Tribe D Documentation

ELP305

Design and System Laboratory
Project 1

Requirements and Specifications Submission

Submitted to:
Prof. Subrat Kar

Submitted by:
Tribe D (Demantors)

Document type: Private Release
Document Authorised by: Ayush Sharma
Contact Details: mt1210244@maths.iitd.ac.in
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Abstract

In this project, we want to conceptualize and develop an innovative fabric-cleaning apparatus that specifically targets and effectively eliminates oil stains, particularly those situated near the edges of manufactured cloth.

The unique selling proposition (USP) of our designed fabric-cleaning machine lies in its remarkable capability to selectively target and clean only the areas of the cloth that are stained, leaving the already pristine portions untouched. This distinct feature not only contributes to maintaining the fabric's quality and durability but also streamlines the cleaning process, by doing this we reduce the time and resources required for subsequent drying processes.

Furthermore, a significant aspect of our project involves the systematic testing of various Solvents which effectively removes oil and grease stains commonly encountered during the cloth manufacturing process. Our research and experimentation have led us to focus our model on the thorough cleaning of the edges of the cloth since there is a higher probability of deterioration in the peripheral regions of the cloth. It is necessary to note that the clean cloth which will be obtained after undergoing all the processes is not completely dry.

The initial phase of our design focuses on the development of a prototype model for the fabric-washing machine. In subsequent iterations, we will further incorporate more advanced features. The said Iterations will be done after extensive surveys and research conducted throughout the project's duration, aimed at aligning with the evolving needs of contemporary users. Through this entire process, we aspire to create a fabric-cleaning solution that not only addresses specific manufacturing challenges but also anticipates and adapts to the dynamic requirements of the industry.

Motivation

The textile industry owned by the client produces fabric of fixed width that is delivered in batches that get stained on the edges with grease and oil due to the industry equipment. This cloth must be cleaned before it can be shipped to the market. Since this type of staining is localised, our team is developing a machine that only focuses on the area of the cloth that is expected to be dirty and cleans it in two stages: scrubbing/washing and drying. The end product is a cloth with clean and dry edges, with the rest of the material left untouched to preserve quality and lifespan. The relevance of this model lies in the fact that it speeds up the cleaning process without having to spend extra resources for cleaning the cloth as it utilises the localised nature of the stain to its full advantage. The cloth is folded to a vertical configuration with the help of rollers and then the cleaning is performed only on the bottom areas, where the edges lie. This separates the clean part of the cloth with the dirty part and makes it easier to clean while also making it easier to dry. The scope of this type of machine is in industrial applications where the stain is only towards the edges, which may be due to faulty rollers in the assembly line, and the rest of the cloth is clean. This machine cannot be used for general-purpose cleaning where the stain is outside the target region on which the machine operates.

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Mind Map

Note: Mindmaps provided here are abbreviated versions to ensure visibility. For detailed mindmaps, refer to the Xmind files provided in the .zip file.

