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Implementation of A Low-Cost Spray Controller for Precision Coloration of Irregular Shaped Leather

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Abstract: In this research paper, an instrumental solution for detecting an object of irregular shape and then controlling the coloration of irregular shape leather on its surface area, is presented. Consumers and related businesses have always had a significant need for leather-based items, and equipment for accurate shaping of naturally obtained leathers have always been in high demand. Industrial resources available in Bangladesh with the goal of precisely detecting and shaping random-size and-shape leather sheets confront great problems in the handcrafting technique, which readily leads to poor quality of consumer-end leather products being created for export.To overcome this challenge, a prototype of an instrument is described that, at first, detects an irregularly or randomly shaped leather sheet using equally distant IR sensors positioned across a conveyer belt operated by a regulated DC motor. Second, it feeds the sensor data to a controller built on the Arduino Uno platform, which calculates the surface area of the detected piece of leather sheet. The controller gradually measures the unit length and width of the sheet on the belt, gradually perceiving and quantifying the full surface area. The prototype's design method was validated when the experimentally acquired results were compared to reference model data. The Programmable Logic Controller is used for detecting the presence of Leather and controlling the coloration on the surface of irregular shape leather.

Keywords: Leather, Spray, Industry, Irregular Shape, PLC.

1. Introduction

Preliminary phases, tanning, and crusting are the three major steps in the leather [1] production process. These methods are used to a wide range of leather products, and additional sub-processes for surface coating are necessary, which may be added to the successions. It is mostly limited to group preparation, although for surface coating [2,3], the tanning operation can be continuous.The operation flow must adhere to the [preliminary tanning crusting surface coating sub-process] arrangement without deviation; however, some of the sub-procedures may be avoided depending on the product's variation. (H. John Sharp house). Animal hides and skins [4] are conserved by drying, salting, or freezing to ensure that raw hides and skins arrive at leather tanneries in good condition. It is forbidden to use naturally persistent toxics for the preservation of raw hide up and skins. Animal hides and skins [4] are treated in the tanning process to eliminate hair and unstructured proteins and lipids, leaving an essentially pure collagen network.The skins are then maintained by imbuing them with tanning agents. Preparation (in the beam house); tanning (in the tanning yard); and lastly finishing (including dyeing and surface treatment) are the three phases of leather manufacturing. As part of the tanning and finishing processes, a variety of techniques and chemicals, including chromium salts, are employed.

By looking at its goods, the leather industry [5] and its linked downstream industries may claim to be the world's largest modern commercial sector. The raw material for the leather industry is derived from the meat industry. Hides and skins, as well as their downstream goods, are important sources of foreign remittances, and they compete effectively with other rural wares (agricultural products) as well as any globally exported commodity. Tanneries and leather, leather goods, and footwear manufacturers in Bangladesh are donning battle gear to compete for additional supply in international markets (Sarker, 2000). The hides, skins, and leather industry [5] are one of the main agricultural subsectors with a great potential for product improvement that addresses financial concerns in society and has a beneficial influence on local development, wealth creation, and business.

