DESIGN AND FABRICATION OF WASTE FABRIC SEGREGATION SYSTEM

PROJECT REPORT

Submitted by

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In partial fulfillment of the requirements for the award of the degree of

BACHELOR OF ENGINEERING

IN

MECHATRONICS ENGINEERING

DEPARTMENT OF MECHATRONICS ENGINEERING

Estd : 1984

KONGU ENGINEERING COLLEGE

(Autonomous)

PERUNDURAI ERODE – 638 060

DECEMBER 2022

DEPARTMENT OF MECHATRONICS ENGINEERING

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BONAFIDE CERTIFICATE

This is to certify that the Project report entitled **DESIGN AND FABRICATION OF WASTE FABRIC SEGREGATION SYSTEM** is the bonafide record of project work done by **MURALIDHARAN. N (19MTR056), PRITHIVI RAJAN. N (19MTR062), SUGUNESH. M. K (19MTR094),** in partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechatronics Engineering of Anna university, Chennai during the year 2022 – 2023.

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INTERNAL EXAMINER	**EXTERNAL EXAMINER**

DECLARATION

We affirm that the project report titled, **DESIGN AND FABRICATION OF WASTE FABRIC SEGREGATION SYSTEM**, being submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering is the original work carried out by us. It has not formed the part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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ABSTRACT

In textile industries, after large production of textiles like t-shirts, tracks etc., a vast amount of fabrics waste is produced along with it. These waste are called as pre-production waste in industrial terms. The fabrics waste is collected as bundle and moved further to recycling process or sometimes ends up as landfill. The bundle consist of various materials, colors and patterns of textile fabrics. It is then separated by people manually into individual bundles without any machines and then separated bundles are collected back by industries and recycled to raw material. This segregation process is a tedious and time consuming work and our motive is to automate the segregation process easier and rapidly. Our proposed solution for waste fabrics segregation consist of several levels of process. First, the waste bundle must be separated into smaller units and separation is done using mechanical setup. After dividing into smaller units, selection of particular color or pattern is done using color and image recognition sensors. The part of selection and identification process of the particular color or pattern is pre-programmed with an algorithm in the controller of the system. Finally, the respective response for separation of a particular unit is sent to the controller which is interfaced with segregating mechanical setup. Here the waste will be sorted based on color and the rest of waste which is not separated is recycled back. This way, the process of segregation is increased rapidly and done easily.

ACKNOWLEDGEMENT

First and foremost, our sincere thanks to the almighty, who has blessed us to accomplish the project successfully. Then, we thank our correspondent **Thiru. A.K.Ilango B.Com, MBA, LLB**, and all the members of Kongu Vellalar Institute of Technology Trust for providing us with a plethora of facilities to complete our project in a successful manner.

We wish to express our sincere thanks to our beloved Principal **Dr.V.Balusamy B.E. (Hons), M.Tech., Ph.D.,** for allowing us to have the extensive use of college facilities to do this project. We solemnly express our gratitude to our Head of the Department **Dr.B.Meenakshipriya B.E., M.E., Ph.D.**, for her guidance, support and encouragement.

We specially thank our guide **Dr.V.G.Pratheep B.E., M.Tech., Ph.D.**, for his continuous support for the successful completion of the project. We also thank our project co-ordinators **Dr.V.G.Pratheep B.E., M.Tech, PhD. and Dr.K.Gomathi B.E., M.E., PhD.** for their suggestions and encouragement.

We express our sincere thanks to all teaching and non-teaching staff members of Mechatronics Engineering department. We also extend our gratitude to our beloved parents and friends.

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LIST OF UNITS AND ABBREVATION

AC	Alternating Current
DC	Direct Current
Hz	Hertz
IR	Infrared
mA	milli Ampere
mm	milli meter
mV	milli Volt
NIR	Near Infrared
RGB	Red, Green, Blue
RPM	Rotation Per Minute

CHAPTER 1
INTRODUCTION

1.1 MOTIVATION OF THE PROJECT

Every day of people is involved with textiles. The worldwide textile business is vast nowadays. It's the biggest it's ever been, thanks to the garment, automotive, home and other industries, and it's producing bigger textile trash than it has ever been. With 150 billion articles manufactured in 2010, the garment industry itself is worth $1.8 trillion. Fashion's never-ending manufacturing of low-cost, "use and dispose" apparel fuels fire. First element of textile waste issues is textile waste generated before consumer use. This covers any waste generated during the production phases preceding the sale of a garment. According to an MIT study, "in 2015, overall global garment sector was anticipated to produce well over 400 billion sqm of fabrics annually, more than enough just to cover entire state of California on a yearly basis."

However, the volume of a textile waste produced is unimaginable as it is hard to quantify or keep track. Due to the natural forms of a fabric, 10-30% of a fabric is always taken away and discarded during the cutting operation. Another source is harder-to-measure waste is dead stock and damaged yards. Some countries possess value recovery methods in place regarding cutting-room waste, but in certain cases, the scrap material is turned into material lower down the value chain, limiting the value of a scraps to be used at their peak value in fabric form.

It will end up in a landfill or incinerator in the worst-case scenario. There are several fantastic programs that recover denim scraps to building insulation, melt nylon or polyester scraps into new yarns, and recycle wool and cashmere into new yarns using age-old technology. These programs, however, are generally confined to fabrics made almost completely of a single fiber, leaving little place for the increasingly prevalent blended fiber materials.

1.2 PROBLEM DEFINITION

The majority of the time, the discussion is around rapid fashion and the disposal of clothing at the end of its life. However, there is already an issue a few steps back in the process. Pre-consumer waste includes all waste materials generated in the production process during the production of a product. Home textiles, electronics, food production, and many other industries generate pre-consumer waste. Materials and completed goods exist in a range of shapes and sizes; getting from one to the other usually takes numerous processes and scraps. Most of our clothes these days are sewed together from various sorts of fabrics. Few are knitted from the ground up. By putting a range of rises and reductions in the pattern, each piece of a garment can already be constructed exactly as the odd form it has to be. There is minimal to no waste in this procedure because none of the components are cut out, but it is generally slower and thus more expensive to manufacture a garment this way.

The quickest and cheapest approach to make a garment is to cut off the sections needed from a ready-made roll of fabrics, which usually comes in a fairly long rectangular shape. The cloth is often 140cm or 150cm wide, depending on the widths of the industrial knitting or weaving machines used to make it. Fabrics is so inexpensive nowadays because it is machine-made (typically from low-priced ingredients), and creating leftovers during the manufacturing process does not cost the company much. Figure 1.1 shows manufacturing of standard T-shirt from a roll of fabrics.

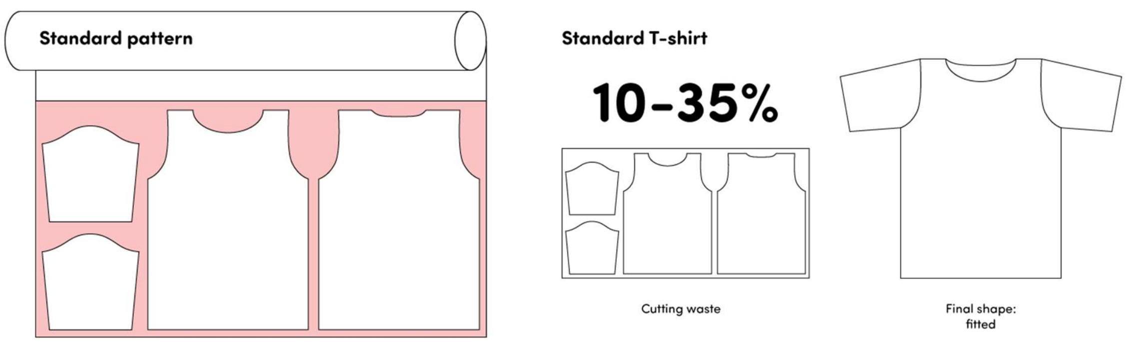

Figure 1.1 Manufacturing of standard T-shirt

The pattern parts for a regular T-shirt do not fit well onto the rectangular cloth, as shown above. There are estimates that even with the pattern components perfectly aligned, roughly 10% of the fabrics is wasted, and in many cases much more. If you open your closet and examine your clothes, you will see that practically every single one of them has unusual shapes and curves. So, for practically every single item of clothes you own, some excess fabrics has to be wasted in order for it to be the form it is. If the quantity of pre-consumer waste in production is 10%, then there should or could have been one additional garment for every nine you own if the fabrics was used completely. If it's 20%, there should be one more for every four you own. That's a lot, especially considering how many resources have already gone into manufacturing a roll of fabrics up to this point.

