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Development of a PLC Based Automation Cell for Industry

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Abstract
In recent years there is a considerable growth and development of automation mainly in industrial sectors. This technological revolution is quickly reducing the need of humans to operate machines. To reduce cost and increase the production rate every industry tries to invent new technology. Bringing automation in the industrial sector is one of them. Automation in the industrial sector reduces human effort, makes the system smooth and also increases productivity. For this tendency every industry wants to design an automatic production process with minimal amount of cost (MAC). The main purpose of this paper is to give an idea about automatic shrink packaging of the final product and sorting technique which reduces the overall packaging and sorting time and also increases productivity. In this project a PLC based low-cost automation cell will be developed for industry. This automation cell combines two different types of work in one frame. One is shrinking packaging of final products and another one is sorting which is done by measuring the size of the product. The purpose of combining two different types of work in frame is to reduce the overall production time. Pneumatic system introduced here for sorting purpose. This pneumatic system works faster than an electric pusher which finally reduces the sorting time. This pneumatic system is also safe from fire hazard where there is a high chance of fire hazard in electric pusher. Sorting is done here by using a double acting cylinder acting as a pneumatic pusher and this cylinder is controlled by a 5/2 Solenoid valve. Here Sorting is done after finishing the packaging of the final product. To perform different tasks in one frame it will be helpful for industry because both labor cost and time will be reduced as well as increased the production rate of industry. By using the PLC whose model name is Siemens S7-200 and using the Micro-WIN software for making the ladder diagram, the entire system will be controlled. The experimental findings demonstrate that the system has high sorting accuracy, is reliable, and satisfies the design specifications.

Keywords:
Ladder diagram;
Programmable Logic Controller;
Pneumatic system;

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INTRODUCTION

Industrial automation is becoming the global trend in manufacturing, packaging and sorting processes is one of the most used in industry; more and more companies are switching to automate their industry. Development of control systems in the industrial world leads to production automation. The purpose of production automation is not only to increase productivity and reduce the working costs but also to be able to run the whole system

automatically and computerized. The development of an industry mainly depends on his better use of new innovative technology. Every industry wants to increase their production rate. For this mass production is the main goal of every industry to go forward in the competitive market. When the whole production line is fully automated it's easy to produce mass production [1]. So, bringing automation in the industrial sector is much required here. In the manufacturing sector, the same products are repeatedly produced with minor variations in color, length, height, and shape [2]. Finding the right product from a bank of several is particularly challenging because of the variety of shapes. Here, sorting is a key principle. There may be a potential of error if the sorting is done manually. Industry cannot tolerate human error in the product sorting process [3]. Sorting that is carried out mechanically lowers both human work and mistakes. Therefore, creating an automated procedure is crucial for accurately categorizing the products.

Here, a low-cost automated system will be created to sort the products according to their size and shrink packaging. Every sector makes extensive use of packaging. A variety of dangerous objects can ruin a product's quality. Packaging is therefore necessary in this situation to ensure the product's safety and protection. The environment contains a lot of dampness, fumes, dust, etc. The product is shielded from these risks by packaging. Packaging is also better in terms of handling. The cost of manual packaging increases, and many workers are needed in this situation. As a result, many businesses are automating industries to make work easier and generate enormous amounts of profit. Shrink packing is the technique of employing a hot air cannon or heat chamber to shrink a plastic film around a number of products or a single product. The primary purpose of shrink packing is to shield the goods from moisture as well as dust and grime. Additionally, it is done to provide the product's exterior a polished appearance. Regularly used for wrapping purposes is polyolefin. Most products are wrapped with polyvinyl chloride (PVC) or polyethylene film, which has a thickness of 50–350 microns. After wrapping, the product is heated using a portable hot air pistol or another heat source. The temperature range is around 350°C at a distance of approximately 300mm, plus or minus.

The main objectives of this study are developing a PLC based shrink wrap packaging and object sorting system. Here, a cell is introduced in which two different types of work are combined. The main goal of this cell is to reduce the overall processing time. Pneumatic system is introduced here to increase the sorting capability. Because an electric pusher will take more time than a pneumatic pusher for sorting purposes. When IR sensors detect a finished product this double acting cylinder which acts as a pusher will be pushed the finished product into the sub conveyor belt. If an electric pusher is used here, it will take more time for sorting. So pneumatic pusher will play a vital role here for reducing the sorting time. As a result, total production time is reduced and also increases productivity. Packaging is also incorporated in this cell due to saving the final product for various types of dust, moisture etc. Shrink wrap packaging is used here to save the product from moisture. Due to combining two different types of work in one cell it finally reduces the whole production time which is the main purpose of this study. By using Programmable logic controller (PLC) software the whole system will be controlled.

MATERIAL AND METHODS

Related Works

In this portion a critical analysis will be done of the existing literature which will be relevant to the project named development of a PLC based automation cell for industry. Though the literature consists of many research contributions, here some analysis will be done based on those research and review papers. Finally, a summary will be written about those relevant

research and review papers. Most of the previous works were based on Microprocessor, Arduino and Microcontroller**.** Therefore, the reliability of the system was lower due to the lack of real time operations and inability to carry excessive loads. Earlier projects on automatic packaging were run through old technology.

So, there would remain the probability of any serious fault due to malfunctioning in the control circuitry. Thirumurugan *et al.* [4] proposed a sorting technique which is done on the basis of product height by using programmable logic control (PLC). Here, a conveyor belt is used to move the object and a sensor is used to sense the height of the object. When the sensor senses the height and this height is matched with the desired height then the piston pushes the object from the belt. Tailor *et al.* [5] designed a sorting mechanism which is done for removing impure objects from the whole batch and stacking is also done for sorted pure objects by using Programmable Logic Control. Two conveyor belts are used for performing this operation named product conveyor and box conveyor. To operate this, four IR sensors are used to signal to the PLC and make sense for the presence of both objects and boxes in the conveyor belt. A proximity sensor is also used to trace the metallic defects. M. S. Ali *et al.* [6] developed an idea about automated multi-machine operation with product color and dimension sorting and packaging with motor speed control. This project develops a system for classifying light objects according to their height, width, and color change. Here, proximity sensors, ultrasonic sensors, LDR sensors, and an induction motor are interfaced with a PLC and a variable frequency drive (VFD) to control the process of sorting three various height objects. H. Hassan *et al.* [7] developed an idea about A Low-Cost Automated Sorting Recycle Bin powered by an Arduino Microcontroller. Here sorting is done to recycle waste products like aluminum, paper and plastic. Using an Arduino microcontroller, a recycle bin is developed which automatically sorts different types of waste material. K. M. C. Babu *et al.* [8] published a paper about Design and Development of a Cost-Effective Arduino based Object Sorting System. In this paper, Arduino NANO was the core portion of sorting color objects in which all components meet and interact at one place. UV sensor is used to trace the presence of the object. Here, objects are sorted using color identification with a TCS3200 sensor. S. N. Kulkarni *et al.* [9] proposed a model about an Object Sorting Automated System using Raspberry Pi. This paper consists of a MySQL database, Raspberry Pi, USB webcam, servo motor driver, robotic arm and an ultrasonic sensor. In this paper Raspberry Pi is used to perform sorting operation.