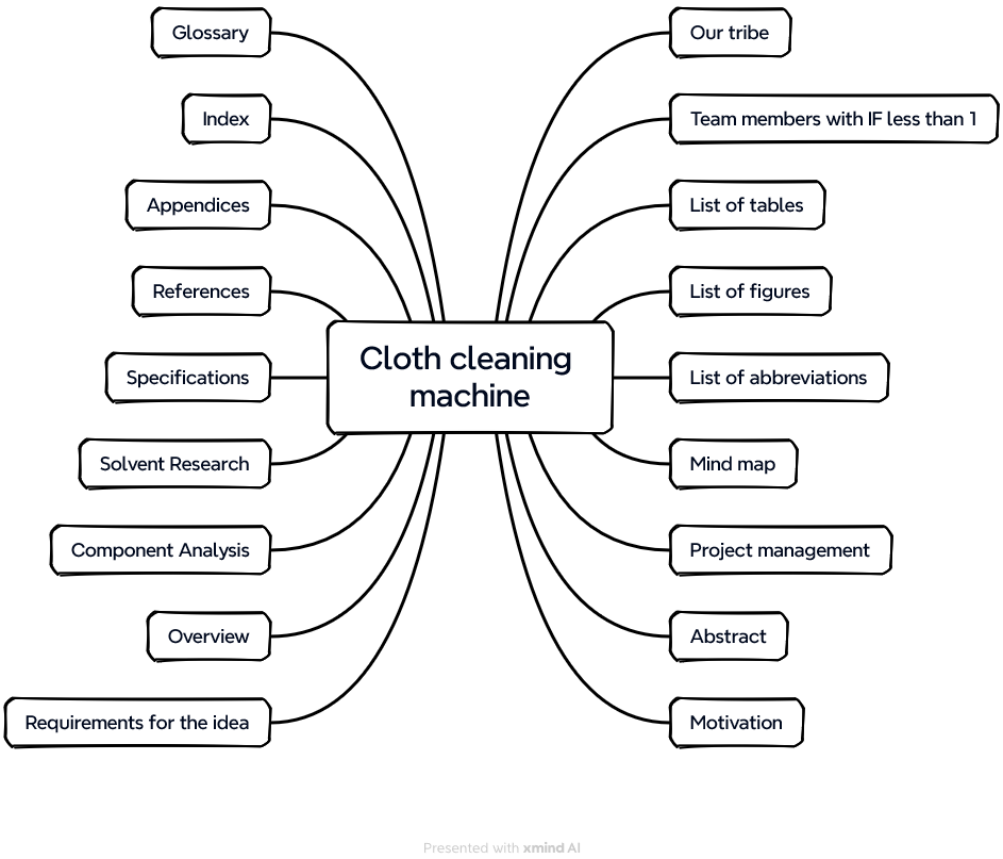


Figure 1: Outline Mindmap

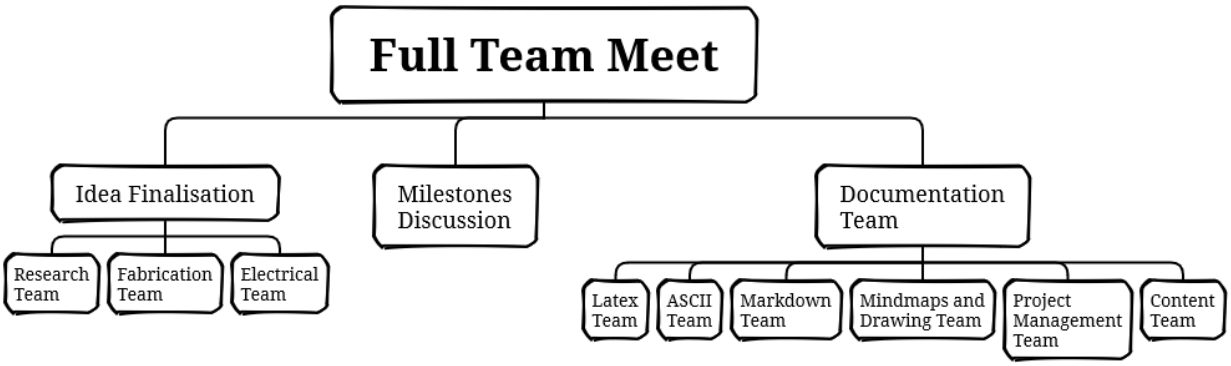


Figure 2: Task Structure

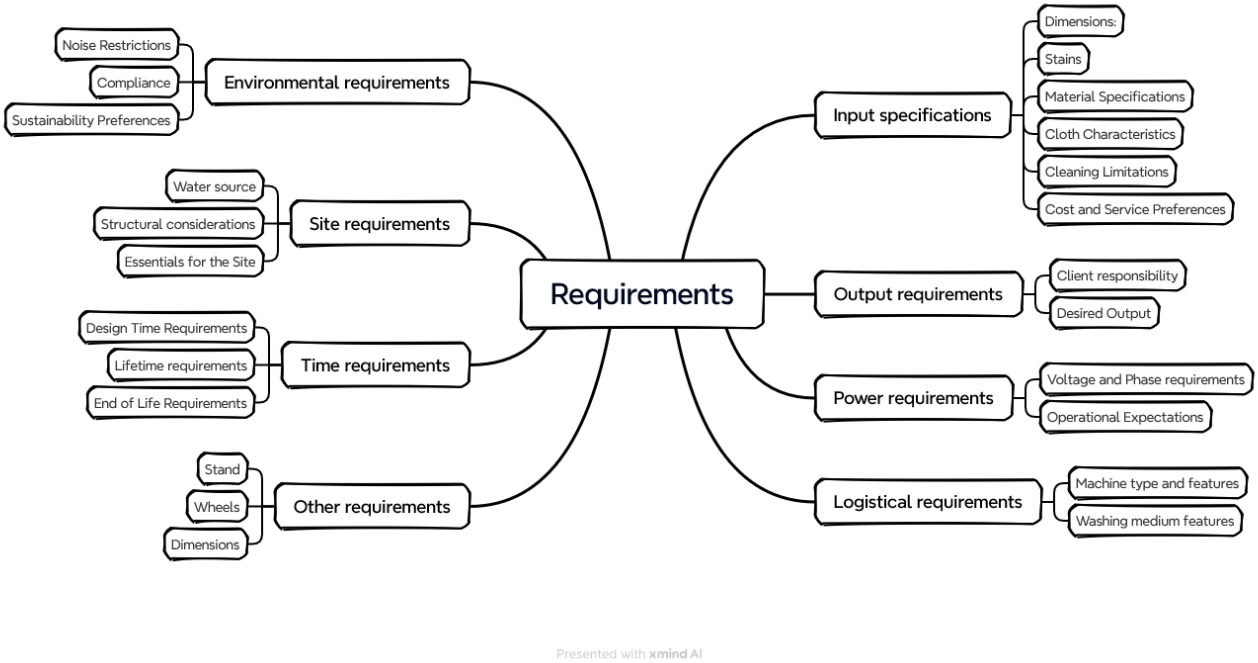


Figure 3: Requirements MindMap

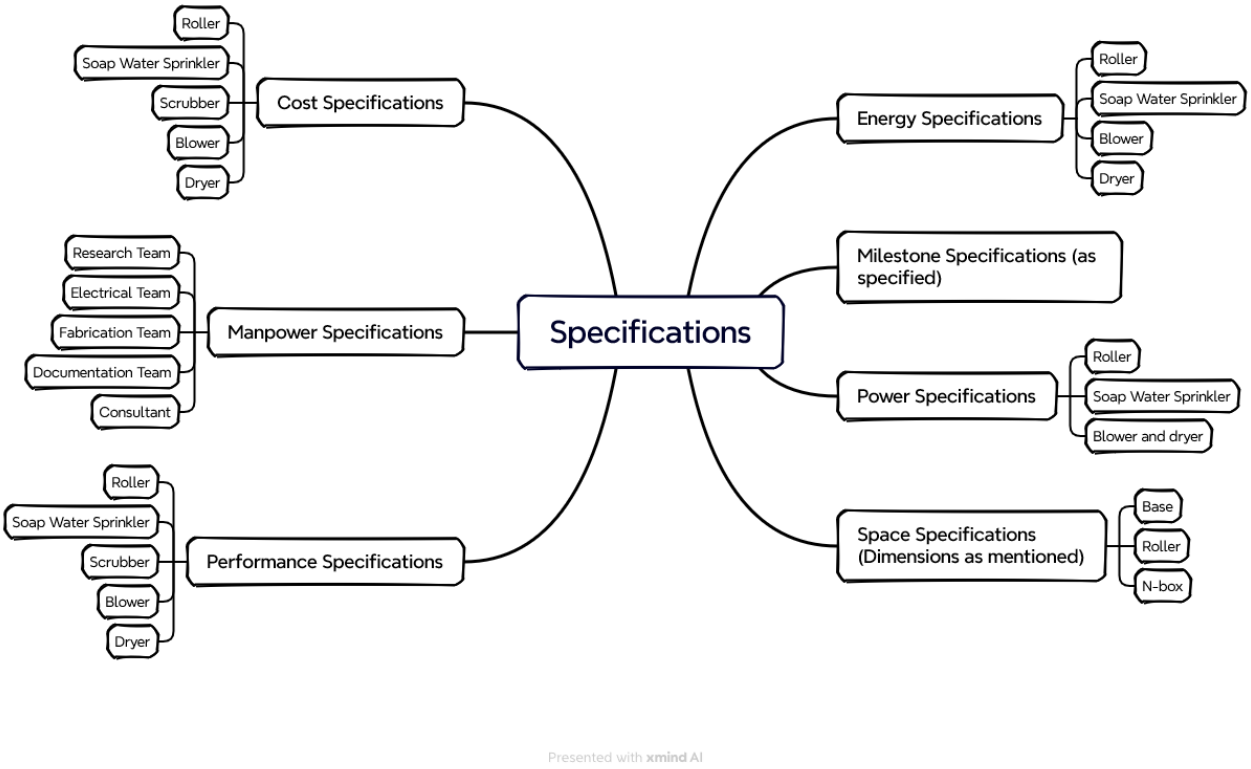


Figure 4: Specifications Mind Map

1 Requirements for the idea

1.1 Input Requirements

1.1.1 Material Requirements

- Newly manufactured white unbleached cotton with single-ply, Denier 60, and a thread count of Thread Count of 400.

1.1.2 Stains

- Only oil and grease stains present on the edges of the cloth need to be removed.

1.1.3 Dimensions

- Cloth is either available on rollers(2m $\times$ 10m) or it can be assumed as an infinite sheet supply of width 2 m.

1.1.4 Cloth Characteristics

- Free from foul odour, slightly damp, and without buttons, zippers, or attachments.

1.1.5 Cleaning Limitations

- Maximum weight for cleaning is set at 11 kg dry, with stains limited to those occurring during manufacturing.

1.2 Outputs Requirement

1.2.1 Desired Output

- A cleaned and dry cloth wound on rollers.

1.2.2 Client Responsibilities

- Treating discharged , managing lint, and ensuring the returned cloth is wrinkle-free and Bone-Dry.

1.3 Power Requirements

1.3.1 Voltage and Phase Requirements:

- The washing machine should operate on 220VAC 15A, with the option for 440VAC 3-phase available at an additional cost.

1.3.2 Operational Expectations

- They are expected to run continuously, 24/7, with an emergency shutdown initiated using a 1-button process.

1.4 Logistical Requirements

1.4.1 Machine Type and Features

- An automatic washing machine with minimal water usage and no need for portability or a programmable timer.

1.4.2 Washing Medium Features

- There are no restrictions on the washing medium, but costs may be incurred for using rare solvents, focusing on overall cost-effectiveness.

1.5 Environmental Requirements

1.5.1 Noise and Compliance

- Noise levels should not exceed 75 dB.
- Must comply with local regulations, including those set by the Central Pollution Control Board (CPCB).

1.5.2 Sustainability Preferences

- Preference for cold water washing, Sustainable components, and optimization of energy consumption, robustness, and durability.