2. Leather Industry in Bangladesh

Bangladesh's leather sector [6] has huge potential to become one of the country's primary sources of foreign revenue after ready-made garments (RMG). Our national economy relies heavily on the remittances generated by this leather industry. Almost all of the leather goods and footwear created here are exported. In the fiscal year (July 1, 2016-June 30, 2017), leather exports were USD 116.73 million, compared to USD 92.50 million the previous year, according to the Export Promotion Bureau (EPB).In 2003, the government devised a plan to upgrade this leather industry and make it a viable alternative to the RMG segment, which saw the transfer of the oldest leather manufacturers from the capital's Hazaribagh area to Savar and the distribution of plots to factory owners begin in 2009. The footwear sector in Bangladesh has also developed a 'green factory' idea.At 2.25 percent buffalo hide and 1.2 percent sheepskin, Bangladesh's leather industry turns out 220 million square feet a year, or around 20 million square meters. Animals sacrificed during the Eid-ul-Azha celebration provide more than half of the food. Another study estimates that the United States collects 16.5 million hides each year."The leather industry was created in Narayanganj before the Second World War by famous entrepreneur Ranada Prasad Shaha," says Mohiuddin Ahmed, Chairman of the Bangladesh [7] Finished Leather, Leather Goods, and Footwear Exporters Association. In 1960, it was moved from Narayanganj to Hazaribagh after a 20-year absence. Hazaribagh was moved to Hemayetpur in Savar on around 200 acres of land by a ruling of the Bangladesh High Court, which was assisted by BSCIC (BSCIC). The relocation of our domestic tanneries cost around Tk 250 crore (Tk 2.5 billion). As a consequence, there was a temporary gap in services. At the time, many of our foreign customers had already migrated to countries nearby. Now it's up to us to get them back as swiftly as possible."For our 50th anniversary as an independent country in 2021, we intend to secure USD 5 billion in leather exports, according to Mohiuddin Ahmed Ahmed. Around 2 million individuals will be employed if we are successful. In order to do this, the government needs entice new companies and investors to the sector. There are, of course, certain limitations, since customers increasingly choose plastic or synthetic leather products. Our country's appetite for leather goods, on the other hand, is growing by the day. A recent survey found that over 20% of Bangladeshis annually purchase shoes costing more than Tk 4,000. As a consequence, the local market has a great deal of potential. Bangladeshi leather and leather goods are most popular in Italy, England, Spain, France, Germany, Poland, China, Japan, the United States, and Canada. "We mostly sell men's shoes to these countries," explains the export manager of the division.

3. Literature review

Many researchers have given an idea to measure the area of irregular shape leather. But a few of them have focused about the spraying of chemical on leather. In this research we have focused the low-cost rotary spray controlling on irregular shape leather. High performance area measurement system for leather industry has proposed by K.S. Tamilselvan et al. In this paper [9] they used camera to capture the whole leather and using the ImLab software they measure the area of leather. FPGA Based Area Measurement of Irregular Objects has been proposed by M. S. K. Sheikh et al [10]. They have used camera, Matlab and Arduino IDE to implement this system. Rehan Adil et. al. has proposed and implement a LED based irregular leather area measurement machine [11]. In this paper they have proposed an IR transceiver to detect the leather and with the help of microcontroller the measure the area of leather. Image processing-based area measurement of irregular shape leather have proposed by Ruchika Argade et.al. They proposed [12] two systems to implement the measuring system. One is for irregular shape leather and others one is for regular shape. Mechatronic design of a leather spray system has been proposed by Sherman Y.T. Lang et. al. In this research [13,25] they proposed an idea to design a system by which the passing leather will be sprayed. PLC and HMI based leather area measurement system have been proposed by Muhammad Rehan et. al. In this [14] system they focused the measurement of irregular share leather through PLC. PLC and Camera based another measurement system [15] have been proposed by PetarPanaiotov and Goran Goranov. Film Forming in Leather Finishing [16-18] based role of machines has been implemented by S. Ponsubbiah& Dr. Sanjeev Gupta. An automatic system for controlling color quality [20] has been proposed by Riccardo BaccidiCapaci et. al. The review paper of cleaning the leather manufacture [21] industry has been focused by MaherAl-Jabari et al. in this paper they proposed a technique for clean production and recovery technique. The scientific report of the Investigation of finishing [22] of leather for inside parts of the shoes are focused by ElżbietaBielak et al. In [23-26] Production of leathers Goods, improvement of Productivity has been focused. From these above research paper, we have implemented a system to spray control for precision controlling.

4. Proposed System

The leather sheet is transmitted through IR transceivers, the activation of which is determined by the presence or absence of the sheet. Then the collecting data are sent into the microcontroller, which collects the sheet's pattern. The number of pieces passing via the IR transceivers is then displayed on the LCD. Fig 1 shows the process of this proposed system.