Patel *et al.* [10] worked for a sorting technique called IOT Color Based Object Sorting Machine. In this published work develop an idea about the internet of things (IOT) by which the sorting mechanism can be done. Here sorting is done using a TCS3200 color sensor which senses the color of the object, Arduino UNO and servo motors are also used here. Different colors have different wavelengths so in this sorting process color is identified using frequency scale of color detection. Palitana *et al.* [11] worked to develop an idea about how sorting could be done using MATLAB. In this paper, image processing is used for sorting purposes. Using image processing techniques, an object can be sorted and counted. Software called MATLAB was used to construct this image processing technology. L. Peilin *et al.* [12] proposed an automatic sorting system for sorting metal cylindrical workpiece based on machine vision and PLC technology. In this paper cylindrical metal workpiece is sorted by using machine vision technology. Here, to detect edge burr of the workpiece an algorithm is developed based on image processing. Programmable Logic Control (PLC) is used to control the sorting process. T. P. Tho *et al.* [13] developed an idea about a sorting system named Design and Development of the Vision Sorting System. In this paper sorting is done using machine vision technology. Here sorting is done following this step – detect the object, analysis the properties of the object as color, size, shape etc. allocate the sorted object, calculate the actual gripping position of the

object, the results of the sorting process will be stored and then converted into a signal to communicate with the control system of actuators to perform the sorting tasks finally. R. T. Yunardi *et al.* [14] studied Contour-based object detection in the Automatic Sorting System for parcel boxes. Here, Measurements of the volume of package boxes are made using computer vision technology. Image processing technology is connected to computer vision technology. Here, image processing is used to create a 3D model of the package box from 2D pictures. The dimensions of parcel boxes are measured by using two webcams. Rokunuzzaman *et al.* [15] Development of a low-cost machine vision system for sorting tomatoes. Using a neural network method, they created a low-cost machine vision system for fruit sorting to automate fruit fault inspection. Atanassov *et al.* [16] studied about controlling the speed of Coding Line Conveyor using fuzzy logic. Here, a system of color and size sorting is created for automatic inspection and path planning. The principal sensor in this system is a camera. To specify the multiple degrees of parcel size, fuzzy logic is used. Eied *et al.* [17] worked about the Development of Automatic Sorting Conveyor Belt Using PLC. A PLC-based system for sorting products is created in the study, and products are compared using a diffused beam type photo-electric sensor. Here, the model is made more user-friendly and effective through the application of supervisory control and data acquisition (SCADA) and human machine interface (HMI). Lin Y *et al.* [18] developed an Automatic sorting system for industrial robots with 3D visual perception and natural language interaction.

In this article, an automatic sorting system utilizing industrial robots with 3D visual perception, natural language interaction, and automatic programming technologies is explored. Here, a matching and interaction technique called "rule-scene" is presented to combine all of these modules. R. B. Mofidul *et al.* [19] worked together for Design and Implementation of Remote Controlling and Monitoring System for Automatic PLC Based Packaging Industry. Here, an automated packaging method is developed based on programmable logic control (PLC). A smartphone application was used to remotely control and monitor the entire process. H. H. Hadi *et al.* [20] pneumatic Control System of Automatic Production Line Using SCADA Implement PLC. Here, a decision-supporting SCADA system is created for the automatic production line to use both during and after the process. This production line is capable of carrying out feeding, transporting, and sorting tasks. FACTORY IO software simulates the procedure before it is put into practice. TIA PORTAL V15 software is utilized to operate the automatic production line using the S7-1200 PLC. Li, S. *et al.* [21] installation and Debugging of Pneumatic Sorting Station in Flexible Automatic Production Line.

This paper gives the structure and workflow of a pneumatic sorting station, summarizes the pneumatic components, and also gives the installation and debugging steps. Varma *et al.* [22] published a paper named Automatic Pneumatic Power Based Object Sorting System by Using MITSUBISHI PLC. Here an Automatic Pneumatic Power Based Object Sorting System is developed by using MITSUBISHI PLC. IR detectors detect the size of the object and pushing the object into the conveyor belt is the main purpose of this project. Mohammadreza Lalegani Dezaki *et al.* [23] developed a pneumatic conveyor robot for color detection and sorting. Here, a mechatronic conveyor system that is autonomous and intelligent is created for the purpose of placing and moving circular products in the manufacturing and packaging sectors. PLC, a color sensor, and an electronic switch manage the entire operation. Al Boteanu *et al.* [24] developed an automatic sorting and handling station which is actuated by pneumatic drive. Here, a robotic electro-pneumatic system is created to handle and organize parts according to color. The entire construction combines an electro-pneumatic drive system with rotary motors, linear actuators, and solenoid valves for control. Algitta *et al.* [25] developed a PLC-based automatic packaging

process prototype which is being used in the manufacturing sector. The main goal of this project is to automate the packaging of small cubic components by designing and creating a compact, straightforward conveyor belt system. Inductive sensors and photoelectric sensors were utilized to supply data to the controller. Conveyor belt is controlled by electrical DC motors. By using a ladder logic diagram, a programmable logic controller (PLC) is used to automate and control the entire system.

