Journal of Integrated and Advanced Engineering (JIAE)
Vol. 2, No. 2, September 2022: 147-157
http://asasijournal.id/index.php/jiae
http://doi.org/10.51662/jiae.v2i2.87

Design & Fabrication of Automatic Color & Weight-Based Sorting System on Conveyor Belt

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Abstract
Object sorting is a basic process that is employed in a variety of disciplines in our daily lives for our convenience. Previously, the sorting operation was done by hand using labor justification. Because product quality does not remain consistent during the typical sorting process, it adds complexity to the segregation of products based on their height, color, size, and weight. This method is also time-consuming and slows down output. To overcome these problems, Low-Cost Automation (LCA) has been implemented in the sorting system, which aims to reduce production time, labor cost, and processing complexity, improve product quality, increase production rate, etc. So, in this project, an effective method has been developed for automatically sorting the object based on color and weight. This method uses a conveyor belt, strain gauge load cell, DC motor, servo motor, TCS 34725 RGB color sensor, LCD, LED, and LDR to identify, separate, and collect the objects according to their color and weight. Arduino is used to controlling all the processes. This work has sorted three types of colors -red, , green, and blue, and the weight of different ranges. Firstly, the weights have been sorted by load cell, and then the desired colors have been sorted by color sensor. A bucket at the end of the conveyor belt can be rotated depending on the signal sent from the Arduino to collect the box. The collecting box has a specific portion in a particular color. Hence, it could be rotated at a specific angle for an exact weight for red, blue, and green colors.

Keywords:
Arduino Mega:
Collecting Box;
Conveyor;
DC motor;
Load Cell;
Servo motors;

Article History:
Received: September 4, 2022
Revised: September 16, 2022
Accepted: September 20, 2022
Published: September 25, 2022

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INTRODUCTION

The shift of an economy from one that is primarily agricultural to one that is reliant on product manufacture is known as industrialization. Individual manual work is regularly displaced by mechanized industrial manufacture, and assembly lines frequently replace craftsmen. Economic development, more productive separation of labor, and the usage of technical advancement to address challenges are both characteristics of industrialization compared to reliance on conditions outside human influence [1]. Industrialization plays a vital role in the economic growth of any underdeveloped country. From the previous record, developed countries broke their poverty by creating industrialization rather than concentrating on agriculture or natural resources.

Nowadays, automation plays a vital role in making industrial operations more efficient and flexible. The use of control systems, such as computers or robots, and information technology for handling various processes and machinery in an industry to replace a human being is known as industrial automation. It is the next step in the industrialization process after mechanization [2]. Automation includes maximum production rates, raised productivity, improved worker safety, reduced production time, and excellent product quality. Enhanced productivity and maximum output are the two biggest causes of using automation.

The manufacturing industry has some products with little differentiation in color, weight, size, height, and shape. For this, sorting plays a vital role in any production system. Previously, sorting was done manually by labor, but it is a very difficult and time-consuming system. To address these issues, an automated sorting system was created. However, the economy is an important element in the development of every sector. As a result, Low-Cost Automation (LCA) must be improved in order to sort the pieces efficiently. Therefore, the Low-Cost Automation System (LCA) has been developed in this project for sorting objects by color and weight [3].

The objectives of this system are: to design a system that can sort the objects according to their color and weight, to fabricate the system for simultaneous sorting, to collect the objects according to their color and weight into the collecting box, and to find the object sorting precision and accuracy based on color and weight. Some scopes while designing this system are: in the food processing industry too, sorting and packaging the products, scaling and classification of agricultural goods, pharmaceutical businesses, assembling the same color products in one packing box, and where risky and repeated works are performed.

MATERIAL AND METHODS

Previous Work

Due to technical advances and the need to run factories rapidly, the developed world's production rate has increased dramatically. Normally, manufacturers create the same commodity type with no weight, color, height, or shape changes. And it's at this point that the sorting process kicks in. In this case, companies are unlikely to accept human errors as a consequence of commodity sorting. Therefore, it is now critical to increasing Low-Cost Automation to sort these materials (LCA) properly. This project is about a color-based sorting device that can be used in any industrial environment. It is important because we want a precise result, but it will struggle if the loss is large. Many scholars have worked on these issues.