Cotton, hemp, or flax have to be grown and gathered, cleaned, colored, spun into yarn, and finally manufactured into fabrics if it is natural. If it is synthetic, fossil fuels must be mined, chemically processed, colored, spun into yarn, and manufactured into cloth. All of this simply to waste up to a third of it? Then about the waste fabrics generated, there is only two options available, it is either discarding the waste fabrics as landfills or segregation and recycling of the waste fabrics. Either way, it is disadvantage to the environment and loss in terms of recycling industrial units. About the recycling process, there are only few industries which is interested in turning back the waste fabrics back to raw material. These industries distribute the waste fabrics to small scale household units to segregate the materials based on colors and after that the segregated materials are recycled. But mostly the waste fabrics are not processed and ended up in landfills. This is due to lack of interest of textile industries in recycling process because it is rather easier to discard the waste fabrics than to recycle them.

1.3 OVERVIEW OF THE PROJECT

The segregation process is done by human labors by their bare hands. This makes the process more complicated and takes more time for segregation. This is one of the reasons, industries does not involve in the recycling process. If the process can be automated and human labors can be replaced, this process could be done in a wide range and the pile of waste fabrics ended up in landfills can be reduced to zero. The proposed solution is a complete system to separate the pile of waste fabric and segregate them based on color.

CHAPTER 2

LITERATURE REVIEW

2.1 OBJECTIVE OF THE SYSTEM

The main objective of the project is to design, construct and evaluate an effective system to separate the waste materials and segregate it rapidly based on color. By switching from traditional segregation techniques to a fully automated system, production will increase and recycling will be simpler, which will result in less waste fabric being disposed of in landfills. Instead of contributing to pollution, this approach will improve textile waste fabric recycling.

2.2 LITERATURES RELATED TO EXISTING SYSTEM

Textile industry contribute significantly to a country's economic growth. Even if they contribute to economic progress, they also contribute significantly to the generation of pre-production waste. These industries simply dispose of waste without giving it a second thought. One of the reasons for dumping waste rather than recycling is the traditional procedure of manual segregation.

The manual process is tedious work, requires too much of labors and takes long time. There are other existing system for segregation of textiles based on type of materials and color but they are used in recycling of textiles which people dispose after use. These processes involve expensive methods like near infrared spectroscopy. A lack of equipment and technology were identified as the main barriers to recycling. Besides technology, the sole prerequisite for recycling apparel waste is to collect and sort it by color and/ or fiber content. Han et.al, (2015) said about upcycling as a design strategy for product lifetime optimization and societal change. This paper aims to analyze the innovative ways in which UK based upcycling designers are recreating style and value from discarded materials, and the benefits of this process.

Hu et.al, (2022) proposed a study on an online rapid sorting method of waste textiles based on near-infrared spectroscopy and the generative adversity network, which utilized the deep learning algorithm is used to intensely mine the potential distribution information about the original spectral data, as well as the generative adversity network is employed to construct the digital data set to compensate for the unequal distribution of the original data set. The results of the tests suggest that the strategy may successfully improve the fullness of the given data and the model's accuracy.Kulkarni et.al, (2017) developed an automated system for object sorting based on color detection. With the images captured from USB camera, colors of objects are identified using color detection algorithm. This detected color is used as object sorting parameter by Raspberry Pi. This system uses image processing algorithm for color detection using HSV model. HSV indicates Hue (H) Saturation (S) and Value (V) of color.

Nrup et.al, (2018) proposed a project to design and evaluate a system for assessing the numbers and quality of fabrics in household waste, with the goal of reducing the amount of things disposed of alongside ordinary household waste. The specific goals are to define what defines a textile fraction and quality, to create a quality assessment that includes product kind, manufacturing process, and fibre composition, to assess the method in a specific waste sorting campaign, and to compare the findings. Pandey et.al, (2020) published about solutions for sustainable fashion and textile industry which contains sustainable fashion and textile industry and green solutions including eco-innovation, eco-selection, effluent treatment, eco-labelling, utilization of textile wastes, reuse and prevalent recycling practices.

Waste management in the format of fabric patchwork from confection industries not only reduces environmental effect but can also be repurposed in the field of household linen craft. When confectionery waste is recycled, it produces quilted fabric trash that is used by craftspeople and others in need. Suryani et.al, (2017) are very interested in investigating clothing waste management, particularly in Makassar. Tomovska et.al, (2014) proposed an investigative research to characterize apparel cuttings waste, define the existing level of apparel waste cuttings management, and determine Macedonian top management attitudes toward managing apparel cuttings. The bulk of garment manufacturers dump their cutting waste, along with community rubbish, on open fields. The production of garment trash not only represents a waste of precious materials and energy, but it also generates environmental issues and costs to collect, transport, and manage the waste.

Habich (2007) offered a summary of automatic sorting methods that have been utilized in trash processing for over ten years to sort light packaging. These devices use Near-Infrared (NIR-) sensors to differentiate between different polymers. Aside from NIR-sorting, which has so far only been effectively applicable with light or transparent plastics, inductive sorting, optical sorting (mostly by colours), and X-ray sorting are potential waste processing technologies. Zhang et.al, (2021) present a fusion neural network-based multi-objective sorting system. The attitude information of the object is obtained by two different networks in this proposed system in order to fully utilize the advantages of the two networks, and normal vector estimation based on point cloud processing and grasping sequence reasoning based on average depth calculation are proposed. Decision-making in textile manufacturing typically takes several parameters into account, which adds to the complexity. Lu et.al, (2021) present a decision support system for the textile manufacturing process that combines the ANN model, AHP, and Q-learning.

2.2.1 SUMMARY OF LITERATURE SURVEY

The existing system of the pre-production waste maintenance system available in various places around the world, methods used to recycle the waste, problem faced due to waste, various solutions proposed for maintenance, other systems to recycle & segregate the waste produced post-customer usage, and methods used to segregate the materials based on colour or materials fibre are all observed from the literatures surveyed.

2.3 EXISTING SYSTEM

About the existing system, the segregation and sorting of the textile pre-production waste is done by people manually by bare hands and without any interference of machines in the process. The waste generated by mass production textile industries is sold for some price to small scale industries and house hold units. Then the waste is segregated and sorted based on different colors manually. This process becomes tedious and complex one and takes a long time due to its large quantity. After the sorting and segregation of materials based on colors and/or fiber content, it collected back by agents of the recycling textile units. The lack of modern technology is identified as one of the barriers of the recycling of the pre-production waste and so the textile industries dispose the waste as landfills rather than sending to recycling units. Figure 2.1 shows the existing method of segregation of textile waste done manually in a warehouse.

2.3.1 Drawbacks

The drawbacks of the existing system are as follows

- Lack of equipment and technology to segregate and sort.
- Requires too much human labors.
- Tedious and complex due to large quantity of materials.
- Take too much time due to manual sorting of material.