1.6 Site Requirements

1.6.1 Essentials for the Site

- Adequate power supply, suitable drainage, and specific design parameters.

1.6.2 Water Source and Structural Considerations

- The water source was specified as having 60 mg CaCO3/l hardness, with an overhead tank and a 50,000-liter refillable capacity at 35 meters.
- Structural considerations include material selection and the ability to withstand the maximum cloth weight.

1.7 Time Requirements

1.7.1 Cleaning and Setup Time

- Cleaning and drying time set at 45 minutes.
- Setup time should be at most 1 day.

1.7.2 Design Time Requirements

- Cleaning and Drying time: At most 45 minutes.
- Usage time: 24 hrs a day.
- Setup Time: As little time as possible, no more than 1 day.

1.7.3 Life-Time Requirements

- Expected Lifetime: The machine is expected to last at least 6 years.
- Service Hours and Cost: No more than 6 hours per year and there isn't an explicit cost constraint for the servicing years.

1.7.4 End of Life Requirements

- Replacement for Old Machine: Client could be interested in replacing the old machine for a new one at a discounted price.
- Parts Availability:Parts of the machine should be available for 10 years to enable servicing.

1.8 Other Non-Functional Requirements

1.8.1 Miscellaneous Considerations

- Dimensions and the inclusion of a stand or wheels are left to the designer's discretion.
- We need to clean only edges of the cloth rather the whole cloth.
- Only oil stains and grease stains are need to be removed.
- Cloth is either available on rollers(2m $\times$ 10m) or it can be assumed as an infinite sheet supply of width 2 m.

2 Overview

We propose the development of an innovative cloth cleaning machine that can be used to clean oil stains (which occur near the edges) off of manufactured cloth after the manufacturing process. Our design consists of rollers, driving motors, a (used to fold the cloth in half vertically), wiping and cleaning surface (brushes/sponge), a soap water mixture compartment, a water compartment, and a drying chamber. This automated system aims to streamline the cloth manufacturing process, ensuring efficient cleaning and drying during the manufacturing process while minimising the impact on the fabric. The USP of our design is that the regions of the cloth that are guaranteed to come in clean are untouched in the process, which preserves the quality and durability of the cloth. This approach also ensures that drying requires less effort and resources in comparison to other approaches.

2.1 Key Components

1. **Rollers with Motor Control:**
    - Two rollers placed on either side of the machine.
    - Motor-controlled to regulate the speed of the cloth movement.
2. **Cloth Attachment:**
    - Cloth is securely attached to the rollers upon loading in batches, ensuring uniform tension.
3. **Guiding Frame:**
    - Positioned between the rollers upon viewing from the side and placed parallelly between the two vertical walls when viewed from the top.
    - The frame when viewed from the side looks like a smoothened plateau with a long flat top and curved sides (coming from and going towards the input and output rollers respectively).
    - Upon viewing from the top, it looks like the edge of a railing.
    - The frame is slightly angled and is broader at the bottom than at the top.
    - All edges on the frame are Filleted and smoothened to ensure that the cloth doesn't rip or tear or get stuck while it slides over the frame due to the pull of the motor.
    - It is shaped this way to guide the fabric to smoothly rise in height from the horizontal roller configuration at the input to the folded vertical configuration in the cleaning and drying chamber.

- This vertical folding ensures that the stained edges are hanging on the two sides of the frame symmetrically with the entire cloth folded along the midline and suspended vertically by the normal reaction from the sleek frame.
- The part of the fabric towards the centre in the horizontal configuration, now slides at the top of the smooth frame as the rollers on the other end pull it at a constant speed and is unaffected by the cleaning and drying process.
- Once the cloth crosses the drying chamber, the guiding frame is shaped in such a way that it lowers the cloth from the raised frame back to its horizontal configuration onto the rollers.

4. **Cleaning Mechanism:**

   - Brushes along the edges of the frame at a fixed distance from the height (coincides with the stained edge of the cloth).
   - The parallel wall also has brushes at the same vertical height, and the two brushes hold on to the edge of the cloth as it moves under the influence of the rollers and scrubs against the brushes, hence getting cleaned.
   - Solvent drizzled from the top onto the stained part of the cloth). The solvent mixture and water are dispensed in succession and recursively creating stages along the length of the frame. (first "x" cm $\rightarrow$ soap, next "y" cm $\rightarrow$ water, next "x" cm $\rightarrow$ soap, etc.).
   - Brushes act as scrubbers to enhance cleaning effectiveness.

5. **Cleaning Fluid Compartment:**

   - Alternating compartments for soap water mixture and water.
   - The soap compartments have brushes along the wall, while the water compartment consists of high-pressure water nozzles to take out the soap from the cloth.
   - Ensures proper cleaning of the cloth during the process.

6. **Drying Chamber :**

   - Located after the cleaning mechanism.
   - Equipped with to blow hot air onto the cloth.
   - Ensures quick and effective drying.

7. **Guiding :**

   - Transfer the cloth from the input roller to the cleaning chamber of the frame and from the drying chamber of the frame to the rollers.
   - Facilitates a smooth movement of the cloth.

8. **Waste Tub :**

- A waste tub at the bottom to collect residual drippings and lint.