Thike *et al.* [4] have improved the Automatic Color Sorting Machine on Belt Conveyor, which is based on an RGB color sensor to sort objects according to their color. They used Arduino UNO, TCS230 color sensor, DC motor to control conveyor, robotic arm etc. Kunhimohammed *et al.* [5] improved the Automatic Color Sorting Machine Using TCS230 Rudresh *et al.* [6] advanced a project on a material handling system. The robotic arm has been used to pick and place objects on moving conveyor belts. Depending on the colour sensor, robotic arm robotic arm grasps objects and placing into correct position and returns to normal position. Patel *et al.* [7] published a paper about sorting objects according to their colour using a TCS3200 colour sensor, Arduino UNO, and Servo motor. This process has been developed by the Internet of Things (IoT) and Global System for Mobile Communication (GSM) modules. Fernandes *et al.* [8] advanced a project utilizing a robotic arm to identify and sort items based on color and form. The machine uses a web camera to record real-time images, which are then converted from RGB to HSV (hue, saturation, value). The method then uses the contour detection technique to determine the shape of the target. Amhani *et al.* [9] developed a project to detect ten different colors and differentiate between them. The materials, operating theory, relations, measurements, effects, and errors will all be explained in this article. The device is designed to identify and distinguish between ten distinct colors. Bhaskar *et al.* [10] designed a project about color sorting of objects by a robotic arm. They have a robotic arm that can pick up various colored cubes and arrange them into various cups. Photo analysis using a webcam is used to create the color processing.

Jyothi *et al.* [11] improved a project about separating objects based on color and size on a conveyor belt. Here they used Arduino Uno and wireless monitoring system. Bargal *et al.* [12] have developed a project about PLC based object sorting system. They have built an LCA system for sorting lightweight items based on height variation, which is operated by DC geared motors. The object is passed in front of sensors by the Programmable Logic Controller (PLC) and the conveyor in the device, and sorting logic is determined. Yadav *et al.* [13] have invented a project about color sorting system based on IoT. Arduino, dc motors, and a mechanical arm are used here for controlling the robotic arm, which separates objects according to color. The outcome of this project can be stored on the cloud Thingspeak. Adebimpe *et al.* [14] discovered a system that can identify objects according to color. A robotic arm used to sort objects. Yang *et al.* [15] published a paper about sorting systems according to height on a conveyor belt using PLC. Also used photo electric sensor. Sasidhar *et al* [16] presented the Color Sorting Machine is controlled by a Programmable Logic Control (PLC) and SCADA-based control system. Dezaki *et al.* [17] designed A pneumatic conveyor robot for color detection and sorting. This project aims to design and construct an automated and intelligent mechatronic conveyor system for carrying and positioning circular products in the manufacturing and packaging industries.

Vandana *et al.* [18] have developed an S71200-PLC-based sorting system according to the color of the objects. They used a TCS2300 Color sensor, electromagnetic actuators and a conveyor belt. Patunkar *et al.* [19] have designed PLC based sorting system for height, and weight. They also used a Color sensor, a Pneumatic actuator, and, a Conveyor belt. Dunakhe *et al.* [20] developed PLC-based color sorting system in the Conveyor belt. They used Image processing algorithms to sort objects according to parameters. Ananthi *et al.* [21] designed and fabricated color based automatic yarn carrier sorting machine. The Pneumatic cylinder has used to transfer yarn in their respective place. Raj [22] *et al.* have advanced Ardino-based product sorting systems according to size. The system consists of a proximity sensor, pneumatic actuator, IR sensor, and conveyor belt. Another work we have done on color sorting using color sensor and something like that [23].

Kumbhar *et al.* [24] proposed a system where weight is used as a sorting criterion in this paper's proposed sorting algorithm. The constructed machine tries to use mechanical and electronic components in conjunction with one another. The load cell arrangement takes center stage in the system. Kannaki *et al.* [25] developed a system for design, construction, assembly, and commissioning of an automatic Sorting machine using a Weighing mechanism are presented in this work. Weighing scales or weighing machines are the most common methods of measurement. Weighing machines are measuring instruments used to determine an object's weight or mass. Anekar *et al.* [26] have proposed an effective method for identifying and distinguishing items based on their weight and color using a load cell, inductive sensor, and TCS 230 color sensor. A microcontroller is used to power the device. The sorting of items as a whole is used. Objects that do not meet the system's requirements are rejected and discarded by a pneumatic cylinder moving them out of the conveyor line.