Figure 2.1 Existing system of textile waste segregation

2.4 PROPOSED SOLUTION

Our proposed solution is a complete machine vision system to segregate the large units of materials to individual smaller units and then sorting them based on colors. This system can be divided into two sections, in first, the large amount of waste is fed in a conveyer is picked as small units by mechanical setup designed which is driven by an external motor. After that, the material reaches another section where an IR sensor is used to sense the object in the output conveyor, then an RGB color sensor to read the color value of the material passes through and electrical actuators to sort or in other terms to push over the material based on the color. The system can only sort particular colors and other unsorted materials can be recycled back to the system and the process can repeated again. In order to obtain high efficiency, and reliability, the system was designed based on the following considerations:

- The system must increase the production rate of segregation and sorting.
- The system must encourage textile industries to recycle rather than disposing as landfills.
- The system must reduce all manual work involved in the segregation process.
- The system should work as a complete machine vision system with less human intervention.
- The system should be enough to entire sorting process in a single stretch in less time.

2.4.1 Advantages

The main advantages of using proposed system will be as follows

- It breaks down the complex part of segregation into simple terms.
- It increases the rate of segregation and sorting the material even more rapid.
- It acts as complete automated system which reduces human intervention.
- This would encourage recycling more than disposing as landfill or incineration.

CHAPTER 3

FEASIBILITY STUDY

3.1 ECONOMIC FEASABILITY

The proposed solution is economically feasible, almost all the components are already available and our system is a combination of those components with some additional fabricated structures. At the level of a prototype, the cost of the system is feasible and it is certain that it will be feasible for industrial conditions also. The system will reduce the number of labors involved in the traditional system and increase the rate of process, hence this will benefit economically.

3.2 OPERATIONAL FEASIBILITY

The project consist of simple and mostly familiar components with simple addition of programming for automation of process, ordinary mechanical setups and simple electrical circuits, there is no big complications involved in operations. Every process is automated and it happens smoothly with a simple click of ON/OFF of a switch. There is no operational difficulty for the user. The waste material is separated into smaller units first and then segregated based on its color on the output conveyor section when the system is powered on and there is no need for any human intervention for the system. It is a user-friendly, convenient system for the user. If any part fails, the replacement is simple and easy to install.

3.3 TECHNICAL FEASIBILITY

The system is technically suitable and can be applied for industrial level of segregation system. The fabricated separator setup may vary according to the amount of material and number of output conveyor unit; based on the output section and number of colors to be segregated, number of actuators used to push over the material from conveyor may also vary. These changes can be customized according to the input given, output required and place to be installed. Hence this system is feasible technically also.

CHAPTER 4

DESIGN SPECIFICATIONS

4.1 BRIEF DESCRIPTION OF THE DESIGN

The setup consist of mechanical components like geared DC motors for more torque and low rpm purpose, rack and pinion assembly, pillow block, conveyor belt, nails, bolts and nuts, fabrications and electrical components like Arduino UNO, IR sensor, RGB color sensor, L298 driver module, connecting wires and power source for the system. All the parts work with synergy to perform the segregation of textile pre-production waste. Table 4.1 shows the components mainly used in the system.

Table 4.1 List of Components

S. NO	COMPONENETS	DESCRIPTION
1.	Micro controller	Arduino UNO R3
2.	IR sensor	5V dc, Range : up to 20 cm
3.	RGB color sensor	28.4x28.4mm, 2.7V to 5.5V dc
4.	L298 Driver module	5V DC, 43 x 43 x 26mm, 26g
5.	Gear Motors	12V dc, 45rpm, 100rpm, 300rpm
6.	Pillow block	Shaft Diameter : 20 ~ 60mm
7.	Rack and pinion assembly	-
8.	Conveyor Belt	-
9.	Separator fabrication	-
10.	Clamps, bolts and nuts	-

4.2 COMPONENTS DESCRIPTION

4.2.1 Microcontroller

Arduino UNO is an ATmega328P-based microcontroller board. It contains 14 digital I/O pins (six of which are PWM outputs), 6 analogue inputs, a 16 MHz ceramic resonator, an USB interface, a power jack, an ICSP header, and a reset button. It comes with everything you want to assist the microcontroller; just connect it to a PC through USB or power it using an AC-to-DC adapter / battery to just get started. Figure 4.1 shows an Arduino UNO R3 microcontroller.

The ATmega328p is a single-chip, fast, and efficient controller of Atmel's megaAVR family. It is an 8-bit AVR RISC microcontroller chip. It has 32 KB of read/write ISP flash memory, 2 KB of SRAM (Static RAM), 1 KB of EEPROM, and 23 general-purpose I/O pins. These boards can operate relays, LEDs, servomotors, and motors as outputs and can be integrated with a variety of other Microcontrollers, Arduino shields, and even Raspberry Pi boards.

The Arduino Uno includes six analogue pins with ADC (Analog to Digital converter). These pins can function as both analogue and digital inputs and outputs. The Arduino Uno has a 10-bit analog-to-digital converter with 210 resolution, and its pins receive data in the form of analogue signals with output values ranging from 0 to 1023. The digital input/output ports of the Arduino UNO board are located on pins 0-13. The digital pins on the Arduino can only read two states: whether or not there is an output signal. This form of input is known as digital (or binary), and the states are represented by HIGH and LOW, or 1 and 0.

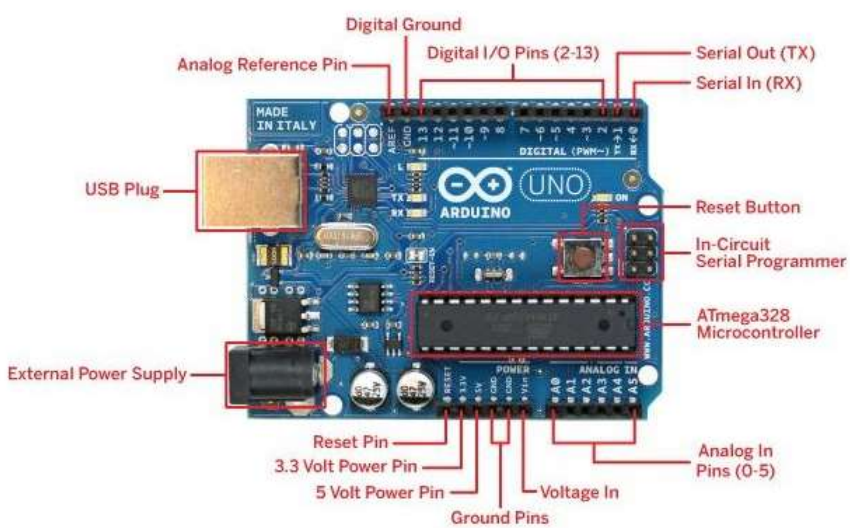

Figure 4.1 Arduino UNO R3

4.2.2 IR Sensor

IR Sensor Module (Active Low) is equipped with two infrared sending and receiving tubes. The reflected Infrared waves will be acquired by the receiver tube when the transmitted waves are reflected back. The onboard comparing circuitry does the processing, and the green indicator LED illuminates. On its tail, the module has a three-wire connection with VCC, GND, and then an OUTPUT pin. It works well with voltages ranging from 3.3 to 5V. The output pin emits a digital signal in the presence of hindrance/reflectance. The onboard preset assists in fine-tuning the operating range; the accurate limit is 2 cm – 80 cm. Figure 4.2 shows an IR sensor.

IR radiation can be found in the visible and microwave areas of the electromagnetic spectrum. The wavelengths of such waves typically range from 0.7 m 5 to 1000 m. The IR spectrum is separated into three regions: near-infrared, mid-infrared, and far-infrared. The wavelength of infrared radiation in the near IR region ranges from 0.75 to 3m, the wavelength of infrared radiation in the mid-infrared region ranges from 3 to 6m, and the wavelength of infrared radiation in the far IR region is greater than 6m.