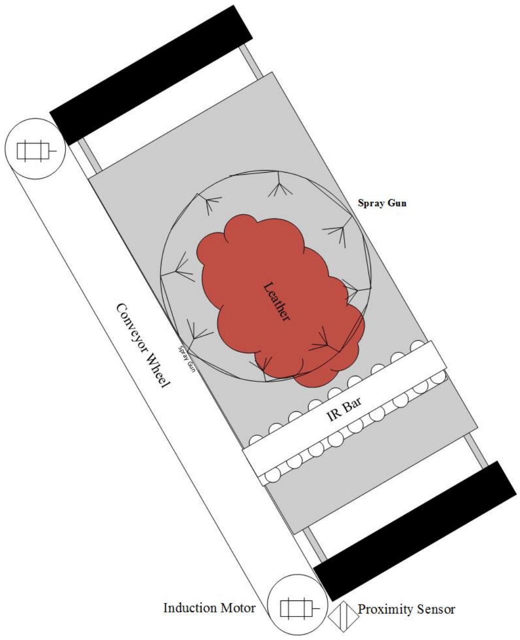

Fig 1: Schematic Diagram of automatic Spray controller of irregular share leather

This procedure will begin with the first pulse from any first sampled width represented by Y, which will be high if any IR transceivers connected in "OR logic" represented by W1, W2, W3...W7 are high, and will continue until any of Ln goes to low. As seen in the image, Ln indicates the sampled length of the piece under observation, and W1 - W7 represents the width of the section under observation as detected by IR transceivers. The presence or absence of the leather sheet at the required position is shown by triggering the IR transceiver [13]. The system's "hold and accumulate" function measures the area of each segment from the first sensor to be activated to the final segment, and then adds all the segments together to compute the overall area.

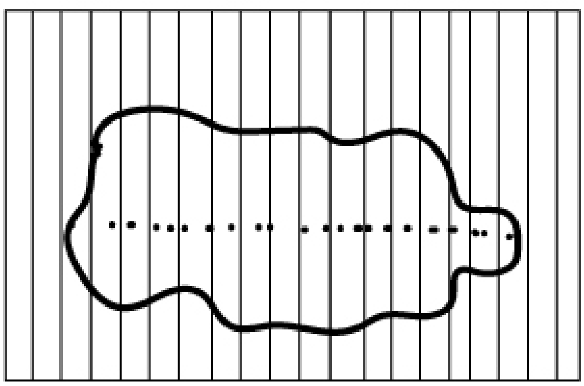

Fig 2: Irregular shape Leather

For each length patch, the LED will indicate the presence or absence of sheet. When the entire piece is passed, the LCD will display the total area of the leather piece in square inches using a mathematical formula stored in the microcontroller. The sampled time is the period after which the controller collects data from the processor and feeds it into the microcontroller. The whole pattern of the leather sheet is then transmitted to the CPU for monitoring purposes through the CD4021Bserial interface [14].

After going via the IR transceivers, the leather is routed to the Rotary Spray controller's economizer. The spray cannon automatically sprays the chemical over the leather based on the region of irregular form.

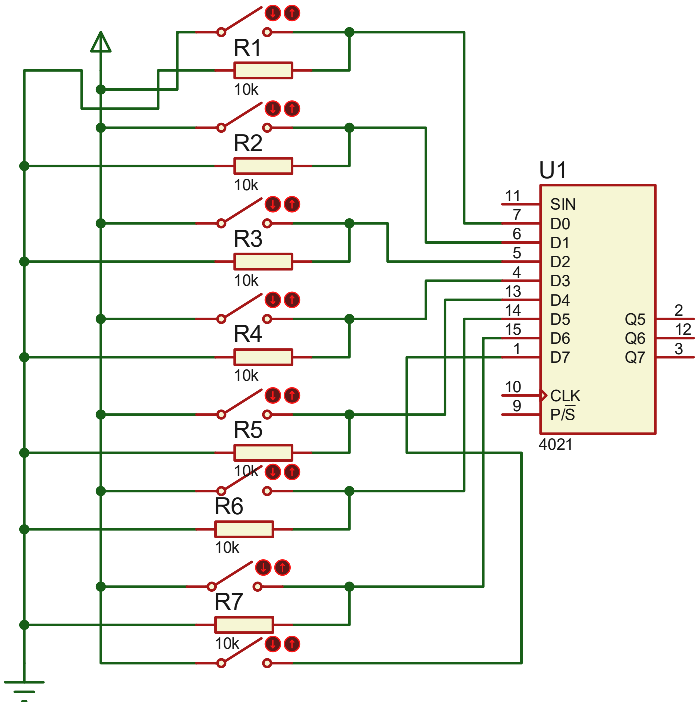

Fig 3: Parallel to serial connection diagram to collect the exitance of leather in the conveyer.

