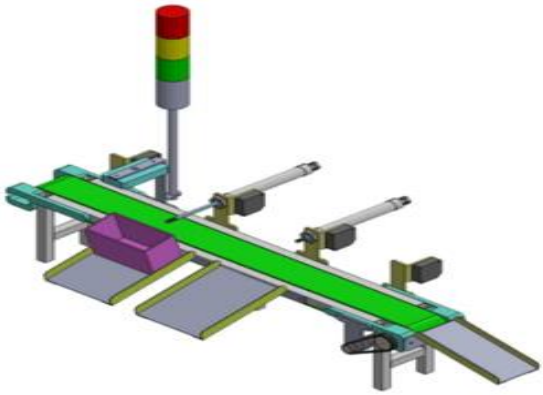

Fig 10. Simulation of the box arriving at push position 1

c) Assembly and connection of system devices

- **Implementation of the assembly process of RFID and PLC devices according to the design**

  + Prepare devices including PLC, 3-tier tower light, HMI screen, single-phase circuit breaker, 24V power supply, push button box, solenoid valve, electrical terminal block, sensors, card reader, base and 24V intermediate relay.
  + Assemble the mechanical part of the conveyor belt using shaped aluminum bars, bearing brackets, rollers and conveyor belts.
  + Connect the motor, sensors, card reader and tower light to the conveyor belt.
  + Install the air cylinders and solenoid valves according to the design diagram.
  + Connect all electrical devices through intermediate relays and overall electrical connections.
  + Install the HMI screen and air pressure gauge to monitor system information.

- **Connection of devices to the power supply**

  To ensure the system operates stably, the author team carries out the following steps:
  Step 1. Check the connections of the devices before powering up
  Step 2. Power up the sensors, PLC, and 24VDC source.
  Step 3. Ensure all devices have properly received power and are operating stably.

After connecting and careful checking, the author team proceeds to power up the system as shown in the figure

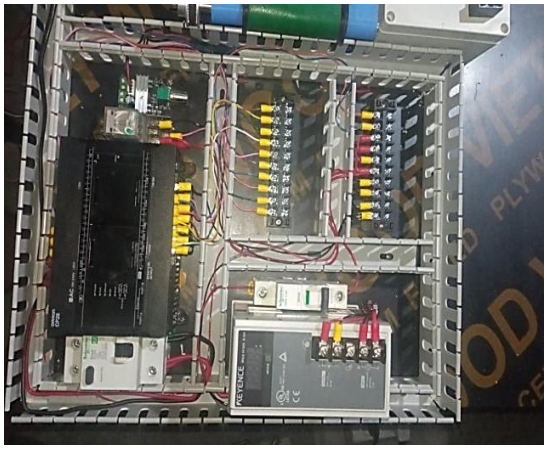

Fig 11. Completion of Electrical Connections

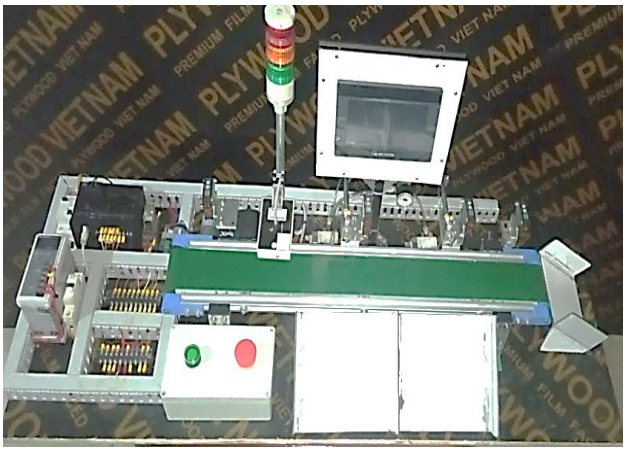

Fig 12. Completion of Installation, Electrical Connections

Fig 13. Powered sensors

Fig14. All powered - up devices

Fig 15. Specification of installing code onto the RFID card

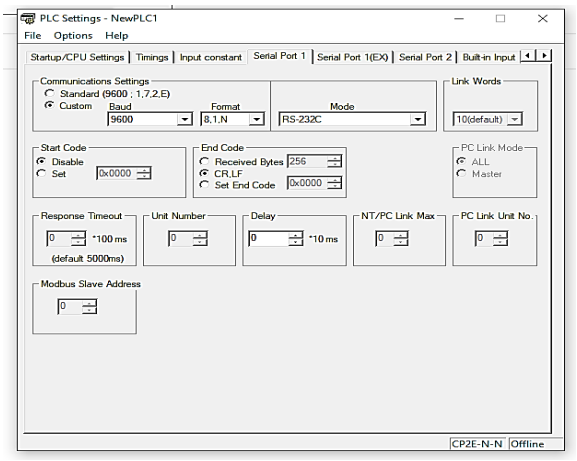

Fig 16. Set-up communication with the GP30 card reader

- *Development of control program for PLC*
  + Use Omron's CX-ONE programming software to create a new program for the PLC.
  + Set up the parameters of the PLC and create sub-programs (Section) to manage different functions such as RS232 communication, pressing Start/Stop, processing signals from sensors and controlle outputs.
  + Define the Inputs and Outputs for the product sorting system.

+ Write a control program for the sorting system based on data from the RFID card, including programs for reading cards, sorting, and resetting the system.
+ Design the HMI screen interface using EasyBuilder Pro software to display information about the sorting position, RFID card code, and the number of boxes at the push box positions.