Methods

The project is based on the size base product sorting and wrapping system so many conveyor belts are required here. In our project we used three conveyor belts where one is used as the main conveyor belt and the remaining are sub conveyor belts. The conveyor belt is made of an aluminum frame, plastic roller, DC geared motor and belt. On the front side of the main conveyor belt a hot air gun and IR sensor is mounted. The remaining IR sensors were mounted at the end of the main conveyor belt. The sensors are mounted here based on the height of the product. The pneumatic pusher is also mounted alongside with the IR sensor to push the product from main conveyor belt to sub conveyor belt. A PLC controller is used to control the whole operation. The process block diagram is shown in Figure 1.

Circuit diagram

Here, Figure 2 shows the pin connection of the whole process. Power supply is fed via 220 V AC. To operate and regulate PLC, relays, IR sensors, DC geared motors, solenoid valve, and compressor, 220 V AC is transformed into 24 V, 12 V, and 5 V DC. The conveyor belt motors, pneumatic pusher, and heat chambers (hot air gun) are all controlled and operated using the output from the PLC, which is fed digital signals by IR sensors and solenoid valves. PLCs are used in industrial and commercial settings.

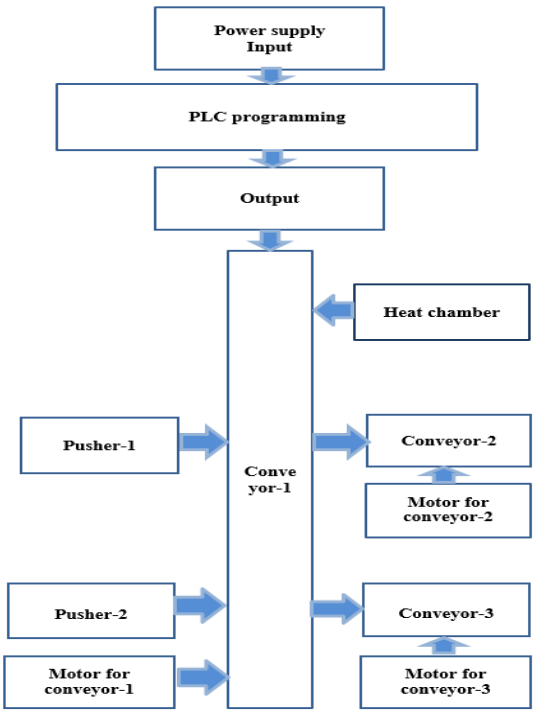


Figure 1. Block diagram of the sorting and wrapping operation

Here, the input is start stop switch (push button) and IR sensors which are connected with PLC pin no I0.0, I0.1, I0.2, I0.3 and I0.4. The output is conveyor belt, Hot air gun (used as heat chamber) and Solenoid valve which is connected with PLC pin no Q0.0, Q0.1, Q0.2, Q0.3, Q0.5 and Q0.6. A timer T37 is used for setting the wrapping time for the product. Here, a PLC (SIEMENS S7-200 module) is used to automate the process by monitoring the inputs, making decisions based on its program, and controlling the outputs. To identify objects and their height, IR sensors, push buttons, and solenoid valves are connected to a PLC as a digital input device. The 24-volt DC power source is mostly used to run the Automatic system. The desired output will be discovered when all desired programs have been executed. All outputs will be processed afterwards in accordance with the program. The circuit diagram of the proposed project is shown in Figure 2. Here, Table 1 shows the symbol of the circuit diagram and its working function both input and output.

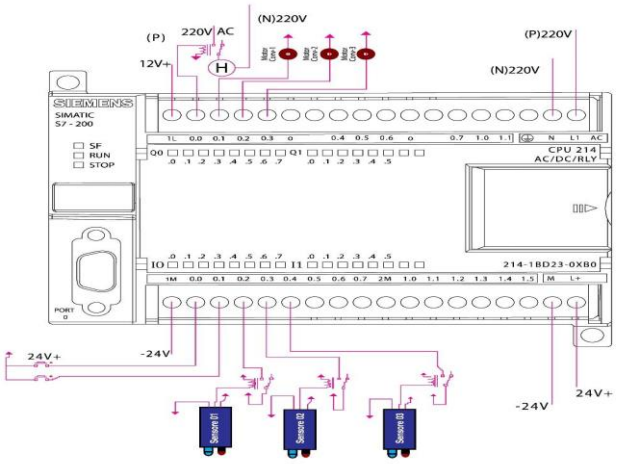


Figure 2. Circuit diagram of the sorting and wrapping operation

Table 1. Symbolic table of the circuit diagram

Symbol	Address (Input)	Function
START	I0.0	Start the Whole operation
Stop_sw	I0.1	Emergency switch
Heater_sensor	I0.2	Detect the product for wrapping
Small_sensor	I0.3	Detect the small sized product
SET_RESET	M0.0	SET_RESET
RESET_HEATER	T37	RESET_HEATER
Big_sensor	I0.4	IR sensor detect big sized product

Symbol	Address (Output)	Function
Heater_on	Q0.0	Hot air gun is start wrapping
Main_Conv	Q0.1	Move main conveyor belt (Conv-1)
Big_Conv	Q0.2	Move sub conveyor belt (Conv-2) with small product
Small_Conv	Q0.3	Move sub conveyor belt (Conv-3) with big product
Big_SV	Q0.6	Solenoid valve for big sized product
Small_SV	Q0.5	Solenoid valve for small sized product
Small_Conv	Q0.3	IR sensor detect small sized product

Hardware Implementation

In this portion all the equipment like DC geared motor, IR sensor, solenoid valve, double acting cylinder, hot air gun is shown in Figure 3 which are required for the automatic wrapping and sorting system. Here sorting is done by pneumatic pusher. First of all, Aluminum frames are used to make conveyor systems. Then different equipment like solenoid valves, pneumatic pusher, DC gear motors are incorporated with the conveyor belt. IR sensor and hot air gun also placed in the right position due to trace the object correctly.

The program is created with the software name Step 7 Micro/Win before the project is started. IR sensors locate the product at the start of the main conveyor belt, and a hot air gun begins wrapping the item in the heat chamber. The merchandise is wrapped here to protect it from dampness. All product sizes are supplied on the main conveyor belt, and an IR sensor determines the product sizes. The pneumatic pusher pushes the product into the sub conveyor belt based on the size of the product.