Calculation using some variables for measuring Leather area:

W = Width of the Irregular Shape Observing Leather in mm
L = Length of the Irregular ShapeObserving Leather in mm
Total_area,Ta = Area of the Irregular ShapeObserving Leather mm^2
Tsam = Sampling time in seconds
Sc = Speed of the Conveyer belt in mm/sec
N_Sensor = Number of active sensors

As = Sensor footprint in mm
160 (inches / second) = 4.06400 m / s (1)
S = 40.64 mm/sec (2)
If the sampling rate is a sample after every second.
Ln= S * Tsam (3)
Wn = N_Sensor* As (4)
Total_area=∑ = ∑ WnL + ∑ WnL+∑ WnL+….∑WnL (5)

Footprint of Sensor:
For Ta6: -
W6 = No. of triggered sensors * As = 4 * 4 mm = 16mm (6)
L6 = S * Tsam = 40.64 mm/sec * 1sec = 40.64 mm (7)
Ta6 = 16mm * 40.64 mm = 650.24 mm^2 (8)
Total Area = Ta = Ta1 + Ta2 + ……+Ta8 (9)

The working procedure is depicted in the block diagram in Fig 4. Each block has its own set of capabilities. The first block is an infrared transmitter that detects the presence of leather. The IR pulse detects leather presents. The next block represents the system's primary processing unit. The system's heart is the Programmable Logic Controller. With the assistance of a speed measuring sensor, the microcontroller gathers the total pulse present by the IR and also measures the speed to determine the length. After the IR identifies the number of pulses, the PLC collects the pulses to determine if the spray controller will spray with the presence of leather. The rotary encoder takes the pulse from the PLC and, based on the PLC's decision, the encoder assists us in identifying the number of Spray guns that are located in the location of Leather. The spray cannon will turn on and off atomically based on the PLC's choice. The rotary encoder detects angles ranging from 0 to 360 degrees in a single circular movement.