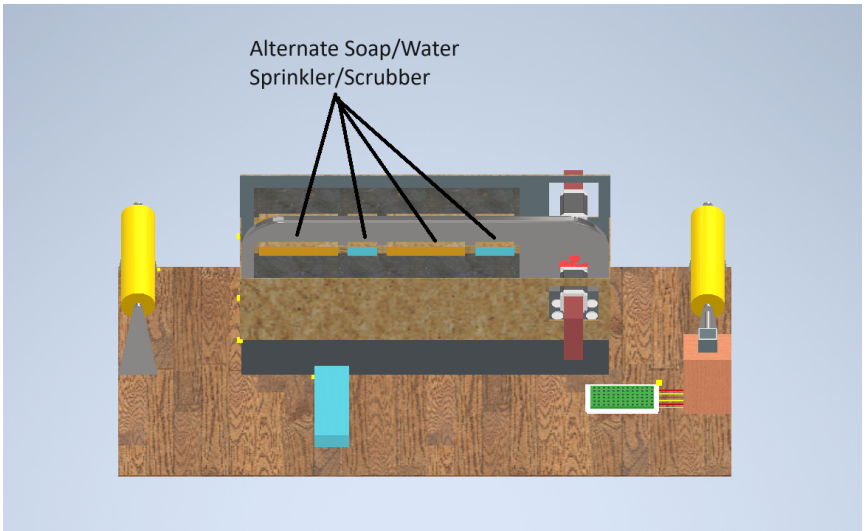


Figure 5: Side view of the final CAD model

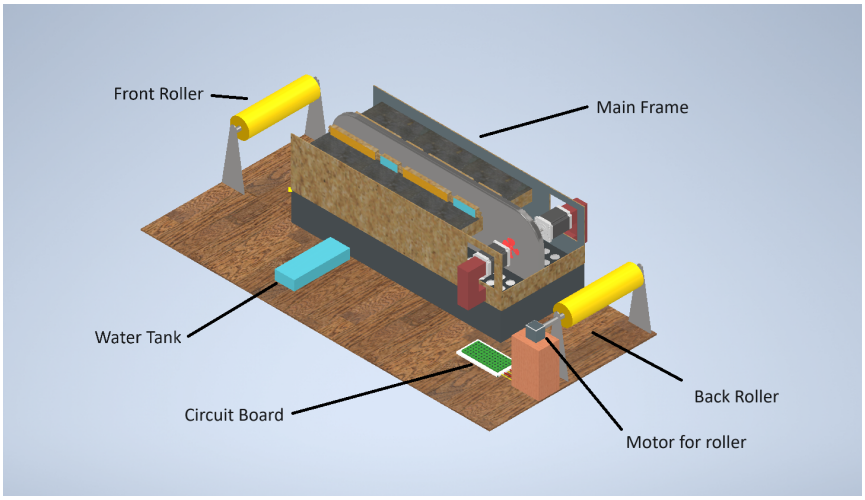


Figure 6: Isometric view of the final CAD model

2.2 WorkFlow

- Cloth is loaded onto input rollers over the guiding frame, through the cleaning and drying chamber and onto the output roller. In order to prevent wastage of a significant initial length of the cloth roll, we can attach it to a clean dummy cloth of machine length, with the help of a speed punching system and later detach the dummy cloth and reuse it for the next batch. This is not relevant for demonstration but crucial during industrial scaling.
- Then a lever/switch is activated which brings the two walls closer to the guiding frame with the cloth attached to it and the horizontal line of brushes lock onto each hanging edge of the cloth securing it in place.
- Motors are powered on, and the cloth starts sliding on the frame while being kept in place by the walls and guiding fixtures.
- The Solvent is drizzled from the top with targeted precision on the edges, and brushes act as scrubbers for thorough cleaning as the cloth slides over them.
- The cloth passes through multiple alternating soap water mixture and water compartments and gets recursively cleaned for better results.
- The cloth then enters the drying chamber, where hot air is blown to expedite the drying process.
- After drying, the cleaned and dried cloth moves through guiding fixtures onto the rollers for subsequent manufacturing processes.

2.3 Benefits

- Improved cloth cleaning efficiency.
- Minimized impact on the fabric during the cleaning process.
- Streamlined manufacturing workflow.
- Enhanced drying capabilities for increased production speed.

Calculation of order of magnitude of the length of chamber:

- Load in one batch = 11 kg.
- Breadth of cloth roll = 2 m.
- The Areal density of Single ply cotton cloth unbleached, denier 60, thread count 400 = 0.180 kg/m^2.
- Time provided for cleaning = 45 minutes.

- $l = \frac{90 \times 11}{0.18 \times 2 \times 45 \times 60}$ m =1 m approx = 40 inches approx (l = cleaning and drying length).
- Varying soaps changes the time cloth needs to spend in the chamber which increases/decreases the length of the machine.

3 Component Analysis

3.1 Roller

1. The roller will roll the washed cloth, coming through the conveyor belt.
2. A controlled DC motor will be used to drive the roller.
3. Appropriately select the dimensions of the roller, like the diameter of the roller and its length, based on the conveyor width.
4. Choose a proper outer covering for the roller, which can provide a better grip and friction for the cloth.
5. The cloth will also be straightened using 1 or 2 uncontrolled rolling cylinders which can provide the requisite tension in the fabric and guide the fabric onto the roller.

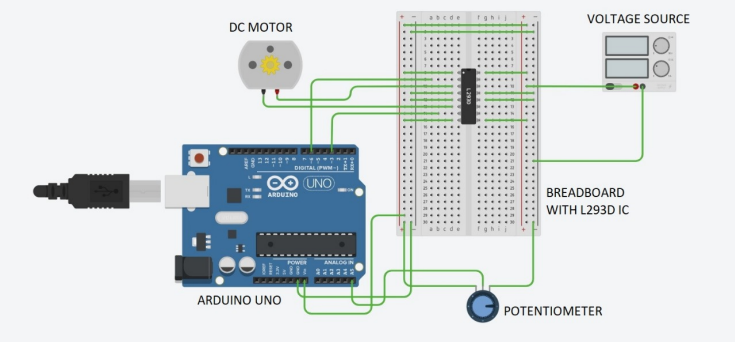


Figure 7: Circuit diagram for controlling roller's motor

3.1.1 Controlling DC Motor using Arduino

To control the speed of a DC motor using Arduino, we need to adjust the input voltage supplied to the motor. We can control the input voltage with a pulse-width modulated (PWM) signal. To change the speed of the DC motor we need to change the amplitude of the input voltage that is applied to the motor. A common technique to do that is PWM (Pulse Width Modulation). In PWM the applied voltage is adjusted by sending a series of pulses so the output voltage is proportional pulse width generated by the microcontroller that is also known as duty cycle.

Figure 8: A square wave with 50% duty cycle

The higher the duty cycle, the higher the average voltage applied to the DC motor (resulting in higher speed) and the shorter the duty cycle, the lower the average voltage applied to the DC motor (resulting in lower speed).

3.1.2 Arduino and L293D Circuit Diagram

A common and cheap solution to drive motors and efficiently control them is to use a Motor Controller module along with Arduino. L293D Motor driver module is a readily available IC which can be easily interfaced with Arduino, to control the various aspects of DC motors like speed, direction and braking. It is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36V. Below is an example of a circuit diagram to drive multiple motors from a single module, and Arduino code to interface a motor with the module.

```
1  # Define constants for pin numbers
2  leftForward = 6
3  leftBackward = 3
4  pot = A5
5
6  # Initializing some variables
7  pwm
8  x
9
10 # Running the Setup function once at the beginning
11 setup()
12
13   # Set the leftForward and leftBackward as outputs and pot as
       an input
14   pinMode(leftForward , OUTPUT)
15   pinMode(leftBackward , OUTPUT)
16   pinMode(pot, INPUT)
17
18   # Begin serial communication for debugging
19   Serial.begin(9600)
20
21 # Loop function to run repeatedly
22 loop()
23   # Reading the analog value from pot
24   pwm = analogRead(pot)
25   # mapping the value of pwm within appropriate bounds
26   x = map(pwm, 0, 1023, 0, 255);
```

```
27   # Assigning the value of pwm to x, and configuring the values
         to drive the motor in a particular direction
28   analogWrite(leftForward , x);
29   digitalWrite(leftBackward , LOW);
```

Click here for the Arduino code reference

3.2 Soap Water Requirements

3.2.1 A. For split cloth pieces using sensor

```
1  const int poten = A3;
2  int var;
3
4  void setup()
5  {
6    pinMode(6, OUTPUT);
7  }
8
9  void loop()
10 {
11   var = analogRead(poten);
12   analogWrite(6, var);
13 }
```