Prasad *et al* [27] developed an automatic sorting machine prototype uses a pneumatic system to allow systematic sorting of carton boxes according to their sizes, which is accomplished using pneumatic cylinders and direction control valves. Ali *et al.* [28] have developed an LCA system for multi-machine operation and sorting light weight objects based on height variation using DC geared motors, induction motors, and stepper motors that are controlled by a PLC, Variable Frequency Drive (VFD), and the conveyor in the system passes the object in front of sensors and thus sorting logic is decided.

Aruna *et al.* [29] invented an Automatic conveyor System with In–Process Sorting Mechanism using PLC and HMI System. Many businesses use the same conveyor belt to transport task parts of varied sizes, which must be separated at various points along the manufacturing line. They are employing an automated procedure to separate materials of various sizes for this purpose. Yadav *et al.* [30] improved an LCA (Low-Cost Automation) system that has been devised to categorize things according to their height. The PLC is in charge of this LCA system (PLC). This project is divided into two sections. The first is software that comprises ladder logic programming and is used to program a PLC that controls the entire project's operation. The second component is the hardware, which includes conveyors for transporting the articles and sensors for detecting their height.

Method

In this project, the conveyor belt was initially designed in Fusion 360 software. Then, it was made by frame, roller, pillow block, motor and belt. On the front side of the conveyor belt, the load cell and servo mechanism were mounted, and at the end of the conveyor belt, there is a collecting box with a red, blue and green portion for collecting objects. All of the hardware equipment was attached above the conveyor belt. Arduino has controlled the whole system. Power supply has been given through the adapter for activating the sorting system. And then, a full color and weight-based sorting were obtained. The process is shown in Figure 1.

Design and Construction of Conveyor belt

Designing an automated sorting machine with a conveyor belt to meet the industrial business's needs in various fields is difficult. The system must meet industry demands [31]. Conveyor systems come in various shapes and sizes, and a belt conveyor system is one of them. A belt conveyor system is made up of the following components: Belt, roller, dc motor, Aluminum bar etc. Also, Fusion 360 software is used to design conveyor belts. The design of the conveyor belt is shown in Figure 2. The conveyor belt is driven by three plastic rollers, and a dc motor is used to activate the conveyor belt. The frame of the conveyor belt is made of an Aluminum bar. The plastic rollers have been used, so the conveyor did not run smoothly. Moreover, it slipped with a plastic roller. Silica paste and super glue mixed were used to overcome this problem. The final Conveyor belt is in Figure 3.

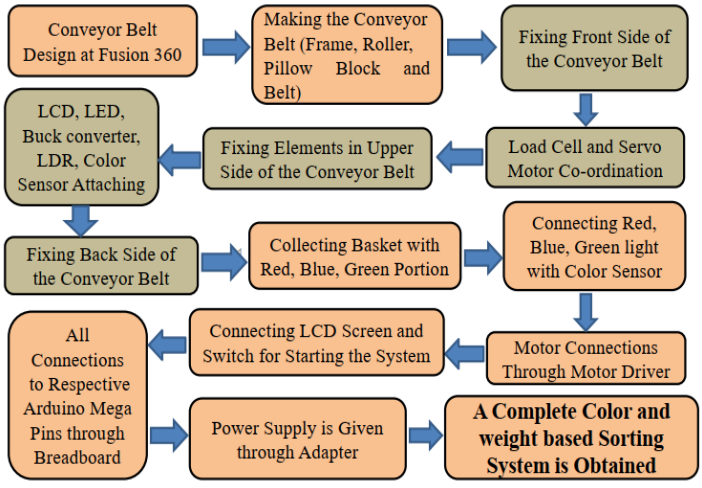

Figure 1. Schematic Diagram of Whole Process

Figure 2. Designing Conveyor Belt in Fusion 360

Figure 3. Conveyor Belt

Development of Mechanical Structure

Adjusted Color Sensor, Arduino Mega, LDR, LED, LCD, Motor Driver Module, Buck converter, above the Conveyor Belt in is depicted in Figure 4. At the very beginning of the conveyor belt, the weight sensor and servo motor have been adjusted. Here weight sensor can measure the weight of objects, and a servo motor is used for pushing objects backwards and forward. The adjustment is shown in Figure 5. Adjusted Color Sensor, Arduino Mega, LDR, LED, LCD, Motor Driver Module, and Buck converter above the Conveyor Belt can be seen in Figure 6. The collecting box was fixed at the end of the conveyor belt. That was used for the collection of required coloring objects. This box has three portions for three different color. This process has shown in Figure 7 and Figure 8 to become a complete sorting machine.