- *Configuration of RFID devices to communicate with PLC and transmit product data*

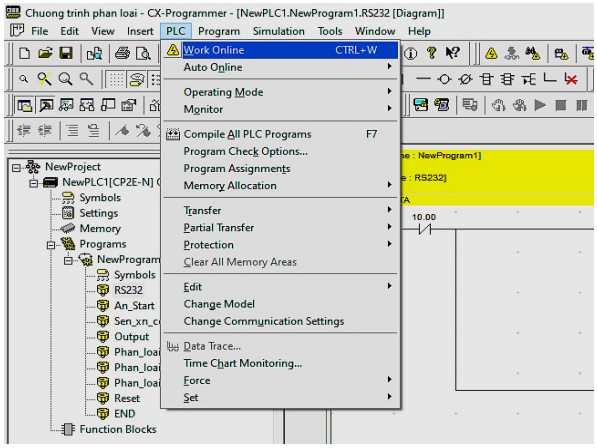

Fig 17. Loading data into PLC Figure

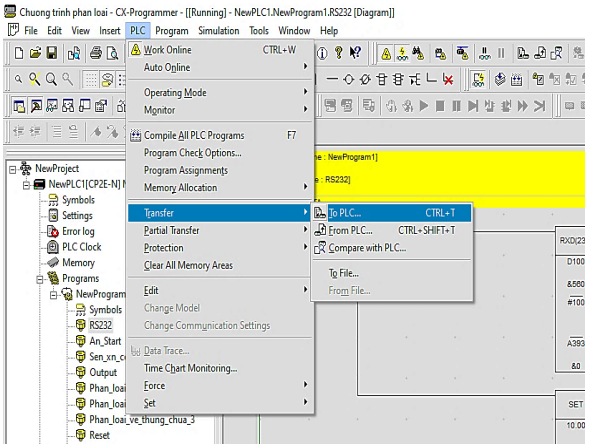

Fig 18. Loading data from PC into PLC

+ Install data into the RFID card using a data scanner.
+ Set up the communication configuration for the GP30 card reader in the PLC programming software.
+ Connect the GP30 card reader to the PLC via the RS-232C port and check the data transmission process.

d) Testing and Evaluating Results

- **Testing the demo system under simulated conditions**

+ Run system tests and check the functions of classifying product containers into corresponding bins.
+ Check the display of information on the HMI screen about the classification position, RFID tag code, and the number of containers at the push bin locations.

- **Adjustment and Setup of the Program for the System**

+ Adjust the position of sensors and the thrust of the pneumatic cylinders to ensure accurate box pushing.

Fig 19. The operational system

+ Adjust the speed of the conveyor belt to meet sorting requirements.
+ Reconnect the communication ports between the GP30 card reader and the PLC to avoid data loss.
+ Check and reset the Ethernet network configuration to ensure accurate data transmission to the HMI screen.

IV. EXPERIMENTAL RESULTS

The product classification system using RFID tags operates effectively, accurately dividing the containers into corresponding bins. The HMI display shows complete information about the classification location, the number of containers, and the RFID tag code without confusion. The RFID tag reading system operates accurately and is not affected by environmental factors such as light or dust.

V. DISCUSSION AND EVALUATION

Through the design, assembly, and testing process, the product classification system using RFID tags has proven effective in accurately and quickly sorting product containers. Compared to traditional classification methods based on color and height, the RFID system is more capable of handling products with complex shapes and small sizes. In addition, the system minimizes errors due to environmental factors and increases flexibility in expanding the classification scale.

However, the system still needs to be upgraded in terms of data security and the ability to connect with enterprise information management systems to enhance integrity and efficiency in supply chain management.

VI. CONCLUSION

The research and implementation of the product classification system using RFID tags have achieved positive results, significantly improving efficiency and accuracy in the process of goods classification. The system is not only superior to traditional methods but also meets the requirements for flexibility and the ability to handle products of various shapes and sizes. The improvements and proposals in this study contribute to enhancing production efficiency and management in the modern industrial sector.

VII. ACKNOWLEDGEMENTS

The author gratefully acknowledges the Posts and Telecommunications Institute of Technology and Bac Ha International University, VietNam college of Science and Technology for supporting this work.

Disclosure of conflict of interest: The author declare that they have no conflicts of interest.

REFERENCES

[1] Rafael G. Vastag, Milena M. de Campos and Cesar da Costa (2019), Implementation of a RFID Technology-Based AutomaticTraceability System for Industry 4.0, *European Journal of Engineering Research and Science*, 15-18.

[2] Richard Kapolyo (2013), Integration of Radio Frequency Identification with Programmable Logic Controller for Design of Industrial Control System, *International Journal of Science and Research*, 1168-1172.

[3] Sudip Phuyal, Diwakar Bista & Rabindra Bista (2020). Challenges, Opportunities and Future Directions of Smart Manufacturing: A State of Art Review, *Sustainable Futures*, Volume 2.

[3] Tuyen, Nguyen Tai. (2016). Smart Sensors in Automatic Power on Off for Projector Based on User Monitoring Signals, *International Journal of Research in Engineering and Science*, 51-55.

[5] ZHOU Zhengjie (2015), The Design of PLC Entrance Guard System Based on RFID Technology, *2nd International Conference on Electrical, Computer Engineering and Electronics*, 1671-1674.

[6] https://automation.omron.com

[7] https://www.rfidjournal.com