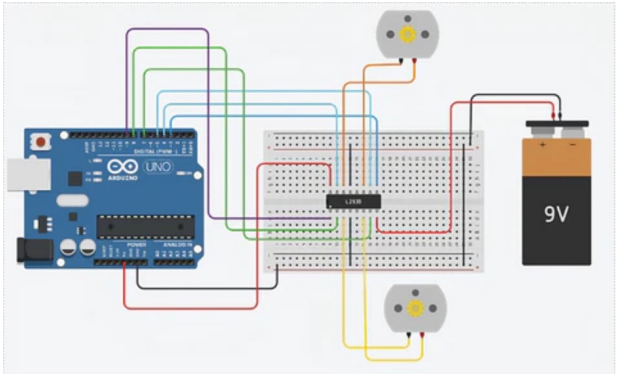


Figure 9: Sample circuit diagram of motor control

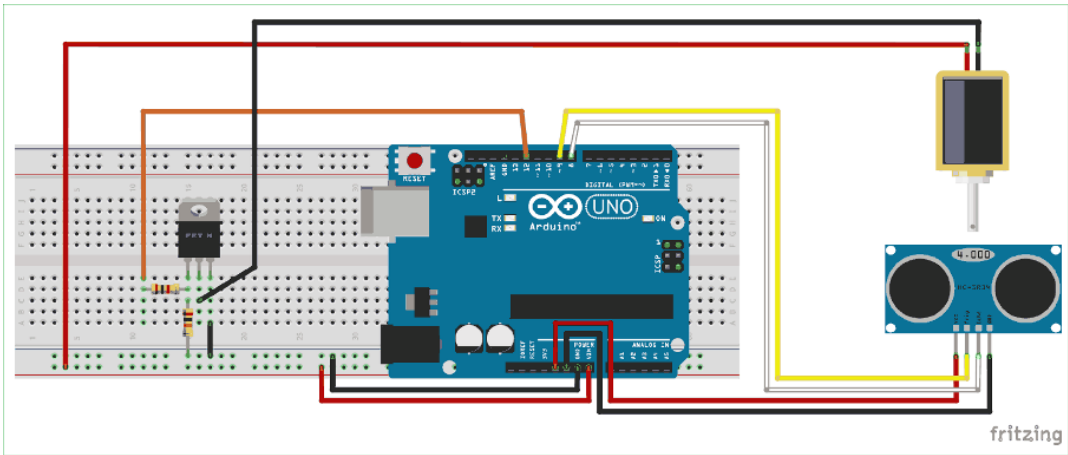
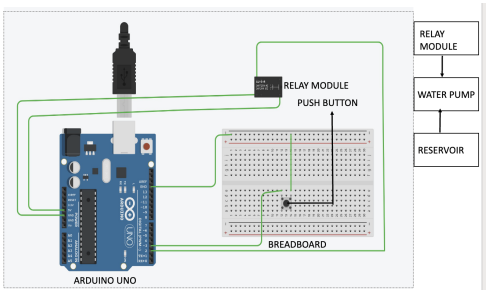


Figure 10: For cut cloth pieces using sensor

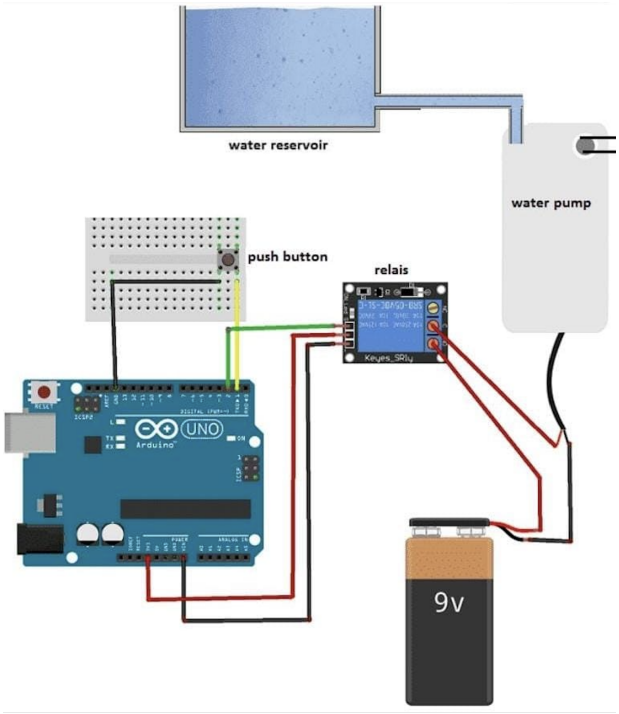
Explanation:

- When the distance is less than 10cm, we have to turn on the MOSFET, and otherwise, we have to turn off the MOSFET. We will also use the on-board LED connected to pin 13 and toggle it along with the MOSFET so that we can ensure if the MOSFET is in the turned-on or turned-off state.
- Inside the main loop function, we call for the function called `measure_distance()`. This function uses the US sensor to measure the distance of the object in front of it and updates the value to the variable `distance`.
- The input or the detection will send a sonic blast of Ultrasonic signals into the air, which will get reflected by the object in front of it, and the echo pin will pick up the signals reflected by it. Then we use the time taken value to calculate the distance of the object ahead of the sensor.
- Once the distance is calculated, we have to compare the value of distance using a simple if statement. If the value is less than 10cm, we make the MOSFET and LED go high. In the following else statement, we make the MOSFET and LED go low.

3.2.2 B. Without Sensor, using push button



(a) Using Push Button



(b) Full circuit

Figure 11: Sprinkler

Explanation

- A push button is employed to toggle the relay, managing the on/off state of the pump.
- The relay is cycled at regular intervals, simulating control over a device, such as a solvent pump. To activate the relay, the relay pin (control pin) is set to HIGH. To deactivate the relay, the relay pin is set to LOW.

Click here for code reference

```
# Define constants for pin numbers
relayPin = 2
buttonPin = 3

# Setup function to run once at the beginning
setup():
    # Set the relayPin as an output and buttonPin as an input
       with pull-up resistor
    pinMode(relayPin, OUTPUT)
    pinMode(buttonPin, INPUT_PULLUP)

    # Begin serial communication for debugging
    Serial.begin(9600)

    # Turn off the relay initially
    digitalWrite(relayPin, LOW)

# Loop function to run repeatedly
loop():
    # Read the state of the button (HIGH or LOW)
    buttonState = digitalRead(buttonPin)

    # Print the button state for debugging
    Serial.println(buttonState)

    # Check if the button is pressed (LOW state)
    if buttonState is LOW:
        # Turn on the relay
        digitalWrite(relayPin, HIGH)
    else:
        # Turn off the relay
        digitalWrite(relayPin, LOW)
```

3.3 Scrubber

- Static stationary brush scrubber is an industrial cleaning tool designed for efficient cloth cleaning. This device features stationary brushes that remain fixed during operation, providing a stable cleaning surface. The static design allows for controlled and targeted cleaning of fabrics, ensuring uniform and effective removal of dirt and contaminants. This type of scrubber is commonly employed in industrial settings where precision and consistency in cloth cleaning are essential for maintaining high standards of hygiene and product quality.

- Stationary brushes would be used near the edges of the cloth.
- Static cleaning mechanism.

3.4 Dryer

We are planning to use the configuration of tunnel dryer to dry the clothes. The power and torque requirements of the motor used in blower and power requirements of the heater will depend on the time needed to dry the cloth, rate at which the cloth is being fed, width and height of the chamber, final moisture content and initial moisture content. Also, since counter current configuration is most efficient, we will be using the same in our design. Using tunnel dryers also allows us to move the conveyor belt slowly as it is very efficient in processing materials taking long drying time and thus requiring lesser motor drive.
Optimisation for power requirements will be done once design specs are provided and it would be based on the mathematical modelling and simulations done to observe the humidity content with rate of air flow and power input to heater and blower.