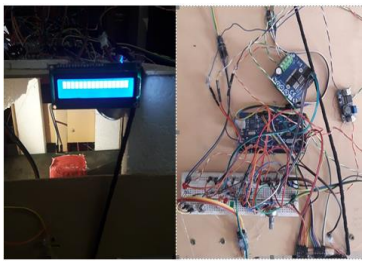

Figure 4. Components above the conveyor belt

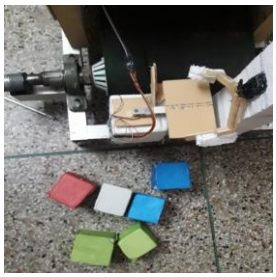

Figure 5. Servo mechanism and Load cell

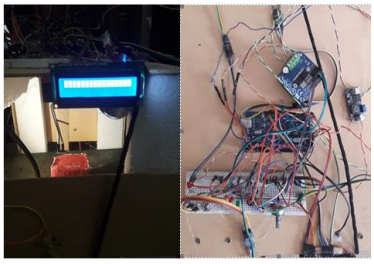

Figure 6. Adjusted all components above the conveyor belt.

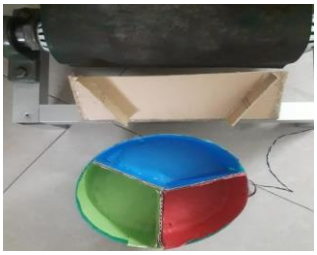

Figure 7. Adjusted Collecting Box

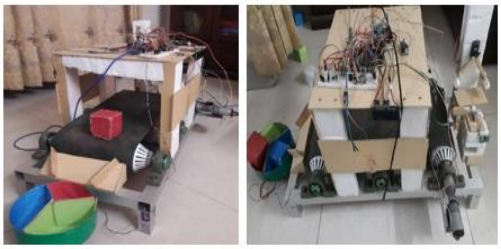

Figure 8. Color and weight-based Sorting Machine

Development of Electrical System

220V AC power supply has been given through the power adapter to activate the sorting system. The adapter converted the 220V AC into a 12V DC supply. Buck module then converted 12V DC into 5V DC supply. Then 5V power was given to Arduino, sensors, LED, LCD and motors. Here, sensors are input, and motors are output for Arduino. The circuit diagram of proposed system is depicted in Figure 9.

Working Process of Weight and Color Sorting System

Generally, the working process of the systems can be seen in Figure 10. The explanation is as follows. At first, the power supply was given through the adapter and pressed the button for initialization of the system. Then, LCD started to display this project in Figure 11. Secondly, the objects of different color and weights are put on the weight sensor for measuring weight, and the measuring weights have shown on the LCD. Then, the response of the weight sensor is sent to the Arduino mega.

So, the objects with a range of weight of 100-250gm were pushed into the conveyor belt. The range of weight of 30-99gm was pushed outside the conveyor belt through the servo mechanism. The process is shown in Figure 12. Then, the response of the weight sensor is sent to the Arduino mega. So, the objects with the range of weight of 100-250gm were pushed into the conveyor belt and out of the range of 100-250gm were pushed outside the conveyor belt through the servo mechanism. The objects were then sensed by color sensor for three colors as Blue, Red, Green and also unknown color. And the detected color showed on the LCD. Such as Red color detected. Blue and Green colors were also detected in same process in Figure 13, as no color was detected.

Then, Arduino sent a signal to the DC motor, and the conveyor rotated reversely, and objects were back into the initial position of the conveyor. Then, the LCD showed Pick up your product in Figure 14. Finally, color and weight sorting are perfectly done, as shown in Figure 15.