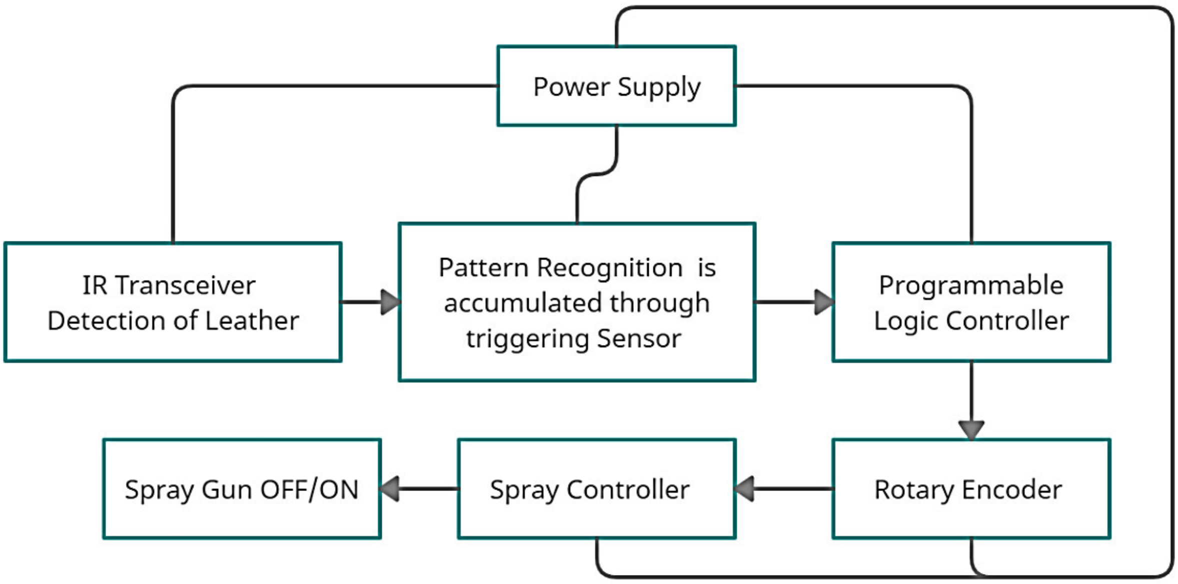

Fig 4: Block Diagram of Spray Controller for Precision Coloration of Irregular Shaped Leather

5. Implementation Technique

The entire system is designed using the aforementioned Fig 4. This system's software implementation followed the pattern shown in Fig 5. First and foremost, the variable utilized in this approach has been initialized, and the scanning sensor has begun to detect leather when the measuring leather is present. Following that, the IR sensor recognizes the leather and sends it to the microcontroller. The microcontroller measures the collecting pulse and the area of the leather. Following that, the value is sent to the PLC, and the PLC makes a decision to the spray controller using the Rotary encoder to determine the position of the Spray gun. When the leather is present in the area, the spray pistol will spray. In this system the manual controlling of spray-controlled area has been attached.

In this implementation technique Arduino platform is being used to instruct the microcontroller measuring the leather irregular area. The sensing part of this implemented circuit is IR sender and Photodiode. The object is passed with the conveyer in between the IR and Photodiode. All the sub area of the leather is calculated by multiplying the speed and detected IR. The total area of the leather will be the integrating of the sub area. The Spray controller will do spray in the area that the microcontroller detected firstly.

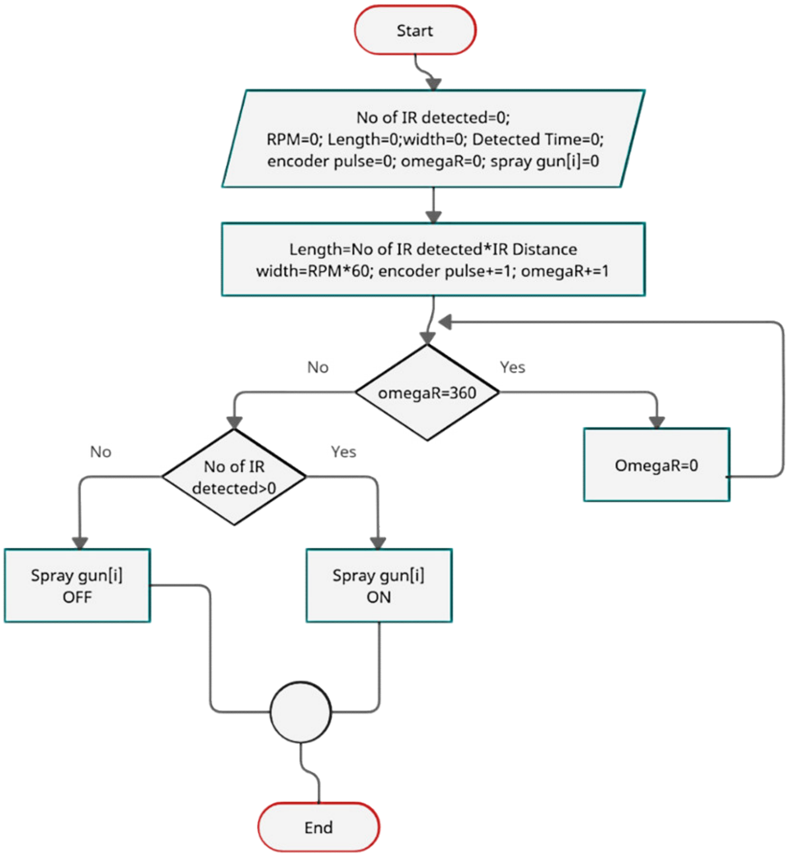

Fig 5: Flow diagram of Spray Controller for Precision Coloration of Irregular Shaped Leather

6. Results and Discussion

6.1 Result

This proposed system has been implemented and tested, and it has been operationally successful. Fig 6 and Fig 7 depict the implemented and tested circuits. This method sprays the irregularly shaped leathers precisely. This system can also be operated manually.