To control the heater we will use Arduino, a temperature sensor (thermocouple), a relay module, battery and bunch of connecting wires. One of the circuits which can be used is as follows:

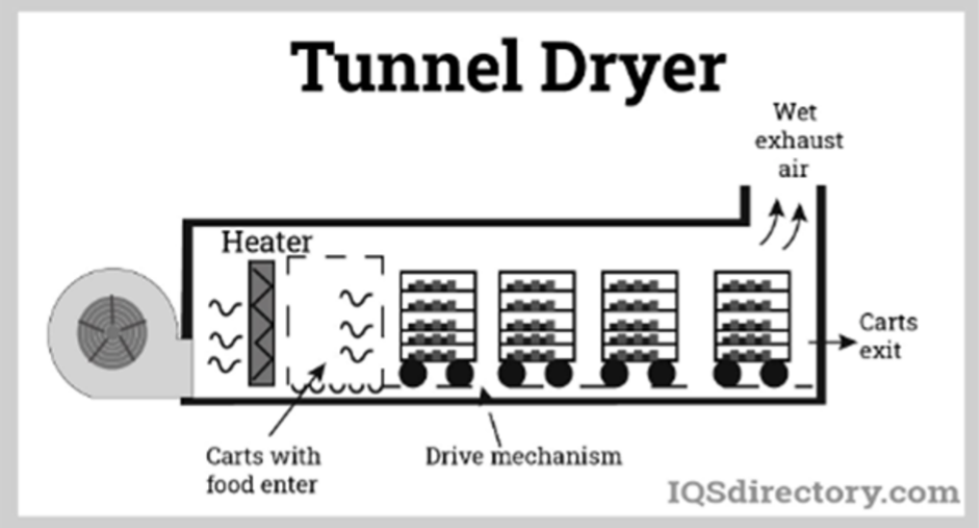


Figure 12: Tunnel Dryer

One can have LCD display to keep track of any errors in the functioning. The Arduino code for controlling heater is as follows:

```
# Arduino will only be used if motor speed was found to
    exceeding the limits to run a fan
#The limits will be found out when material is fulfilled
# Define constants for pin numbers
leftForward = 6
leftBackward = 3
pot = A5

# Initializing some variables
pwm
x

# Running the Setup function once at the beginning
setup()

  # Set the leftForward and leftBackward as outputs and pot as
      an input
  pinMode(leftForward , OUTPUT)
  pinMode(leftBackward , OUTPUT)
  pinMode(pot, INPUT)

  # Begin serial communication for debugging
  Serial.begin(9600)

# Loop function to run repeatedly
loop()
  # Reading the analog value from pot
  pwm = analogRead(pot)
  # mapping the value of pwm within appropriate bounds
  x = map(pwm, 0, 1023, 0, 255);
  # Assigning the value of pwm to x, and configuring the values
      to drive the motor in a particular direction
  analogWrite(leftForward , x);
  digitalWrite(leftBackward , LOW );
```

Click here for code reference

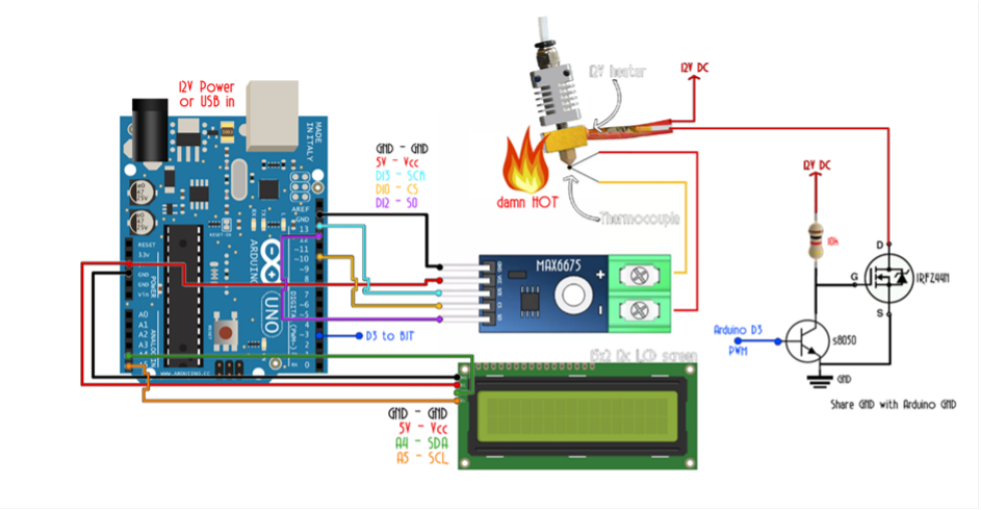


Figure 13: Control circuit for heater

For running and controlling the blower we need to have an Arduino controlling motor, anemometer, battery, and a bunch of wires.

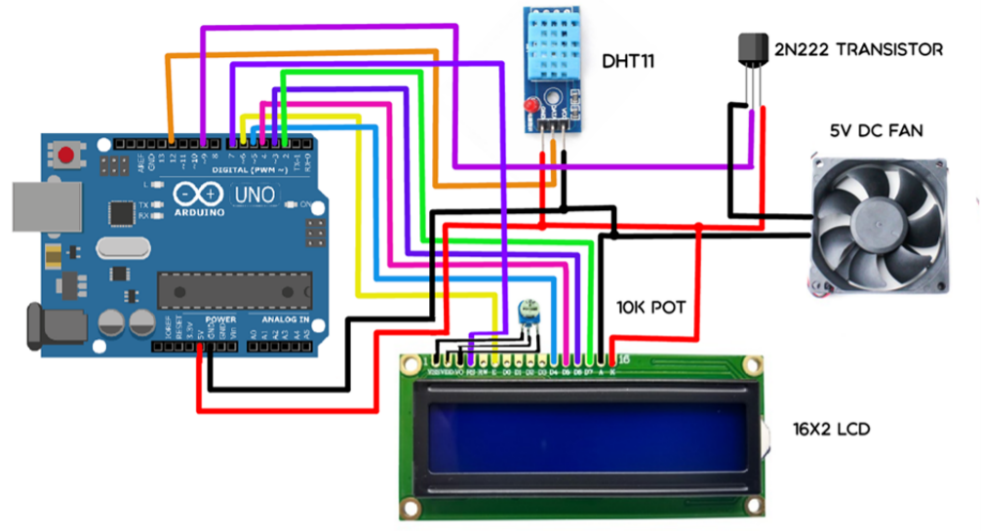


Figure 14: Control Circuit for a DC motor/fan.

4 Solvent Research

Some of the cleansing agents that were researched and tested for oil and grease stains:

1. **Lipase Enzyme**
    - **Pros:** Lipase is an enzyme that breaks down oil, making it a potential solution for cleaning oil and grease stains.
    - **Cons:** Requires slightly warm water (~40-50°C) for optimal enzyme action, which may be challenging to maintain.
2. **Spot Remover (e.g., Shout) and Hot Water**
    - **Pros:** Effective in removing both oil and grease stains. Hot water and brushing enhance results.
    - **Cons:** Increases energy requirements and costs due to hot water usage. Spot removers add to the overall cost.
3. **Spot Lifters (e.g., K2R Spot Lifter) followed by Dry Brushing**
    - **Pros:** Overcomes the need for scrubbing in hot water. After application, a short waiting period lifts the stain, requiring only brushing in the end.
    - **Cons:** Costly (`~3300 Rs for 150 ml`) and availability may be an issue for large quantities due to US manufacturing.
4. **Baby Powder/Cornstarch/Salt/Vinegar followed by Washing**
    - **Pros:** Effective in cleaning oil and grease stains significantly.
    - **Cons:** Time-consuming, requiring soaking and multiple iterations to remove stains.
5. **WD-40 or Lighter Fluid**
    - **Pros:** Effective in cleaning oil and grease stains significantly.
    - **Cons:** Requires 20 minutes of soaking time, and hot water is needed for washing.
6. **PCE (Perchloroethylene)**
    - **Pros:** Nonflammable liquid solvent widely used in dry cleaning, effective in removing oil and grease stains in small quantities.
    - **Cons:** Extended exposure to large quantities may cause irritation to eyes, skin, throat, nose, and respiratory system.