Working Process

The working procedure of this whole process is: at first pressing the left side green color push button to start the whole process. When an emergency situation is arising to stop the whole operation, a red color push button is placed in the panel board which is used to stop the whole operation. A green color indicator light is used at the top of this panel board. When this indicator blows up it means the process is working. If there is no signal in this indicator it means the operation is stopped. The panel board is shown in Figure 4.

The whole operation is started after pressing the start button (push button). There is a red color emergency switch beside the start button. This switch is used to stop the whole operation when an emergency situation arises in the factory to stop the operation. The main conveyor belt begins to move once the start button is pressed. When large and small products are detected by IR sensors, hot air guns begin wrapping for 10 seconds. Conveyor Belt 1 is moving as the product is being wrapped.

The IR sensor measured the product's height. If the height of the product is 14cm then conveyor belt 2 is started and a pneumatic pusher pushes the product into sub conveyor belt 2 and collects the product from the container.

Figure 3. Components for the whole project

Figure 4. Panel board

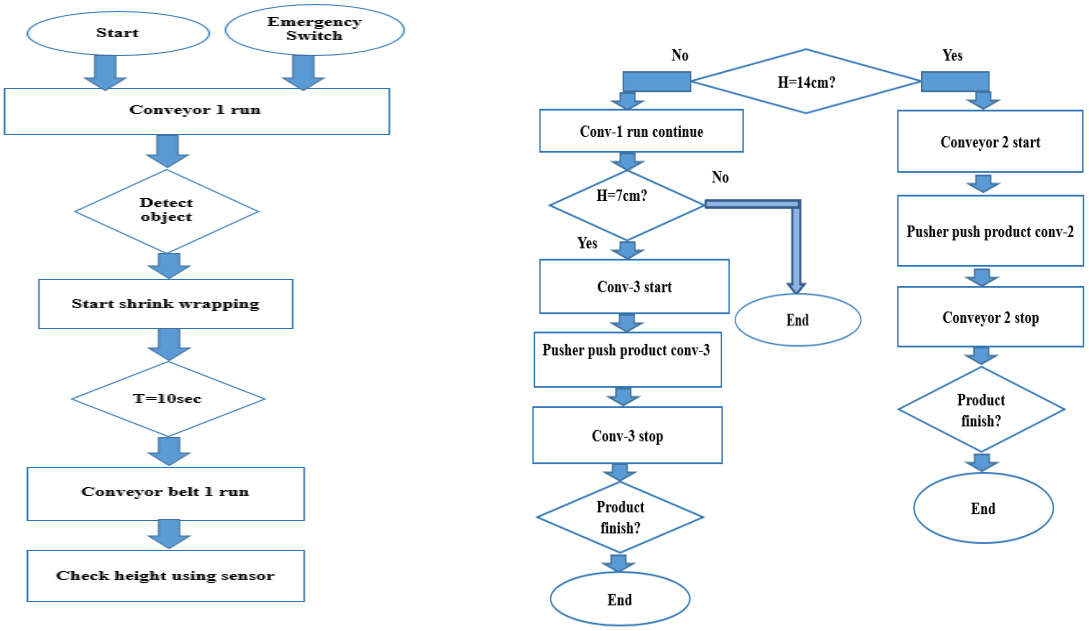


Figure 5. Flow chart of the project

If there is no product in the lot then the machine is stopped. If the IR sensor checks the height of the product is 7 cm, then conveyor belt 3 is started and a pneumatic pusher pushes the product into sub conveyor belt 3 and collects the product from the container. If there is no product in the lot then the machine is stopped. The sub conveyor belt 2 and 3 start only the time when IR sensors detect big and small size products and stop automatically. Both conveyor belts are stopping due to energy loss in the factory. The whole process is a continuous process. If there is no product in the conveyor belt then the machine will stop. The whole working process is shown in Figure 5.

Figure 6 shows the overall view of the proposed project. Both wrapping and sorting operations are shown in Figure 7. The first part of this figure shows the wrapping operation which is done by using a hot air gun. When IR sensors detect a product passing through the main conveyor belt then hot air guns start wrapping this product for 10 sec. The hot air wraps both small and big sized products. The second part of this figure shows the sorting mechanism. When small and big sized products pass through the main conveyor belt after finishing the wrapping the IR sensor detects all finished products based on their size and pushes the sub conveyor belt using a pneumatic pusher.