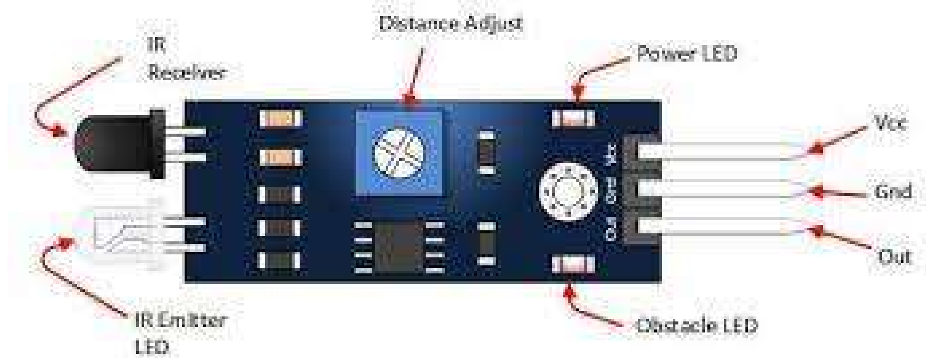

Figure 4.2 IR sensor module

4.2.3 RGB color sensor

Color Sensor (TCS3200) is a surface color detector with a TAOS TCS3200 RGB sensor chip and four white color LEDs. This measure and recognize a virtually infinite number of colors. The Color Sensor (TCS3200) is comprised of a series of photodetectors, each equipped with a green, red, blue filter and no filter (clear). To eliminate color location bias, the filters for each color are placed uniformly over the array. Figure 4.3 shows the image of color sensor.

An oscillator inside the device generates a square-wave signal whose frequency is proportionate to intensity of the color which is selected. The Color Sensor generates an output waveform (50% duty cycle) of a frequency that corresponds to color and light intensity; the frequency is proportionate to light intensity. TCS3200D's usual output frequency ranges from 2 Hz – 500 KHz. The frequency values of 2%, 20%, and 100% via two programmable outputs, S0 and S1 can be changed. TCS3200D consist of varied sensitivities to red, blue, and green. The result of white on RGB is not necessarily 255. As a result, white intensity must be adjusted within 2 seconds after powering on.

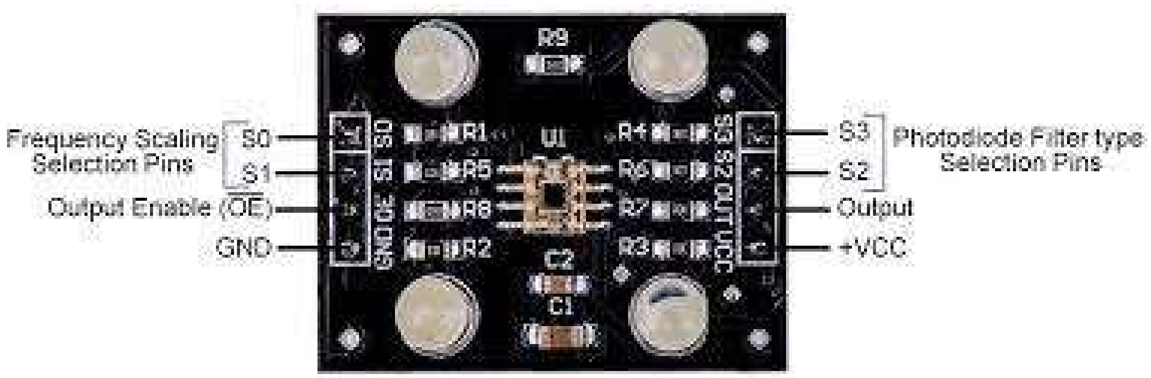

Figure 4.3 RGB color sensor module

4.2.4 L298N driver module

An L298N Motor Driver Module is a high-power motor driver module that can power both DC and stepper motors. An L298 motor driver IC as well as a 78M05 5V regulator are used in this module. The L298N Module is capable of controlling up to four DC motors or two DC motors plus directional & speed control. The L298N Motor Driver module is made up of an integrated circuit that includes an L298 Motor Driver IC, resistors, a Power LED, a 78M05 Voltage Regulator, capacitors, and a 5V jumper. When the jumper is inserted, the 78M05 voltage regulator will be enabled.

The voltage regulator powers the internal circuitry when the battery source is equal or lower than 12V, and the 5V pin will be used as an output port to power the microcontroller. When the power source exceeds 12V, the jumper should not be used, and an additional 5V must be supplied through the 5V connector to power internal circuitry. The ENA and ENB pins control the speed of Motor A and Motor B, respectively, while the IN1& IN2 and IN3& IN4 pins control their direction. Figure 4.4 shows an illustration of an L298 motor driver.

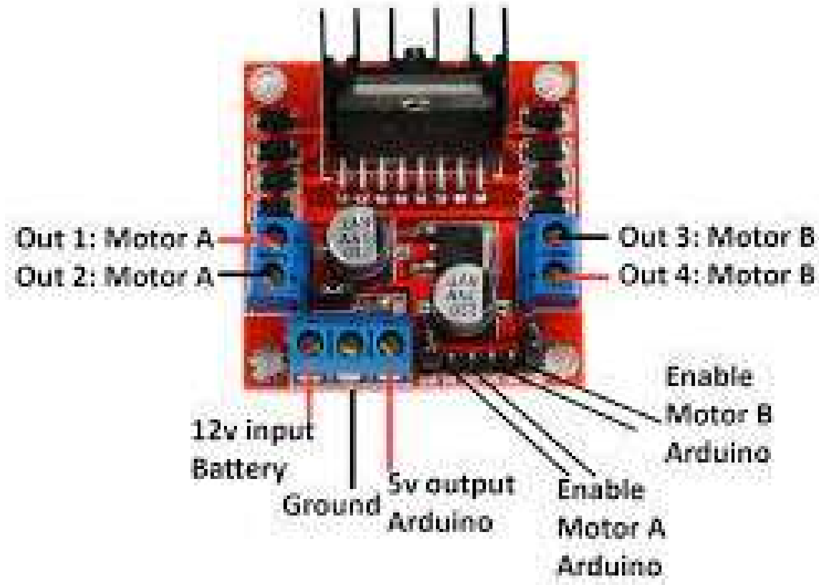

Figure 4.4 L298N driver module

4.2.5 DC Gear Motor

A gear motor, also known as a geared motor, is a small electric motor (AC induction, permanent magnet DC, or brushless DC) that has an attached gearhead that is integrally (and permanently) connected to the motor. An end shield just on motor's drive end (seen below in light blue) is made to serve two purposes.

The armature/rotor bearing aid and the sealing area where the integral rotors or armature shaft pinion goes are located on the side of the motor that faces the motor. On the other side of a motor end shield, there are numerous bearing supports for such gearing itself, as well as a provision for sealing and fastening the gear housing.

This design has several advantages for the user and takes the uncertainty out of choosing the right size for a motor and gear reducer. Generally speaking, gear motors serve as speed reducers and torque multipliers, requiring lesser motor power to operate a given load. The gear motor performance is influenced by the gear housing design, the gearing type, the gear lubrication, and the particular way of integration. Figure 4.5 shows 12V DC gear motor.

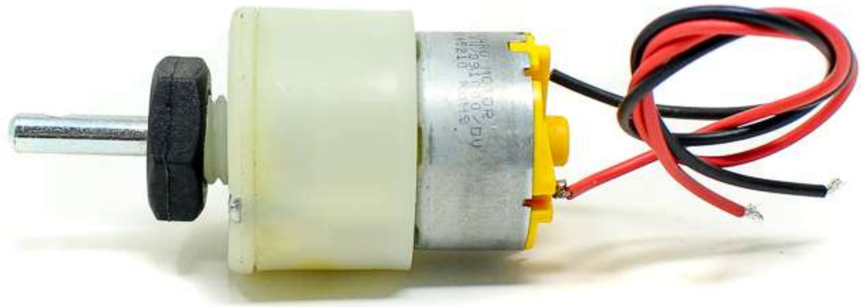

Figure 4.5 DC gear motor

4.2.6 Pillow block

A pillow block bearing (also known as a pillow block) is just a pedestal that supports a spinning shaft using a set of bearings that are compatible with one another and a number of other parts. An assembly's main component is a mounting block that contains a bearing. A shaft is put into the block, which is affixed to a foundation, allowing the inner portion of the bearing or shaft to revolve. To guarantee a snug fit, the inside of bearing is normally 0.001 inches (0.025 mm) bigger than the shaft. To secure the shaft, set screws, locking collars, or set collars are frequently employed.