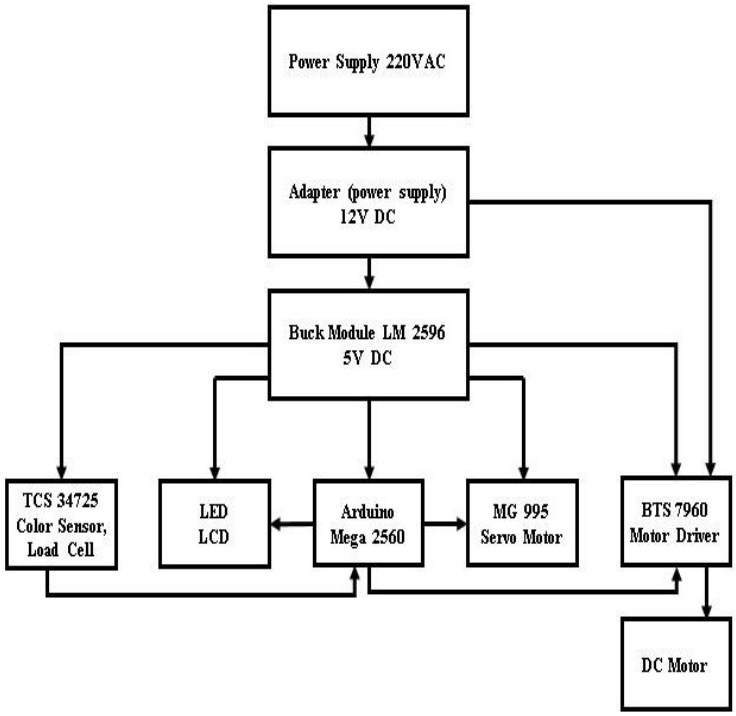

Figure 9. Circuit Diagram

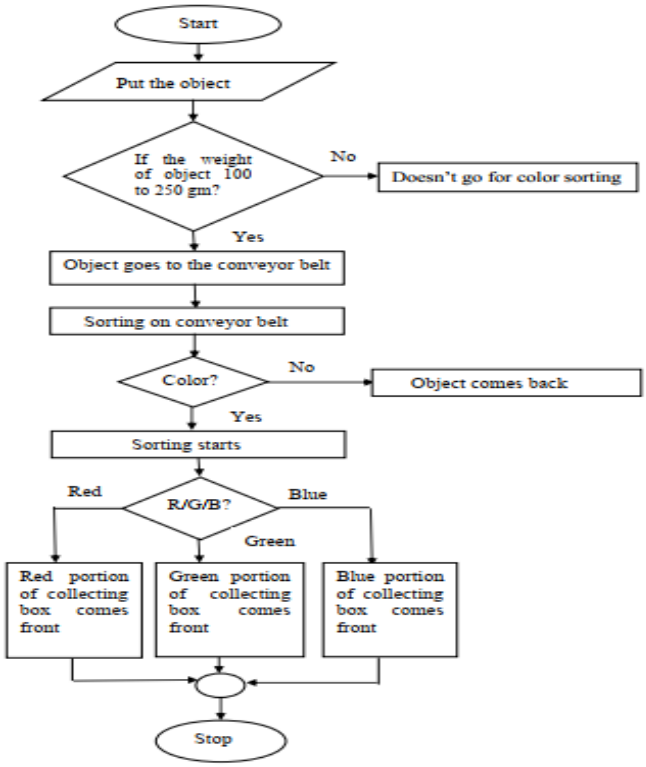

Figure.10: Flow Chart of the sorting process

Figure 11. LCD Display

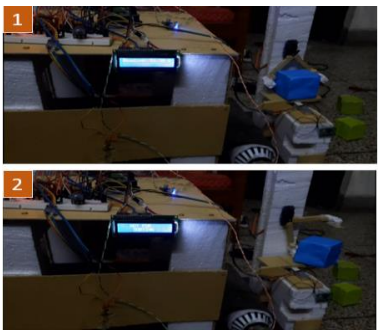

Figure 12. Pushed out the product out of the range of weight 100-250gm

Figure 13. Color and weight sorting for Red color object

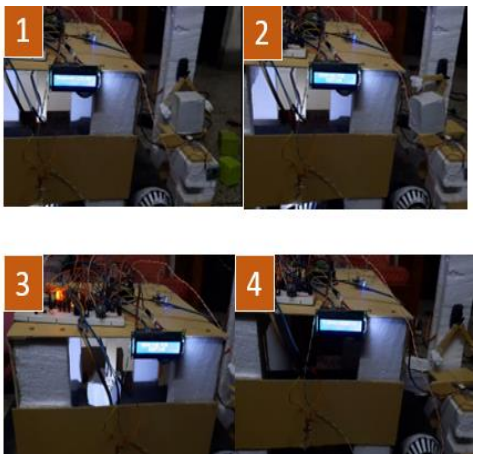

Figure 14. Color and weight sorting for no color object

Figure 15. Objects are in the collecting box in their respective portion

RESULTS AND DISCUSSION

The changes or consequences that are projected to occur as a result of implementing the project are referred to as project results. The outcomes are overwhelmingly favourable. The design and manufacture of a conveyor belt, and the output of expected color and weight sorting procedures, will be discussed in this chapter. Accuracy and precision have also been discussed for various colors of things.