7. **Handwash (Dettol)**
    - **Pros:** Biodegradable, environmentally friendly. Can be washed and reused multiple times. Soft and less abrasive.
    - **Cons:** May be more prone to staining depending on material and color.
8. **Dishwasher (Vim Drop)**
    - **Pros:** Effective in removing both oil and grease stains by scrubbing with Vim Drop and water with normal pressure.
9. **Trichloroethylene (TCE)**
    - **Pros:** Stain remover and degreaser. Evaporates quickly, leaving behind a dry surface.
    - **Cons:** Linked to various health risks, including respiratory, neurological, and reproductive effects. Considered a potential human carcinogen. Flammable and persistent in the environment.
10. **Isopropyl (Rubbing Alcohol 68-72%)**
    - **Pros:** Natural degreasing agent.
    - **Cons:** Ineffective in practical experiments on grease and oil-stained cotton cloth. May be effective after longer soaking, making it inefficient due to time constraints.
11. **Detergent (Surf Excel)**
    - **Pros:** Effective on oil stains with slight scrubbing.
    - **Cons:** The idea was rejected as it was not effective on grease stains, even after hard scrubbing.
12. **Acetone**
    - **Pros:** As it is volatile, it would be quite convenient in the drying stage.
    - **Cons:** We have experimentally seen that it does not work efficiently on grease stains

4.1 Solvent Testing

- **WD-40**

(a) Before

(b) After

Figure 15: Application of WD-40

- **Acetone**

(a) Before

(b) After

Figure 16: Application of Acetone

- **Dishwash (Vim)**

(a) Before

(b) After

Figure 17: Application of Dishwasher (Vim)

- **Some more applications**

(a) using Isopropyl

(b) using Detergent

Figure 18: Image of greased cloth after cleaning

Factor	Acetone	Stain Remover	Isopropyl Alcohol	Liquid Washing Soap
Suitability for oil-based stains	Excellent	Good	Good	Moderate
Amount of solvent	5-10 mL, test in inconspicuous area first	Follow product instructions (5-15 mL typical)	5-10 mL, test in inconspicuous area first	Apply directly to stain or dilute 5-10 mL in water for pre-treatment
Cleaning time	5-10 minutes	10-15 minutes	5-10 minutes	Depends on washing cycle time
Scrubbing intensity	Light scrubbing with soft cloth	Light to moderate scrubbing	Light scrubbing with soft cloth	Moderate scrubbing with brush or hands
Evaporation/ drying time	Evaporates quickly (5-10 minutes)	Dries moderately fast (15-30 minutes)	Evaporates quickly (5-10 minutes)	Depends on fabric and drying method
Safety	Flammable, use with caution and good ventilation	May contain harsh chemicals, follow product instructions	Flammable, use with caution and good ventilation	Generally safe, but test on inconspicuous area first
Fabric suitability	Works well on most fabrics, but test first on delicate fabrics	Check product label for fabric compatibility	Works well on most fabrics, but test first on delicate fabrics	Suitable for washable fabrics

Table 1: Comparison of Different Solvents for Stain Removal

5 Specifications

5.1 Energy Specifications

Roller	Maximum Operating Voltage	36 V
	Maximum Current rating (per channel)	600 mA
Sprinkler	Relay Module Voltage	5 V
	Battery Voltage	9 V
	Water Pump Voltage	12 V
Dryer	Operating Voltage	220 V

Table 2: Energy specifications for the Model

5.2 Space Specifications

Frame (3mm sheet)	Height	20 cm
	Length	75 cm
	Width	2 cm
	Arc radius of the corners	9 cm
Roller	Height from ground	21 cm
	Length	30 cm
	Diameter	8 cm
Box	Length	75 cm
	Height	10 cm
	width	30 cm
Wall	Height	20 cm
	Length	75 cm
	Width	30 cm
Scrubber	Length	18 cm
	Width	3 cm
Fan	Diameter	3 inches

Table 3: Space specifications for the Model

5.3 Power Specifications

Roller	Power Rating	21.6 W
Sprinkler	Power Rating	18 W
Dryer	Actual machine requirement	4-6 KW
	For Prototype	1 - 2 KW

Table 4: Power specifications for the Model

5.4 Cost Specifications

Roller	Prototype Average Cost	200 INR
Sprinkler	Arduino	2500 INR
	Nozzle	500 INR
	Resistors	1 - 2 INR
	Breadboard	90 INR
	Relay Module	50 INR
	Connecting Wires	15 INR
	Pipe (2-3 meters)	200 INR
	Solvent Pump	200 INR
Scrubber	Cost per meter	300-400 INR
	No of scrubbers	2 - 4
Dryer	Actual Machine Cost	1,00,000 INR
	Prototype cost	800 INR

Table 5: Cost specifications for the Model

5.5 Performance Specifications

Roller

- Rolling Capacity: ∼60-80 meters/min.
- Rewind Diameter: 1.8-2 meters.
- The driver module for the prototype can be used simultaneously by other motors in the system.
- The cost of the actual machine can be reduced significantly because it would be integrated with other components.
- If a small DC motor is used, a no-load speed of ∼9000 rpm, and a loaded speed of ∼5000 rpm can be achieved in the prototype.

Soap Water Sprinkler

- HCSR04 Ultrasonic Sensor will check if there is any object placed before the dispenser. A solenoid valve will be used to control the flow of water by energising and deenergising.
- Arduino controls the operation of the water pump. It also controls the flow rate and directions of water.

Scrubber

- Stationary scrubbers/brushes remain fixed during operation, providing a stable cleaning surface.
- The static design allows for controlled and targeted cleaning of fabrics, ensuring uniform and effective removal of dirt and contaminants.

Dryer

- Control Mechanism: Arduino, a temperature sensor (thermocouple), a relay module, battery and bunch of connecting wires will be used
- Efficiency: Most efficient counter current configuration will be used
- Power requirements will be optimized on the basis of mathematical modelling and simulations done to observe the humidity content with rate of air flow and power input to heater and blower

5.6 Manpower Specifications

Team	Man Hours
Research Team	82 Hours
Electrical Team	60 Hours
Fabrication Team	13.5 Hours
Documentation Team	127 Hours
Consultant	2 Hours

Table 6: Manpower specifications for the Machine

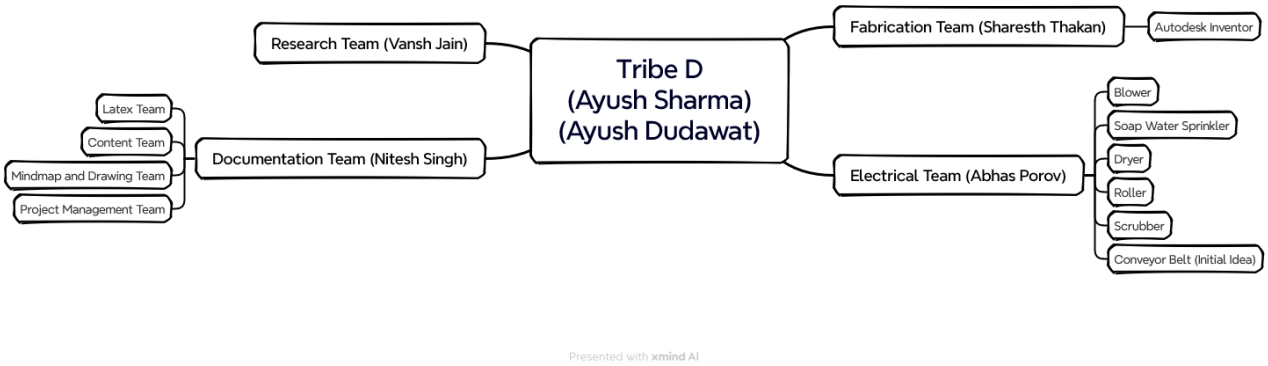


Figure 19: Work distribution mind map

5.7 Milestone Specifications

Phase 1 (25 marks) (25% completed)

1. Outline and ideation of the initial design based on the initial requirements of the client. Discussion of the initial design with the whole team, looking for solutions to the loopholes suggested by the team to make it feasible in the real world. (6 marks)

2. Empirical research on various solvents and cleaning agents like isopropyl alcohol, WD40, acetone, dishwashing liquid (vim drop), detergent, and vanish stain remover by application on the cloth, and finalizing the best solvent. (6 marks)

3. Scraping of the previous idea due to some last-minute changes and ideation of the new design based on the revised requirements of the client. (6 marks)

4. Validation of our idea with Fabrication and Electrical Teams and making on-site visits to find facilities to build our final product. (4 marks)

5. Discussion of the new idea with the consultant and incorporating the changes suggested by them to finalise the idea. (3 marks)

TRL 2: Outlining the proposed design, learning skills, and formation of a team indicates the initiation of the project. The use of AutoCAD for basic visualization enhances the maturity by translating ideas into tangible forms, although it's still in the early stages of development involving ideation and conceptualization.