Cast iron / cast steel is generally used as the housing material for pillow blocks.The type of pillow block depends on the type of rolling element used in the bearing, which can be a ball, cylindrical roller, spherical roller, tapered roller, metallic or synthetic bushing, or any combination of these. These are distinct from "pillow blocks," which are bearing housings delivered empty and typically intended for greater load ratings with a separately installed bearing. Pillow block bearings are made for more corrosive situations. Figure 4.6 shows a pillow block.

Figure 4.6 Pillow block

4.2.7 Rack and pinion assembly

The components of a rack and pinion steering system are a pinion (a circular gear) and a rack (a linear gear). The mechanism transforms a rotating motion into a linear motion. In rack and pinion steering, the rack moves linearly as the pinion rotates, turning the wheels of the vehicle left or right. While a rack and pinion system may appear complex, Advance Autoparts claims that all it is is a gear fastened to a toothed bar. A pair of tie rods are used to attach the bar.

A generating rack is a rack outline used to show the details and dimensions of the teeth in the construction of a generating tool, such as a hob or a gear shaper cutter. Simple linear actuators are frequently made out of a rack and pinion combination. To provide linear movement, the shaft movement of the pinion is driven by hand or by a motor. Figure 4.7 shows a rack and pinion assembly.

Figure 4.7 rack and pinion assembly

4.2.8 Conveyor belt

A conveyor belt is a type of material handling system that is used to transfer supplies, materials, and components in an efficient and effortless manner, saving time, energy, and money. Conveyor belts are made up of two motorised pulleys with conveyor fabric looped over them. To trigger the action of the conveyor belt, the pulleys move at the same speed and in the same direction. Conveyor belts come in an infinite variety of styles and applications. All of the types are used to convey items and materials along a constantly moving course. Though motorised conveyor belts are the most common type of conveying system, there're systems that employ rollers to move goods without the use of a motor.

Conveyor belts are used in a variety of industrial settings and applications. Conveyor belt system efficiency contributes to increased productivity, lower labour costs, and shorter lead times. Conveyor belts convey and store vast numbers of products in a safe and dependable manner. The primary reasons for the widespread usage of conveyor systems are labour cost reductions, efficient goods transportation, and the capacity to protect items and materials from damage. They offer the greatest service at the lowest feasible price. Figure 4.8 shows a conveyor belt.

Figure 4.8 Conveyor belt

4.2.9 Separator fabrication

This fabrication is constructed using cyclindrical cross sectional pipe along with pipe couplings and respective quantity of nails. The cross sectional area of the pipe is selected based on length of the nails and distance between input and output section of the system.

The nails are placed in two rows to provide output in two conveyor units simultaneously and it is positioned equidistantly to provide interval between two consecutive materials. Figure 4.9 shows separator fabrication.

The length of the nails is selected in order to reach the material from the feeder section to and pick & place it to the output conveyor section. The function of the whole fabrication is to pick individual pieces which is fed by the feeder section and place it in the output conveyor section, the main purpose is to divide the whole waste into smaller units.

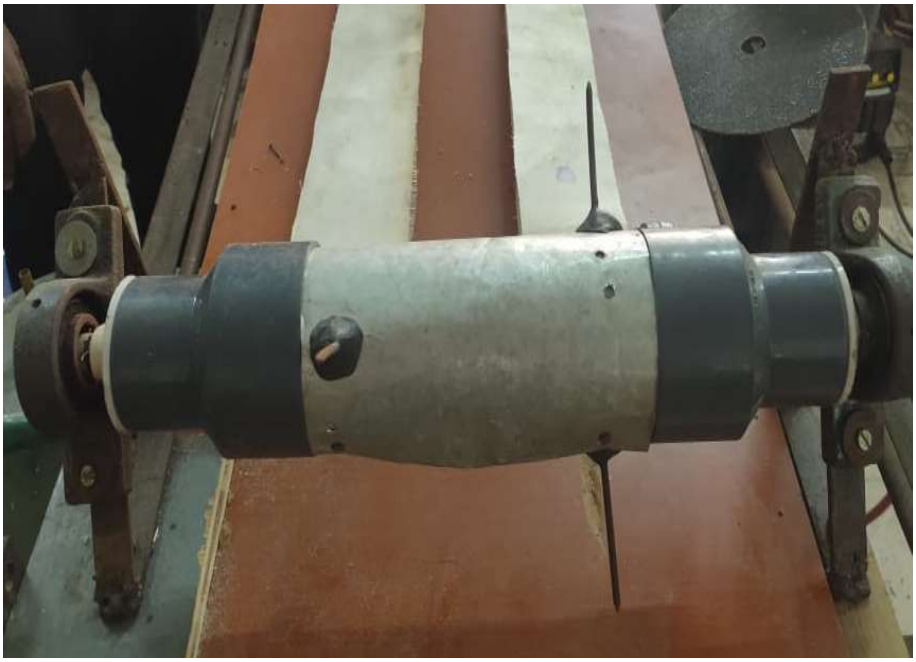

Figure 4.9 Separator fabrication

4.2.10 Clamps, bolts and nuts

The clamps are tools which have different structures for different purposes used to hold a object on a structure or surface firmly. Here it is used to hold the motors used to drive the conveyor units on the surface. Bolts and nuts are tools used to hold some structure to a surface. They differ in size with respect to the purpose it is used. In our system, they are used to hold the pillow block used for conveyor units motion to the surface and other than that to hold the separator fabrications and several other structures too. Figure 4.10 shows clamp, bolts and nuts.

Figure 4.10 Clamps, bolts and nuts.

4.3 DESIGN CALCULATION

4.3.1 Mass of the components

The mass of the system cannot be determined accurately. As our system is a prototype model, the mass of the components is very less and compared to an industrial level setup it may vary entirely. Various masses associated with the fabrication is given below:

Material used	=	Mild steel
Density	=	$7.85 \times 10 - 6$ kg/mm ^{3}
Holder Frame	=	2 kg
Separator Fabrication	=	1.2 kg
Pillow blocks	=	0.49 kg x 10 nos.
Motor mass	=	0.145 kg x 4 nos.
Conveyor belt	=	0.5 kg
Rack & pinion	=	0.15 kg x 2 nos.
Other fabrications	=	1.8 kg
Total mass (W)	**=**	**11. 58 kg = 12 kg (approx.)**

4.3.2 Separator fabrication specification

The separator fabrication is designed based on the existing mechanism for picking a fabric material. The base structure of the fabrication is cylindrical pipe with a certain diameter. The parameter of nails fixed around the structure also based on distance between the feeder and segregator conveyor section. The parameters of the separator fabrication may vary according to the size of the system, amount of materials, number of colors, and number of output conveyor sections.

In our system, due to only two output conveyor sections, the fabrication consist of only two section of rows of nails. According to the diameter of cylindrical pipe used, only two nails for one section can be placed at the most equidistantly.