Figure 6. Overall view of the proposed project

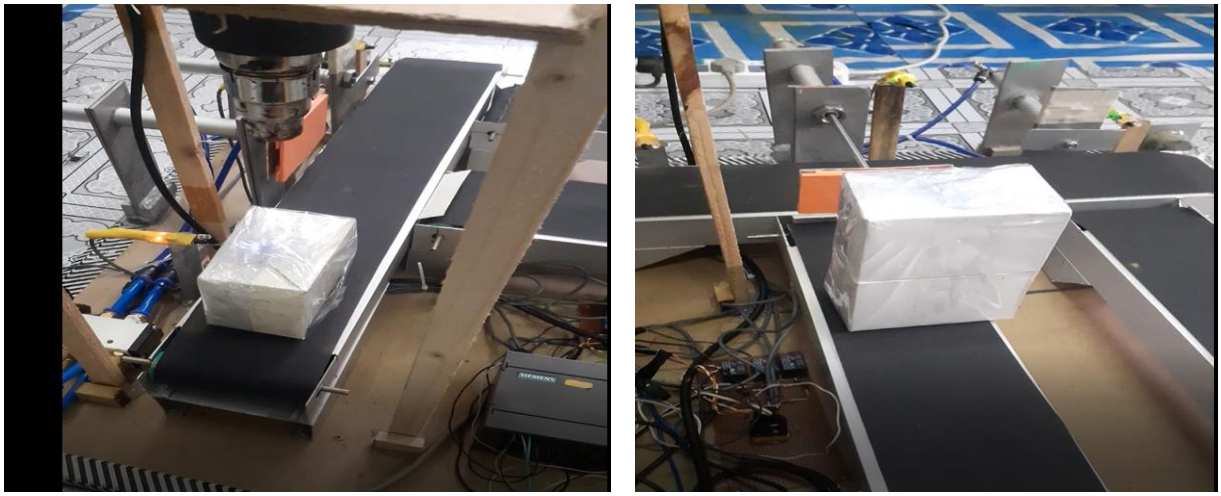
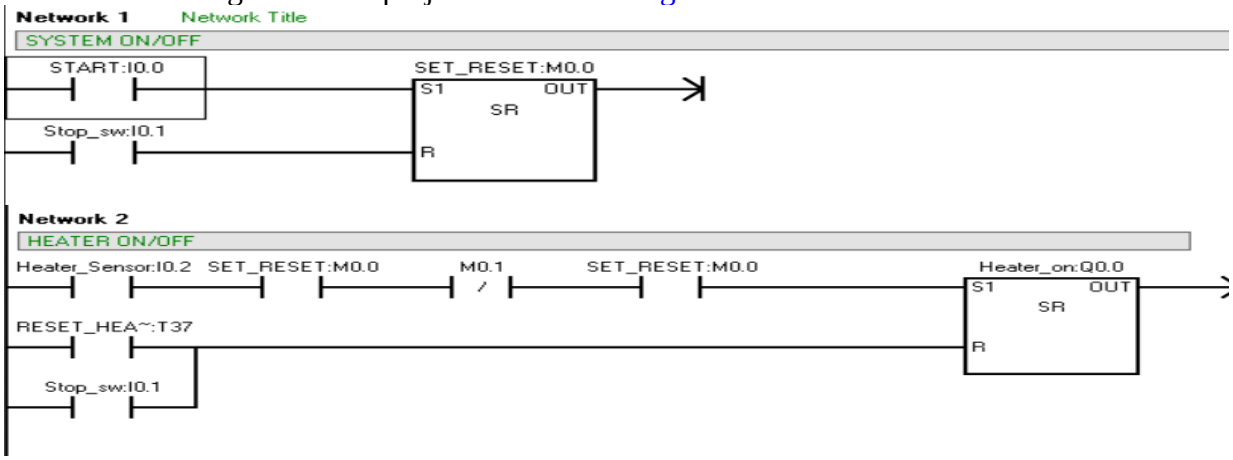
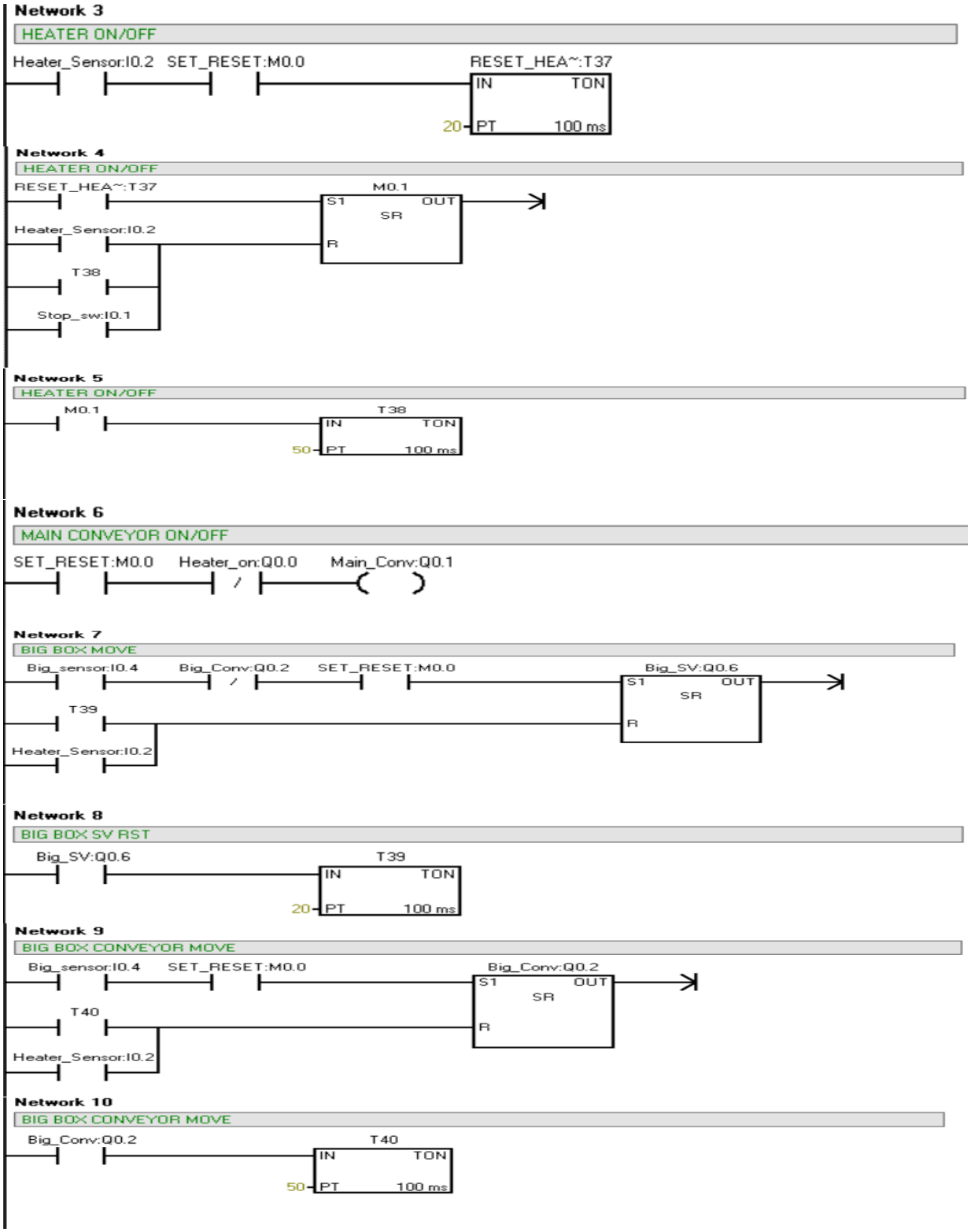


Figure 7. Wrapping operation and sorting operation using pneumatic pusher

Ladder Diagram of the proposed project

The ladder diagram of the project is shown in Figure 8.