Accuracy and Precision

Table 1 shows the designed system's capabilities in the conveyor movement. It is proven that the system can distinguish colors from the detection results. If a color is detected that is part of the red, blue or red color, the system moves forward. In addition to those colors, the system moves backwards. Meanwhile, the load detection process is to give effect to the direction of conveyor movement. If the weight of the load is in the range of 100-250gm then move the conveyor in same direction. However, if the load weight is in the range of 1-99gm or more than 250gm, the feeding conveyor moves in the opposite direction. The results of this test are shown in Table 2.

In testing the color sensor calibration accuracy gives very good results. All tests carried out up to 5 times, the color sensor calibration accuracy has a 100% result. While the accuracy of the load sensor calibration test gives good results, with a range of 96.30-99.44%. The results of this test accuracy are shown in Table 3 and Table 4, respectively. Meanwhile, Table 5 shows the test results of the sample sorting chart on the basis of color and weight. Overall, the results of this test have accuracy for color 100% and accuracy for weight 99%.

Table 1. Color sorting parameter

Color	Movement direction
RED, BLUE, GREEN	Forward movement
Without RGB color	Backward movement

Table 2. Weight sorting parameter

Weight (gm)	Movement direction
100-250	Conveyor
1-99 and >250	Opposite to conveyor

Table 3. Color calibration of color sensor

Actual color	Color sensor reading (5 values)					Accuracy (%)	Precision
	1st value	2nd value	3rd value	4th value	5th value		
RED	Red	Red	Red	Red	Red	100	High
BLUE	Blue	Blue	Blue	Blue	Blue	100	High
GREEN	Green	Green	Green	Green	Green	100	High
WHITE	No color	No color	No color	No color	No color	100	High

Table 4. Weight calibration of strain gauge

Actual Weight (gm)	Strain Gauge Weight (3 Values)			Accuracy (%)	Precision
	1st value (gm)	2nd value (gm)	3rd value (gm)		
50	49.22	49.40	49.46	98.72	High
100	100.90	100.61	100.16	99.44	High
150	148.82	147.97	145.21	98.22	High
200	194.31	194.28	190.42	96.50	High
250	247.54	243.88	260.17	96.30	High
500	522.47	489.55	479.97	96.47	High

Table 5. 21 samples sorting chart on the basis of color and weight

Sl.	Actual Color and Weight (gm)	Weight from strain gauge (gm)	Color from RGB sensor	Accuracy for weight (%)	Accuracy for Color (%)
0	Red- 138	137	RED	99.27	100
1	Green-134	127.66	GREEN	95.26	100
2	Red-135	150.14	RED	88.785	100
3	Blue-138	118.41	BLUE	85.80	100
4	Green-134	134.25	GREEN	99.813	100
5	Red-135	126.79	RED	93.9185	100
6	Blue-138	142.48	BLUE	96.75	100
7	White-135	131.24	NONE	97.21	100
8	Red-135	125.61	RED	93.04	100
9	White-134	142.14	NONE	94.71	100
10	Blue-138	129.30	BLUE	93.695	100
11	Green-134	130.93	GREEN	97.70	100
12	White-135	148.93	NONE	89.68	100
13	Blue-138	125.86	BLUE	91.20	100
14	White-135	116.88	NONE	86.577	100
15	Red-135	124.05	RED	91.888	100
16	Green-134	138.39	GREEN	96.72	100
17	Blue-138	137.39	BLUE	99.557	100
18	Red-135	134.01	RED	99.26	100
19	Green-134	131.99	GREEN	98.50	100
20	Blue-138	129.53	BLUE	93.86	100

CONCLUSION

Industrial manufacturing procedures are becoming more competitive and complex these days. With high quality and precision, supply product management, from raw material to final product, is a critical component of any manufacturing process. As a result, any large-scale industry that performs mass production would benefit from an automatic color and weight sorting system. This project will boost production rate, repeatability, labor cost reduction, error reduction, and labor material handling time. This sorting system will automatically separate things based on their weight and color and package the products. The sorting system comprises mechanical and electrical components like an Arduino, a load cell, sensors, a conveyor belt, a collecting box, and motors, among other things. This sorting system will save money and be simple in any industry. Finally, this sorting method will be critical in industries and a country's economic progress.