Diameter of the pipe used	=	4” (10.16 cm)
Length of nails used	=	8 cm

4.3.3 Microcontroller Specification

Due to more number of inputs from sensor and output actuators in our system, specifications of micro controller considered are

Manufacturer	=	Arduino
Model name	=	Arduino UNO R3
Memory	=	2KB SRAM, 32KB FLASH, 1KB EEPROM
Digital I/O Pins	=	14
Analog input pins	=	6
RAM	=	1 Giga bytes
Timers	=	Two 8bit and One 16 bit
I/O Voltage	=	5V
Input voltage (nominal)	=	7-12V
Clock speed	=	ATmega328P 16 MHz

4.3.4 Motor specification

The system consist motors at different sections of the process. The specification of the motor varies with respect to the purpose it is used. In feeder section, the conveyor motor must carry lots of material at low speed to provide time for picking maximum material in a period. For the next segregation section, same motor is connected for both separator fabrication and the output section conveyor for same speed and to provide perfection synchronization of time period between pick and place event and segregating event. And finally for the actuator section, the motor should be faster with efficient load pushing capacity. The specifications of the motors considered for various purposes are

Feeder section

Motor Type	=	Plastic Gear Box Motor
Rated Speed	=	45 rpm
Torque (T)	=	4.45 kg-cm or 0.4368 Nm

Segregator section

Motor Type	=	Plastic Gear Box Motor
Rated Speed	=	100 rpm
Torque (T)	=	3 kg-cm or 0.295 Nm

Actuator section

Motor Type	=	Plastic Gear Box Motor
Rated Speed	=	300 rpm
Torque (T)	=	1.2 kg-cm or 0.118 Nm

4.3.5 Motor driver specification

In order to actuate the rack and pinion assembly in both sides of motor (i.e.) to control over the direction of motor rapidly, a motor driver is required for our system. The specifications of the motor driver considered are

Motor driver	=	L298N
Driver Chip	=	Double H Bridge L298N
Motor Supply Voltage (max)	=	46V
Motor Supply Current (max)	=	2A
Logic Voltage	=	5V
Driver Voltage	=	5-35V
Driver Current	=	2A
Logical Current	=	0-36mA
Maximum Power (W)	=	25W

4.3.6 Sensor specification

The system consist of two type of sensors used for different purposes. One sensor is used for detection of material in the output conveyor section and this is to provide prior information about position of the material. Another one is used to determine the color of the material moving on the conveyor. The sensor observes the color of the material in terms of red, green, blue and no color. This sensor only determines after the response from the previous sensor. The specification considered for sensor are

Object detection sensor

Sensor	=	IR sensor
Operating voltage	=	5VDC
I/O pins	=	3.3V & 5V
Type	=	Mounting hole
Range	=	1 - 20 cm
Supply current	=	20mA
Range of sensing	=	Adjustable

Color determination sensor

Sensor	=	TCS3200 Color sensor
Input voltage	=	2.7V to 5.5V
Working temperature	=	-40°C to 85°C
Interface	=	digital TTL
Output frequency	=	2Hz to 500 KHz

4.3.7 Holder Frame Specification

This part of the system is fabricated in a certain design to provide support the cylindrical fabrication which is held by pillow blocks. The pillow blocks are obviously used to provide rotational motion for separator fabrication. The dimension of pillow block is chosen with respect to the fabrication pipe. The specification of holder frame considered are

Frame

Material	=	Mild steel
Structure	=	Right angled triangle
Dimension	=	20cm (h), 15cm (b), 20cm (d)

Pillow block

Diameter	=	30mm (Inner dia.)

CHAPTER 5

FABRICATION PROCESS

5.1 CAD MODELLING

The system model is designed using solid works software. The parts of the system is drawn individually and then the parts are assembled as shown in Figure 5.1. The design specifies the position and placement of the every individual parts and depicts the relation between input and output section of the system. First, a feeder conveyor continued by separating fabrication and finally output conveyor section consist of consecutive level of sensors and actuators.

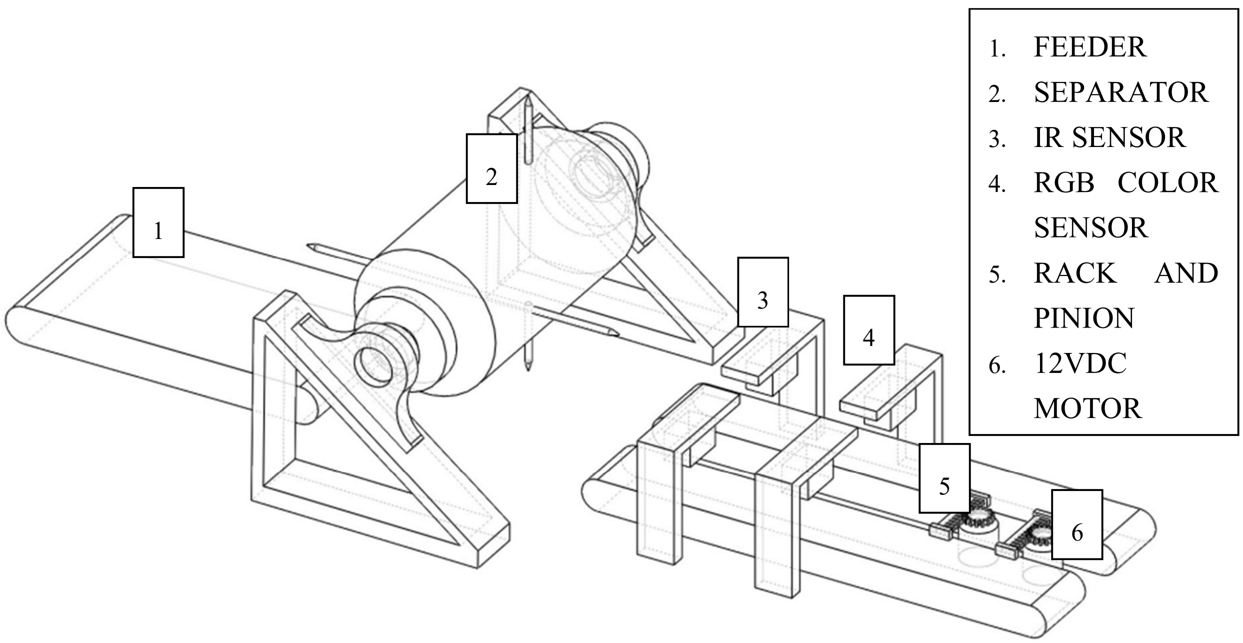

Figure 5.1 3D model of system

5.2 ELECTRICAL SECTION

The system consist of electrical components equal to the mechanical section. It consists of microcontroller circuit, obstacle detection sensor circuit, color recognition sensor circuit and motor driver control circuit interfaced with two actuators. The inputs from the sensor are received by controller and the respective output response is send to actuators by the controller. Due to more number of electrical components, it makes the electrical connections tedious. Figure 5.2 shows the electrical section of the system.