Network 3
HEATER ON/OFF
Heater_Sensor:I0.2
SET_RESET:M0.0
RESET_HEA~:T37
IN
TON
20
PT
100 ms
Network 4
HEATER ON/OFF
RESET_HEA~:T37
M0.1
S1
OUT
SR
Heater_Sensor:I0.2
R
T38
Stop_sw:I0.1
Network 5
HEATER ON/OFF
M0.1
T38
IN
TON
50
PT
100 ms
Network 6
MAIN CONVEYOR ON/OFF
SET_RESET:M0.0
Heater_on:Q0.0
Main_Conv:Q0.1
Network 7
BIG BOX MOVE
Big_sensor:I0.4
Big_Conv:Q0.2
SET_RESET:M0.0
Big_SV:Q0.6
S1
OUT
SR
R
T39
Heater_Sensor:I0.2
Network 8
BIG BOX SV RST
Big_SV:Q0.6
T39
IN
TON
20
PT
100 ms
Network 9
BIG BOX CONVEYOR MOVE
Big_sensor:I0.4
SET_RESET:M0.0
Big_Conv:Q0.2
S1
OUT
SR
R
T40
Heater_Sensor:I0.2
Network 10
BIG BOX CONVEYOR MOVE
Big_Conv:Q0.2
T40
IN
TON
50
PT
100 ms

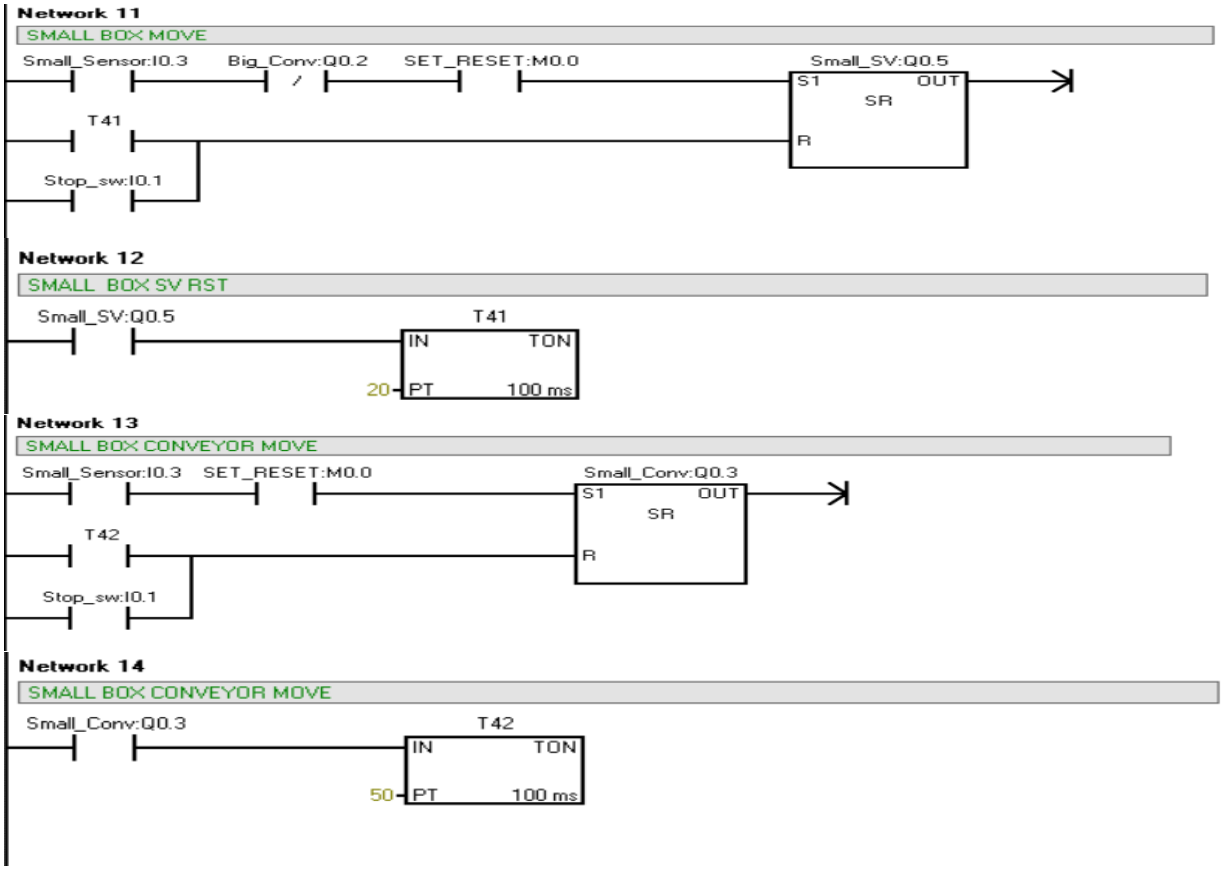


Figure 8. The Ladder Diagram of the proposed project

RESULT AND DISCUSSION

Accuracy Test

For accuracy tests, this bar chart is drawn based on total time required for both wrapping and sorting operation. For a product with a height of about 14cm, total time required for both wrapping and sorting operation is about 7 sec and product which height is about 7 cm is required 10 sec to complete both operations. By using a stopwatch here, that time is counting. For example (14cm height/test 01): Product 1 done both wrapping and sorting operation in 7sec. So, accuracy of product 1 is 100% but product 2 does not complete both operations in due time rather it takes more time to complete both the operation. So, its accuracy is around 78%. Again product 3 completes both operations on due time. Rest of the test is done by following this process. The chart1 for the accuracy test is given in Figure 9.

Discussion

The final output of this project is that the total sorting time is reduced because a pneumatic pusher is used here. Pneumatic pusher response very quickly which reduced the sorting time as compared with electric pusher. Electric pusher works very slowly as compared with pneumatic pusher because there is some gear mechanism which reduces its speed. The pneumatic pusher receives a signal to push the product to the main conveyor belt to the sub conveyor belt when IR sensors identify the presence of a product.