Fig 6: Rotary Encoder's Controlling Using PLC (Controller) when Spray gun is switched off

Table 1: *Measuring Area of irregular shape leather*

Actual Area of Irregular Shape Leather (Square feet)	Measuring Area of Irregular Shape Leather (Square feet)	Error in Percentage (%)
5.5	5.4	1.81
3.7	3.69	0.27
7.9	7.8	1.26

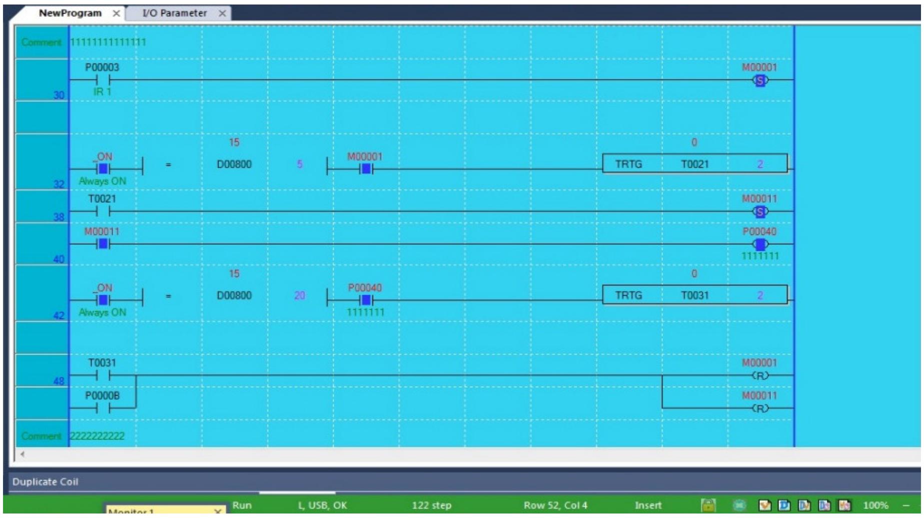

Fig 7: Rotary Encoder’s Controlling Using PLC (Controller) when Spray gun is switched on

Table 2: *Spray GunOn Time and Off Time to spray on leather*

Area of Irregular Shape Leather (Square feet)	ON Time of Spray Gun (millisecond)	OFF Time of Spray Gun (Second)
1.2	500	2.5
2.1	1000	2.0
1.1	480	2.52

[Total Time required to rotate one cycle bythe spray gun Total_Time=3s (Measuring Time)]

The spray gun is controlled by the spray controller. The spray gun is opened when leather is detected and closed when the leather is not present below the spray gun.From the above table of Table 2 we have showed for spraying the color on 1.2 square feet leather the spray gun ON for 500 ms and OFF for 2.5 Sec for one rotation in 3s. For 2.1 square feet leather the ON time of Spray gun is 1000 ms and for 1.1 square feet of leather the ON time is 480 ms. From the above table 2 we see that the spray gun is ON when it detects leather and spray on the leather. When the gun not detected any leather then it will be closed.

Fig 10 depicts the PLC Circuit for Spray Controlling. When the encoder reaches the tracking angel of leather, the relay to open the spray cannon is turned on. After spraying, the spray gun will turn off automatically till the next operation. The spray gun's OFF state is seen in Fig.8. For testing the area measurement, a circuit arrangement is developed which is showed in Fig 9. Here the detection of leather is identified by IR and Photodiode.

Fig 8: Spray Gun

We suggested a technique to automatically regulate the spray machine that is easy to implement and works well. From the above table 1, the measurement of irregular shape leathers is showed. For the actual size of leather of 5.5 square feet is measured by this machine is 5.4 square feet. Which is 1.81 % error. We have tested more than one leather to identify the accuracy of the machine. For the measurement of 3.7 square feet leather the machine measures 3.69 square feet. For this measurement the machine is 0.27% error to measure the actual size.