ACKNOWLEDGMENT

The authors would like to express their gratitude to the Mechanical Engineering and Mechatronics and Industrial Engineering departments at Chittagong University of Engineering & Technology for their technological assistance. We would like to convey our

heartfelt gratitude to all of our family members, friends, and anyone who assisted us in any way during the project's development. Finally, I want to express my gratitude to the Almighty for all that He has made possible.

REFERENCES

[1] NN, *What is the relationship between industrial revolution, industrialization and industrial relations? – Quora*, https://www.quora.com/What-is-the-relationship-between-industrial-revolution-industrialization-and-industrial-relations (accessed Sep. 10, 2019)
[2] NN, *What is Industrial Automation? - Sure Controls*, https://www.surecontrols.com/what-is-industrial-automation/ (accessed Apr. 26, 2022)
[3] A. K. Singh and M. S. R. Ali, "Automatic sorting of object by their colour and dimension with speed or process control of induction motor," *2017 International Conference on Circuit ,Power and Computing Technologies (ICCPCT)*, 2017, doi: 10.1109/ICCPCT.2017.8074289
[4] A. Thike, Z. Z. Moe San, and D. Z. Min Oo, "Design and Development of an Automatic Color Sorting Machine on Belt Conveyor," *International Journal of Scientific Engineering and Applied Science,"* vol. 8, no. 7, pp. 176–179, Jul. 2019, doi: 10.7753/ijsea0807.1002
[5] C. K. Kunhimohammed, M. S. K. K, S. Sahna, M. S. Gokul, and S. U. Abdulla, "Automatic Color Sorting Machine Using TCS230 Color Sensor And PIC Microcontroller," *International Journal of Research and Innovations in Science and Technology*, vol. 2, no. 2, pp. 33–38, 2015
[6] H. G. Rudresh, P. S. P, and A. I. T. Ie, "Colour Sensor Based Object Sorting Robot," *International Research Journal of Engineering and Technology (IRJET)*, vol. 4, no. 8, pp. 504–507, 2017
[7] H. Patel and R. Joy, "IOT Color Based Object Sorting Machine," *International Journal of Applied Engineering Research*, vol. 13, no. 10, pp. 7383–7387, 2018.
[8] L. Fernandes and B. R. Shivakumar, "Identification and Sorting of Objects based on Shape and Colour using robotic arm," *Proc. 4th Int. Conf. Inven. Syst. Control. ICISC 2020*, February, pp. 866–871, 2020, doi: 10.1109/ICISC47916.2020.9171196.
[9] A. Amhani and Z. Iqbal, "Automated color sensor system using LDR and RGB leds controlled by Arduino," *ARPN Journal of Engineering and Applied Sciences*, vol. 12, no. 19, pp. 5532–5537, 2017.
[10] P. S. Bhaskar, "Colour Sorting System with Robotic Arm," *International Journal for Innovative Research in Science & Technology*, vol. 2, no. 10, pp. 267–272, 2016.
[11] H. S. Jyothi and B. K. Harsha, "Design A Conveyor Based on Size and Color Separation of Product Using Arduino Uno Microcontroller," *International Journal of Creative Research Thoughts (IJCRT)*, vol. 5, no. 4, pp. 2532–2539, 2017
[12] P. N. Bargal, A. Deshpande, R. Kulkarni, and R. Moghe, "PLC Based Object Sorting Automation," *International Research Journal of Engineering and Technology (IRJET)*, pp. 103–108, 2016
[13] A. Yadav, A. Zanzane, S. Soni, S. Teli, and P. Kamble, "Color Based Product Sorting Machine Using PLC," *SSRN Electronic Journal*, vol. 4, no. 3, pp. 25–29, 2019, doi: 10.2139/ssrn.3372980
[14] A. M. Adebimpe, D. C. Uguru-Okorie and E. O. Oluwagunwa, "Design and Production of an Automatic Solid Waste Sorting Machine with Smart Digital Counter,' Nigerian Journal of Technology, vol. 41, no. 3, pp. 542-546, 2022, doi: 10.4314/njt.v41i3.14
[15] H. Yang, G. Hu and L. Lu, "Research on an Automatic Sorting System Based on Machine Vision," *2022 International Seminar on Computer Science and Engineering Technology (SCSET)*, 2022, pp. 27-31, doi: 10.1109/SCSET55041.2022.00016
[16] K. Sasidhar, S. Farooqi, M. A. Moin, and M. Sachin, "Design and Development of a Colour Sorting Machine using PLC and SCADA," *International Journal of Research and Scientific Innovation (IJRSI)*, vol. 5, no. 7, pp. 198–202, 2018
[17] M. L. Dezaki, S. Hatami, A. Zolfagharian, and M. Bodaghi, "A pneumatic conveyor robot for color detection and sorting," *Cognitive Robotics*, vol. 2, no. March, pp. 60–72, 2022, doi: 10.1016/j.cogr.2022.03.001
[18] S. Vandana, K. Shamukha Sri Sai, P. Rohila, and V. Manideep, "PLC Operated Colour Based Product Sorting machine," *IOP Conference Series: Materials Science and Engineering*, vol. 1119, no. 1, p. 012016, 2021, doi: 10.1088/1757-899x/1119/1/012016
[19] P. A. S. Y. T. R. K. M. Prashant Patunkar, "Design and Development of Product Sorting Conveyor Belt using PLC," *International Research Journal of Engineering and Technology (IRJET)*, vol. 8, no. 6, pp. 4337–4340, 2021
[20] A. Dunakhe, P. Sakhe, A, Sangale and A. Dakre, "PLC based Color Sorting Conveyor System," *International Journal of Engineering Research in Electronics and Communication Engineering*