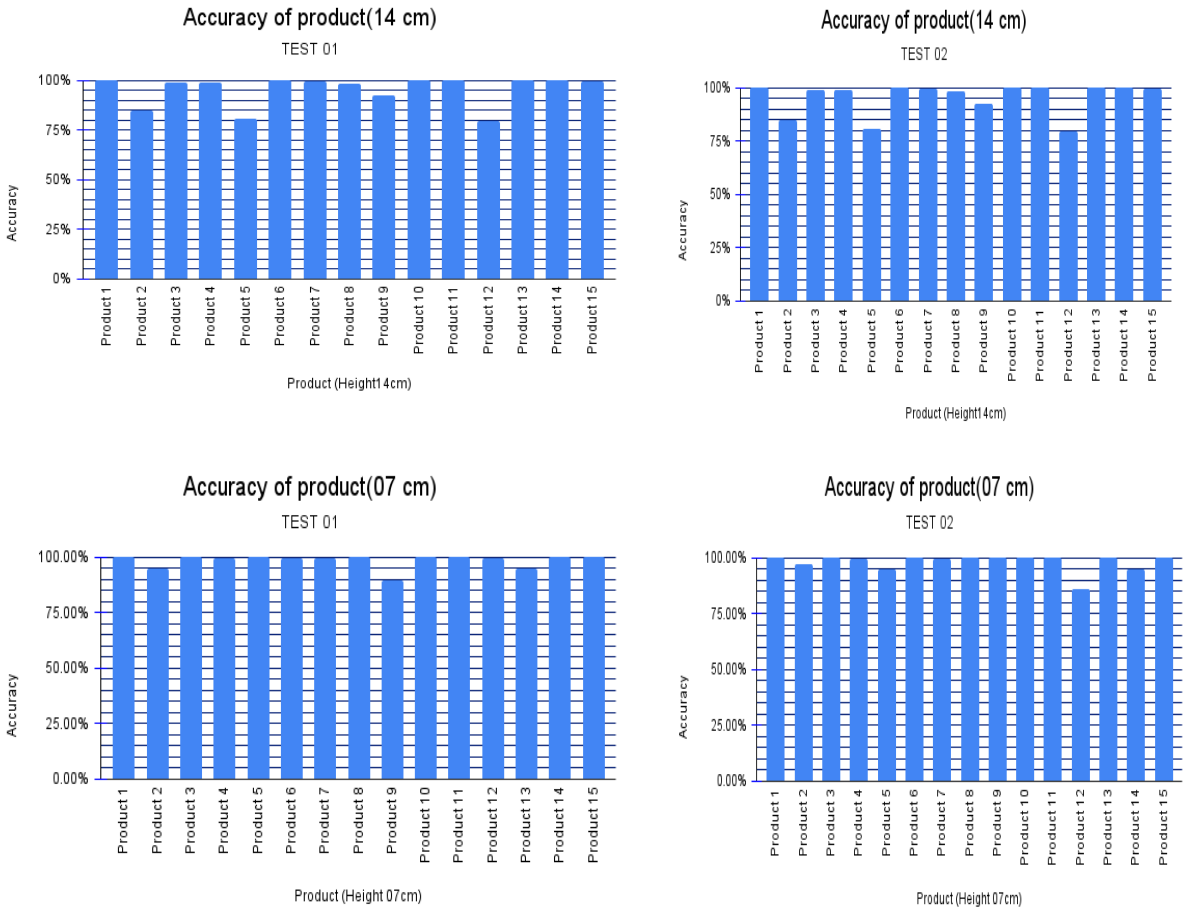


Figure 9. Bar chart for the accuracy test (height 14 cm and 7 cm)

In this case, the pneumatic pusher is crucial in moving the product from the main conveyor to the sub conveyor belt. As a result, the total time required for wrapping and sorting is reduced which increases the production of a factory. But an electric pusher takes a lot of time to perform this operation.

There is some data required for running the whole process. This data is: shrinking paper thickness is about 0.5mm, number of conveyor belts is 3, time required for wrapping the product is about 10 sec, height of big and small sized product is 14cm and 7cm, speed of conveyor belt 1, 2, 3 is respectively 13.083 cm/sec, 21.92cm/sec, 25.6cm/sec. By using this machine, we can complete approximately 210 products per hour with both wrapping and sorting. The system is more efficient than other system [26].

CONCLUSION

The project's aim is to shrink packaging of any final products letting pass through the heat chamber or hot air gun and then to sort them in a manner of different heights and sizes by means of assembler section. After being produced at the main production area, the products are first wrapped using a hot air gun through the main conveyor belt, and then they are organized into other conveyor belts that are designed specifically for certain products. The main goal of this project is to develop a PLC based automation cell in which both shrink wrap packaging and sorting is done. Sorting procedures are merely one of the world's many modern conveniences because they enable businesses to package goods without hiring additional staff to handle that

particular task. There are far too many other crucial parts of any industry to run on human labor. In such circumstances, giving a finishing section to a machine that does both sorting and shrink packing would not only reduce manufacturing costs but also save time, boost reliability, and boost output rate. Therefore, if this automation cell can be used in industry, it will result in the desired happiness, relaxation, and productivity growth.

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REFERENCES

[1] S. L. Jämsä-Jounela, "Future trends in process automation," *Annual Reviews in Control*, vol. 31, no. 2, pp. 211– 220, 2007, doi: 10.1016/j.arcontrol.2007.08.003.

[2] T. Samad, P. McLaughlin, and J. Lu, "System architecture for process automation: Review and trends," *Journal of Process Control*, vol. 17, no. 3, pp. 191–201, 2007, doi: 10.1016/j.jprocont.2006.10.010.

[3] I. H. Saydee, S. M. G. Mostafa, and B. Al Imran, "Automatic Shrinking and Sorting of Industrial Finished Products," *2018 International Conference on Innovations in Science, Engineering and Technology ICISET 2018*, no. October, pp. 74–78, 2018, doi: 10.1109/ICISET.2018.8745634.

[4] P. Thirumurugan, "Automatic Sorting in Process Industries using PLC," *GRD Journals (Global Research and Development Journals)*, vol. 3, no. 3, pp. 8–13, 2018.

[5] P. D. Tailor, V. Kamani, A. Ghetiya, and N. Bhatiya, "Object Sorting and Stacking Automation With PLC," *International Journal of Engineering & Technology*, vol. 9, no. 3S, pp. 197–201, 2017, doi: 10.21817/ijet/2017/v9i3/170903s031.