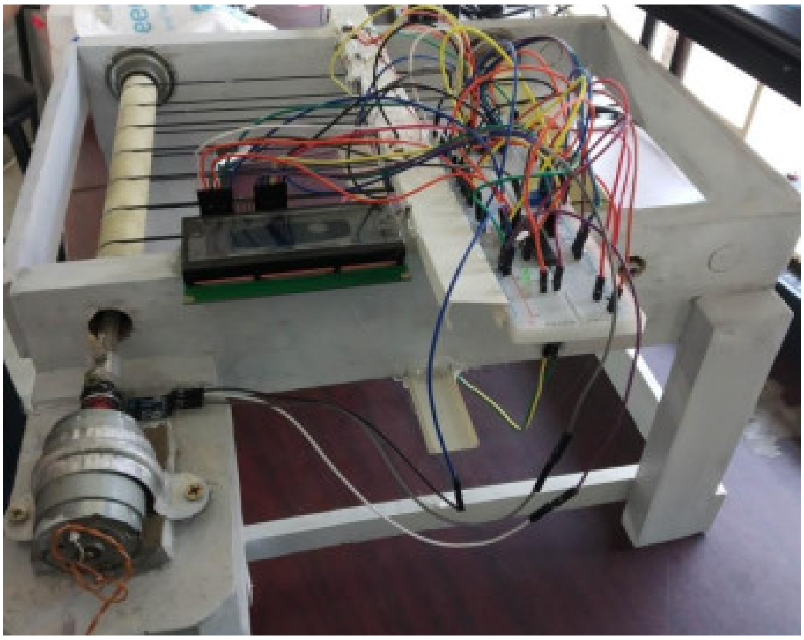

Fig 9: Testing Circuit for Leather Area Detection

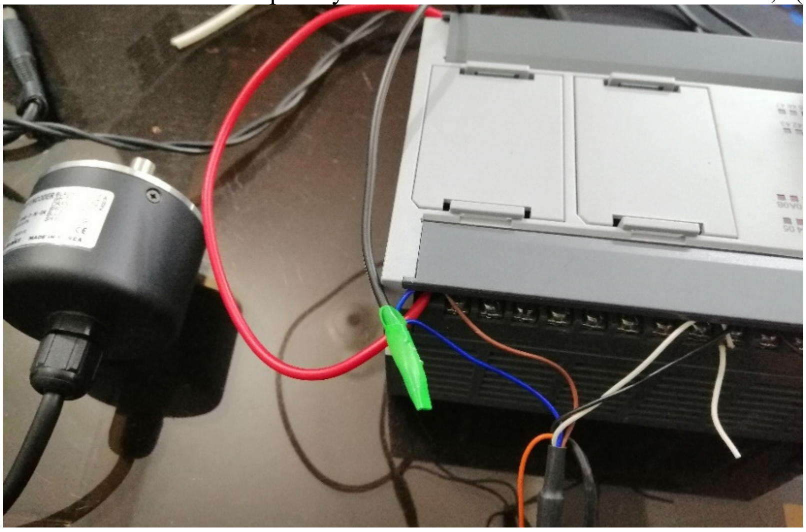

Fig 10: PLC Circuit for Spray Controlling

6.2 Discussion

This established method enables the leather sector to spray on the surface of leather automatically. Because our applied method is low-cost and has a positive impact on the leather sector in Bangladesh, we do not need to import this equipment. This equipment simply sprays on the surface of the leather, reducing chemical costs and allowing Bangladesh's leather industry to earn a lot of foreign cash.

7. Conclusion

The implementation method aids in the spraying of the region of irregular shape leather for industrial purposes. Our implementation method also assists in automatically detecting and spraying the region. There is some inaccuracy for the speed sensor, which will be decreased by utilizing a low motor speed. This machine's smooth functioning aids in spraying the proper region in industry.

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