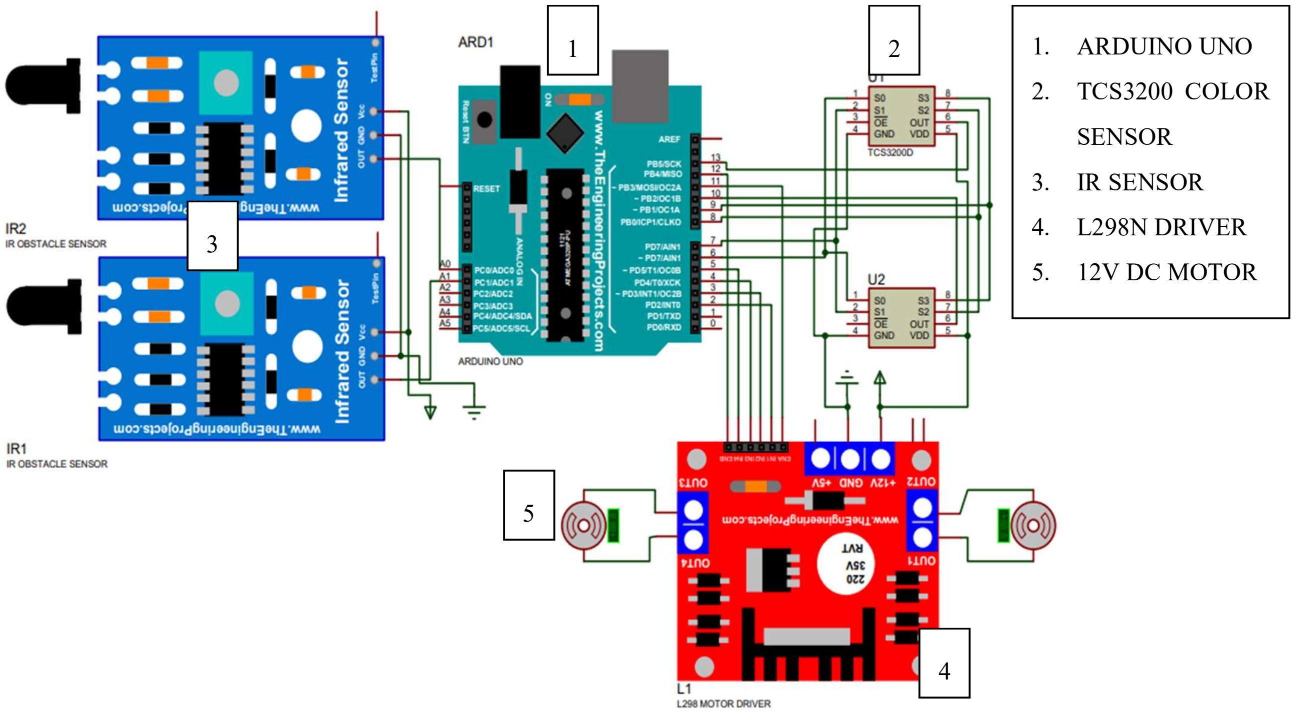

Figure 5.2 Electrical circuit connection

5.3 MECHANICAL SECTION

The mechanical section of the system involves with fabricated frames and structures, rack and pinion assembly, motors, pillow block and conveyor units. The fabricated structure which pick and place the materials into individual units and it is linked with pillow block for rotational motion. These pillow blocks are also used to provide rotational motion for the feeder and output conveyor units. The pillow block linked with separating fabrication is placed over a fabricated triangular frame to provide specific level of height. Furthermore the separating fabrication is linked with motor linked motor which drives the output conveyor unit. Finally, a rack and pinion assembly linked with motor is used to push over the material from the conveyor acting as a actuator of the system. Figure 5.3 shows fabricated setup of the system.

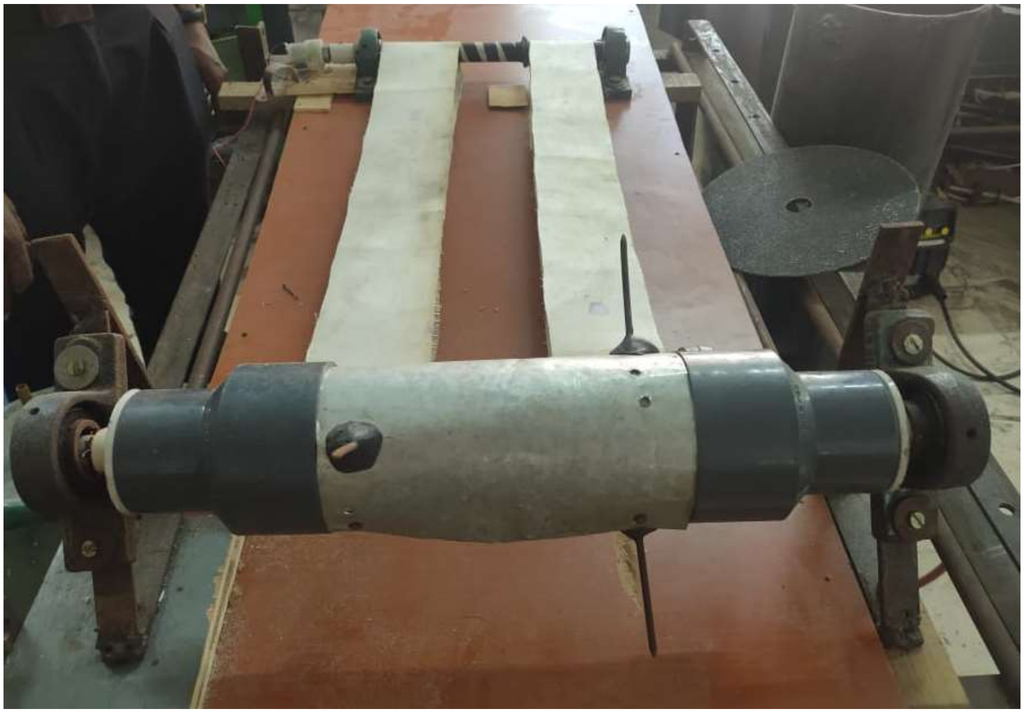

Figure 5.3 Mechanical fabrication

5.4 WORKING PRINCIPLE

The textile pre-production waste is fed by a feeder conveyor in the first section. This feeder is driven by a 12V geared DC motor. Then the waste reaches to material picking mechanical assembly. This assembly consist of sharp nails placed over a cylindrical pipe in two rows. These nails are long enough to pick and place a single piece of waste from the feeder section to sorting section. For every rotation of the cylindrical section, each and every nail pick and place a single material to the other side of the system. These nails are placed in two rows to provide output in two individual conveyor section and arranged equidistantly to provide time of interval between two consecutive materials. The cylindrical section is driven by a 12V geared DC motor which also drives the conveyor section in the sorting section. These geared motors are used to produce more torque and less speed. After the material reaches to the sorting section, it is first sensed by an IR sensor and then consecutively a RGB color sensor determines the color of the material passes through the conveyor. The data of the object detection, color determination and separation of the color by the actuator is controlled a main controller (Arduino UNO R3). The controller is connected to a L298 which is used to control the direction of the motor used. Each motor is responsible for one individual color. Whenever a particular color is sensed, the respective motor responds according to it. The motor is linked to a rack and pinion assembly which is used to push over the material from the conveyor to output box. The motor is placed between two conveyor sections so that it could be used to push over the material in both sides whenever the color is sensed. These motors are also 12V geared DC motor with more rpm for rapid movement of rack and pinion assembly. For multiple colors, respective number of motor are required. Finally the materials will be based on color and then the residual and unsorted materials can be recycled. Figure 5.4 represents workflow of waste fabric segregation system.