[6] M. S. Ali and M. S. R. Ali, "Automatic multi machine operation with product sorting and packaging by their colour and dimension with speed control of motors," *2017 International Conference on Advances in Electrical Technology for Green Energy (ICAETGT)*, Coimbatore, India, 2017, pp. 88-92, doi: 10.1109/ICAETGT.2017.8341466.

[7] H. Hassan, F. Saad and M. S. Mohd Raklan, "A Low-Cost Automated Sorting Recycle Bin powered by Arduino Microcontroller," *2018 IEEE Conference on Systems, Process and Control (ICSPC)*, Melaka, Malaysia, 2018, pp. 182-186, doi: 10.1109/SPC.2018.8704146.

[8] K. M. C. Babu and P. A. Harsha Vardhini, "Design and Development of Cost-Effective Arduino based Object Sorting System," *2020 International Conference on Smart Electronics and Communication (ICOSEC)*, pp. 913-918, 2020, doi: 10.1109/ICOSEC49089.2020.9215269.

[9] S. N. Kulkarni and S. Kumar Singh, "Object Sorting Automated System using Raspberry Pi," *2018 3rd International Conference on Communication and Electronics Systems (ICCES)*, Coimbatore, India, 2018, pp. 217-220, doi: 10.1109/CESYS.2018.8724056.

[10] H. Patel, R. Joy, S. Macwan, and H. Modi, "IOT Color Based Object Sorting Machine," *International Journal of Applied Engineering Research*, vol. 13, no. 10, pp. 7383–7387, 2018.

[11] N. Khan, K. Lakdawala, S. Palitana, and R. Khan, "Object Sorting System based on Colour Sensing using MatLab," *IJSRD - International Journal for Scientific Research & Development*, vol. 4, no. 11, pp. 2321–0613, 2017.

[12] L. Peilin, Y. Zhen, Z. Wenlong and L. Hong, "An automatic sorting system for sorting metal cylindrical workpiece based on machine vision and PLC technology," *2017 2nd International Conference on Robotics and Automation Engineering (ICRAE)*, Shanghai, China, 2017, pp. 446-450, doi: 10.1109/ICRAE.2017.8291427.

[13] T. P. Tho, N. T. Thinh and N. H. Bich, "Design and Development of the Vision Sorting System," *2016 3rd International Conference on Green Technology and Sustainable Development (GTSD)*, Kaohsiung, Taiwan, 2016, pp. 217-223, doi: 10.1109/GTSD.2016.57.

[14] R. T. Yunardi, Winarno and Pujiyanto, "Contour-based object detection in Automatic Sorting System for a parcel boxes," *2015 International Conference on Advanced Mechatronics, Intelligent Manufacture, and*

Industrial Automation (ICAMIMIA), Surabaya, Indonesia, 2015, pp. 38-41, doi: 10.1109/ICAMIMIA.2015.7507998.
[15] M. Rokunuzzaman and H. P. W. Jayasuriya, "Development of a low-cost machine vision system for sorting tomatoes," *Agricultural Engineering International: CIGR Journal*, vol. 15, no. 1, pp. 173–180, 2013.
[16] A. Atanassov, "Controlling the speed of Coding Line Conveyor using fuzzy logic," in *Proceedings of the International Conference on Computer Systems and Technologies and Workshop for PhD Students in Computing*, Rousse, Bulgaria, June 18-19, 2009, pp. 1–6, doi: 10.1145/1731740.1731775
[17] Simran, S. Kamboj and A. Diwan, "Development of Automatic Sorting Conveyor Belt Using PLC," *International Journal of Mechanical Engineering and Technology*, vol. 10, no. 8, pp. 109–118, 2019.
[18] Y. Lin, H. Zhou, M. Chen, and H. Min, "Automatic sorting system for industrial robots with 3D visual perception and natural language interaction," *Measurement and Control (United Kingdom)*, vol. 52, no. 1–2, pp. 100–115, 2019, doi: 10.1177/0020294018819552.
[19] R. B. Mofidul, M. S. H. Sabbir, A. K. Podder and M. Shaifur Rahman, "Design and Implementation of Remote Controlling and Monitoring System for Automatic PLC Based Packaging Industry," *2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT)*, Dhaka, Bangladesh, 2019, pp. 1-5, doi: 10.1109/ICASERT.2019.8934779.
[20] H. H. Hadi and M. Y. Sallom, "Pneumatic Control System of Automatic Production Line Using SCADA Implement PLC," *2019 4th Scientific International Conference Najaf (SICN)*, Al-Najef, Iraq, 2019, pp. 37-42, doi: 10.1109/SICN47020.2019.9019356.
[21] S. Li, X. Zhou, and X. Liu, "Installation and Debugging of Pneumatic Sorting Station in Flexible Automatic Production Line," *Journal of Physics: Conference Series*, vol. 1971, no. 1, 2021, doi: 10.1088/1742-6596/1971/1/012037.
[22] P. C. Varma and G. Venkateswarlu, "Automatic Pneumatic Power Based Object Sorting System by Using MITSUBISHI PLC," *CVR Journal of Science and Technology*, vol. 9, pp. 91–97, 2015.
[23] M. L. Dezaki, S. Hatami, A. Zolfagharian, and M. Bodaghi, "A pneumatic conveyor robot for color detection and sorting," *Cognitive Robotics*, vol. 2, pp. 60–72, 2022, doi: 10.1016/j.cogr.2022.03.001
[24] L. Alboteanu, G. Manolea, and F. Ravigan, "Automatic sorting and handling station actuated by pneumatic drive," *Annals of the University of Craiova, Electrical Engineering Series*, no. 1, pp. 1–8, 2018
[25] A. A. Algitta, "Automated Packaging Machine Using PLC," *IJISET - International Journal of Innovative Science, Engineering & Technology*, vol. 2, no. 5, pp. 282–288, 2015.
[26] T. J. Nuva, Md. I. Ahmed and S. S. Mahmud, "Design & Fabrication of Automatic Color & Weight-Based Sorting System on Conveyor Belt," *Journal of Integrated and Advanced Engineering (JIAE)*, vol. 2, no. 2, pp. 147-157, 2022, doi: 10.51662/jiae.v2i2.87