(IJERECE), vol. 8, no. 8, pp. 21–24, 2021
[21] K. Ananthi, S. Priyadharshini, S. Sabarikannan, R. Dharshini, and K. Dharshini, "Design and Fabrication of Color based Automatic Yarn Carrier Sorting Machine," *2021 7th Int. Conf. Adv. Comput. Commun. Syst. ICACCS 2021*, pp. 677–682, 2021, doi: 10.1109/ICACCS51430.2021.9441995
[22] H. B. Raj, K. S. Reddy, and M. T. Student, "Arduino Based Product Sorting Machine," *Journal of Engineering Sciences*, vol. 11, no. 1, pp. 51–58, 2020
[23] T. Jahan, Md. I. Ahmed, Md. A. Rahman" Designed and Fabrication Of Color Sorting Machine For Industrial Conveyor Based Process" *International Conference on Big Data, IOT and Machine Learning (BIM 2021)*, September, 2021, pp.98-105
[24] Y. S. Kumbhar, C. M. Shete, O. M. Kulkarni, and G. B. Firame, "Design and Fabrication of Automatic Weight Sorting Machine," *International Conference on Ideas, Impact and Innovation in Mechanical Engineering (ICIIIME 2017)*, vol. 5, no. 6, pp. 1680-1683, June 2017
[25] S. Kannaki, S. Karthigai Lakshmi, V. Harish, R. Manikandan, and G. Saktheeswaran, "Development of advanced automatic sorting machine using weighing mechanism," *International Journal of Recent Technology and Engineering*, vol. 8, no. 3, pp. 1703–1707, 2019, doi: 10.35940/ijrte.C4451.098319.
[26] Y. M. Anekar, V. S. Koli, S. D. Degloorkar, S. B. Bharamgonda, and Y. R. Mahulkar, "Development of an Automatic Sorting Machine based on product colour and weight characteristics with Conveyor Belt and sensors," *International Journal of Advance Research in Science and Engineering*, vol. 7, no. 4, pp. 46–52, 2018
[27] T. A. Gray, "Automatic Sorting & Machine Productivity.," *Technical Papers - SME*, no. TE74-154 Apr 29-May 3 974, 1974
[28] 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)*, 2017, pp. 88-92, doi: 10.1109/ICAETGT.2017.8341466
[29] Y. V Aruna and S. Beena, "Automatic convey or System with In – Process Sorting Mechanism using PLC and HMI System," *International Journal of Engineering Research and Applications*, vol. 5, no. 11, pp. 37–42, 2015.
[30] R. R. Yadav, S. S. More, O. N. Mutekar, A. L. Mogal, and R. S. Mahale, "Multilevel Object Sorting System using PLC Controller," *International Research Journal of Engineering and Technology (IRJET)*, vol. 6, no. 5, 2019
[31] H. Chopra et al., "Efficient Fruit Grading System Using Spectrophotometry and Machine Learning Approaches," in *IEEE Sensors Journal*, vol. 21, no. 14, pp. 16162-16169, 2021, doi: 10.1109/JSEN.2021.3075465.