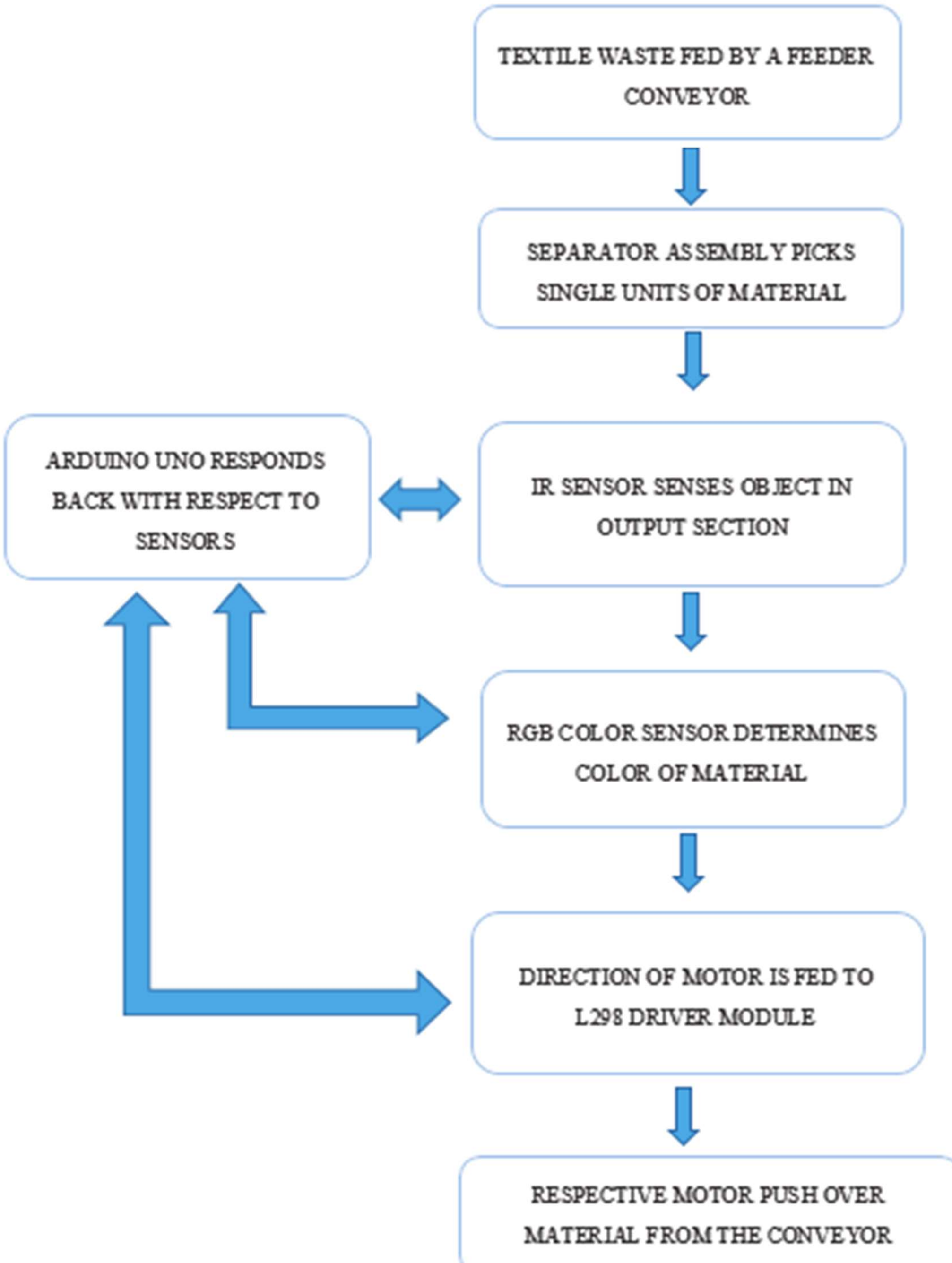

Figure 5.4 Flowchart of Waste Fabric Segregation System System

CHAPTER 6

CONCLUSION AND SCOPE OF FUTURE

6.1 CONCLUSION

Textile pre-production waste management system deals with tonnes of materials daily in industrial terms. But to establish and observe the working principle of the waste fabric segregation system, a miniature version of the system is developed for a minimum quantity of the waste and to segregate at least two colors (Red and Blue). Thus, the system offers a sustainable approach for processing the waste into individual units and then segregate them based on two colors. For an industrial approach, this can be further more developed with more actuators for multiple colors segregation and the separating fabrication can be enhanced more to divide multiple individual items at a time. We are certain that this system will reduce all the manual work, increase rate of segregation and encourage the textile industries towards recycling rather than discarding as landfill which would reduce a part of pollution. The initial cost of the model system developed was estimated at Rs. 6000. The cost estimation of the system may increase when it is built in industrial terms. About the results we obtained, for 1kg of waste material fed as input, red and blue color material is segregated in 20 minutes with generation residual waste (i.e.) the materials which does not reach output section and materials with other colors.

6.2 SCOPE OF FUTURE

This system that we have developed can be used only for segregation of the pre-production waste based on color but it can be furthermore developed to segregate the materials based on fiber or type of material manufactured. This could replace the existing system for material segregation based on types and combines both the process. Another function that can added to system is converting the segregated materials into the form of raw materials (i.e.) thread form. This process combined with other system can be developed into single recycling unit.

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APPENDIX

MICRO CONTROLLER PROGRAM

```
int enA = 11;
int in1 = 2;
int in2 = 3;
int enB = 12;
int in3 = 4;
int in4 = 5;
#define S0 6
#define S1 7
#define S2 8
#define S3 9
#define sensorOut1 10
#define sensorOut2 13

// Stores frequency read by the photodiodes
int red1 = 0,red2 = 0;
int green1 = 0,green2 = 0;
int blue1 = 0,blue2 = 0;

void setup() {
  // Set S0 - S3 as outputs
  pinMode(A2,INPUT);
  pinMode(A1,INPUT);
  pinMode(enA, OUTPUT);
  pinMode(enB, OUTPUT);
  pinMode(in1, OUTPUT);
  pinMode(in2, OUTPUT);
  pinMode(in3, OUTPUT);
  pinMode(in4, OUTPUT);
  pinMode(S0, OUTPUT);
  pinMode(S1, OUTPUT);
```

```
  pinMode(S2, OUTPUT);
  pinMode(S3, OUTPUT);

  // Set Pulse Width scaling to 20%
  digitalWrite(S0, HIGH);
  digitalWrite(S1, LOW);

  // Set Sensor output as input
  pinMode(sensorOut1, INPUT);

  // Setup Serial Monitor
  Serial.begin(9600);

  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4, LOW);
}
int det1 = HIGH,det2 = HIGH;
void loop() {
  analogWrite(enA, 255);
  analogWrite(enB, 255);

  // Setting RED filtered photodiodes to be read
  digitalWrite(S2, LOW);
  digitalWrite(S3, LOW);

  // Reading the output frequency
  red1 = pulseIn(sensorOut1, LOW);
  delay(100);
  red2 = pulseIn(sensorOut2, LOW);
  delay(100);
```

```
  // Setting GREEN (G) filtered photodiodes to be read
  digitalWrite(S2, HIGH);
  digitalWrite(S3, HIGH);

  // Reading the output frequency
  green1 = pulseIn(sensorOut1, LOW);
  delay(100);
  green2 = pulseIn(sensorOut2, LOW);
  delay(100);
  // Setting BLUE (B) filtered photodiodes to be read
  digitalWrite(S2, LOW);
  digitalWrite(S3, HIGH);

  // Reading the output frequency
  blue1 = pulseIn(sensorOut1, LOW);
  delay(100);
  blue2 = pulseIn(sensorOut2, LOW);
  delay(100);

  det1=digitalRead(A1);
  det2=digitalRead(A2);
if(det1 == LOW){
  delay(1500);
  Serial.print(red1);
  Serial.print(green1);
  Serial.println(blue1);
  if (red1 < green1 && red1 < blue1) {
    delay(1500);
    Serial.println(" - RED detected!");
    digitalWrite(in1, HIGH);
    digitalWrite(in2, LOW);
    delay(2000);
    digitalWrite(in1, LOW);
```

```
    digitalWrite(in2, HIGH);
    delay(2000);
  }
  if (green1 < red1 && green1 < blue1) {
    Serial.println(" - GREEN detected!");
  }
  if (blue1 < red1 && blue1 < green1) {
    delay(4000);
    Serial.println(" - BLUE detected!");
    digitalWrite(in3, HIGH);
    digitalWrite(in4, LOW);
    delay(2000);
    digitalWrite(in3, LOW);
    digitalWrite(in4, HIGH);
    delay(2000);
  }
}
else
  {
    digitalWrite(in1, LOW);
    digitalWrite(in2, LOW);
    digitalWrite(in3, LOW);
    digitalWrite(in4, LOW);
  }
if(det2 == LOW){
  delay(1000);
  Serial.print(red2);
    Serial.print(green2);
    Serial.println(blue2 );
  if (red2 <green2 && red2 < blue2) {
    delay(1500);
    Serial.println(" - RED1 detected!");
    digitalWrite(in1, LOW);
```

```
    digitalWrite(in2, HIGH);
    delay(2000);
    digitalWrite(in1, HIGH);
    digitalWrite(in2, LOW);
    delay(2000);
  }
  if (green2 < red2 && green2 < blue2) {
    Serial.println(" - GREEN1 detected!");
  }
  if (blue2 < red2 && blue2 < green2) {
    delay(4000);
    Serial.println(" - BLUE1 detected!");
    digitalWrite(in3, LOW);
    digitalWrite(in4, HIGH);
    delay(2000);
    digitalWrite(in3, HIGH);
    digitalWrite(in4, LOW);
    delay(2000);
  }
}
else
  {
    digitalWrite(in1, LOW);
    digitalWrite(in2, LOW);
    digitalWrite(in3, LOW);
    digitalWrite(in4, LOW);
  }
}
```