Phase 2 (25 marks) (50% completed)

1. Realisation of the components required in the design by using a basic CAD model incorporating specifics such as dimensions and placement of every minor component within the model Incorporating information about the dimensions and positions of all the minor components within the model - (10 marks).

   Frame is curved from corners with arc radius = 9cm for smooth flow of cloth over it.

Frame (3mm sheet)	Height	20 cm
	Length	75 cm
	Width	2 cm
	Arc radius of the corners	9 cm
Roller	Height from ground	21 cm
	Length	30 cm
	Diameter	8 cm
Box	Length	75 cm
	Height	10 cm
	width	30 cm
Wall	Height	20 cm
	Length	75 cm
	Width	30 cm
Scrubber	Length	18 cm
	Width	3 cm
Fan	Diameter	3 inches

Table 7: Dimensions of the Model

2. Conducting trial and error checks on the code and activating the motors through iterative testing to ensure precise and effective control over the motorised components.(8 marks)

3. Finalising the items required for building the prototype model and sending the procurement list to the vendor. (7 marks)

TRL 3: Realizing components, conducting trial and error checks on the code, purchasing required materials, and finalizing the design using 'FreeCAD' signify a transition from the early stages to a more mature state. The culmination of these activities indicates a significant advancement in technology readiness, approaching the stage where it can be practically implemented.

Phase 3 (25 marks) (75% completed)

1. Concluding the circuits and codes for the components.(5 marks)

2. Individual Component realisation (20 marks)

Components	Specifications	Marks
Rollers (2 in number)	Both move clockwise (at the same speed to keep the cloth taut at all times) one to unroll the cloth towards the machine and the other to roll the cloth onto itself after the cleaning process	2
DC BO Motors operation (3 in number)	To control the rotation of rollers and the cloth at constant speed	3
Main frame	The cloth comes from the roller, hangs on it and falls on either side	3
Water sprinkler	Aquarium pipes ooze out water onto the edges of the cloth.	0.5
Soap sprinklers	Located just above the scrubbers, they are similar to water sprinklers but ooze out soap solution instead.	0.5
Solvent Dispenser and water pump operation	To control the dispensing of water and soap from sprinklers, it is essential to regulate the operation of the pumps using an Arduino controlled circuit.	3

Table 8: Marks distribution for Phase 3

Scrubber (4 in number, 2 on each side)	The scrubbers are placed close to the main frame with gaps between them. They are stationary and the moving cloth's edges rub past it (against the middle part), thus cleaning them.	1
Fans (2 in number, 1 on each side)	Constituting the final step, they are placed at a fair distance from the middle part, so as to not rip the cloth off, but dry the cloth to finally roll it back up.	1
DC 555 Motor operation (3 in number)	To regulate the operation of the dryer motors (fans), ensuring efficient flow of air onto the fabric for effective drying.	2
Tub	Placed under the machine in the section of water and soap sprinklers, to collect the water and drain it off.	1
Water and soap solution tanks(bucket)	The water and soap sprinklers take respective solution from this to sprinkle on the cloth.	1
Zero Board	Realisation of the circuits used in controlling the electrical components of the prototype by making the essential connections through soldering.	2

Table 9: Marks distribution for Phase 3

TRL 4: Demonstrating fully functional components to the client, finalizing circuits and codes, and providing detailed specifications represent a high level of maturity. This milestone is marked by a readiness for deployment, with working components and comprehensive documentation that can lead to the assembly of a full prototype.

Phase 4 (25 marks) (100% completed)

1. Assembling all the different components to make a full working Prototype.(9 marks)
2. The following things can be expected to be assured in the model:(8 marks)
    a. For the CAD model-(4 marks)
        i. A detailed CAD model on Autodesk Inventor showing positioning of the parts of the fabric-cleaning machine.(2 marks)
        ii. Circuits showing a general idea of where and how the motors and other components are included.(2 marks)
    b. Fabrication assurances -(4 marks)
        i. Ensuring the seamless operation of all components, such as Scrubber and rollers, in the Prototype model designed for uninterrupted cloth processing.

3. Listing out electrical limitations -

    a. As motors necessitate a direct current Current (DC) power supply, we will employ a regulated power supply to demonstrate the functionality of our prototype.

    b. Considering that the electrical connections are not very complicated and do not demand the use of a printed circuit board (PCB), we plan to implement the circuit using a zero board and establish the essential connections through soldering.

    c. To achieve proper working of DC motors, a requisite power supply voltage not exceeding 12 volts is necessary, along with conductive wires having a current rating of 2 A.

4. Prototype Limitation- The expected cloth obtained after undergoing the process is not sufficiently dry due to the use of cold air blowers rather than hot air owing to the length/power constraints.

5. Conducting a live demonstration for the client using a sample cloth with edges stained with oil and grease to simulate a just-manufactured cotton cloth, followed by an assessment of the model's performance based on the quality of cleaning. (8 marks)

TRL 5: Assembling all components into a working Prototype, conducting a live demonstration using a sample cloth, and assessing performance in real-world conditions with actual stains indicate a high level of readiness for practical application and deployment. The technology has progressed to the point where it can be reliably demonstrated and evaluated in real-world scenarios, signalling a mature state.

List of Tables

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Abbreviations

Abbreviation	Stands For
IF	Involvement Factor
ID	Identification
CPCB	Central Pollution Control Board
mg	Milligram
AC	Alternating Current
dB	Decibals
Kg	Kilograms
ABS	Acrylonitrile Butadiene Styrene
PWM	Pulse Width Modulation
IC	Integrated Circuits
PCE	perchloroethylene
TCE	Trichloroethylene
TRL	Technology Readiness Level
CAD	Computer Aided Design
NMOS	N-type Metal-Oxide-Semiconductor
LED	Light Emitting Diode
TCE	Tri-Chloro-Ethane
PCE	Power Conversion Efficiency

Table 10: Abbreviations

Our Tribe

Table 11: Team Members list 1

SNo.	Name	Roll No.	Position	Email	IF
1	Ayush Dudawat	2021EE10694	Tribe Coordinator	ee1210694@ee.iitd.ac.in	1
2	Ayush Sharma	2021MT10244	Tribe Coordinator	mt1210244@maths.iitd.ac.in	1
3	Nitesh Singh	2021MT10250	Documentation Coordinator	mt1210250@maths.iitd.ac.in	1
4	Vansh Jain	2021MT10234	Research Coordinator	mt1210234@maths.iitd.ac.in	1
5	Sharesth Thakan	2021EE30730	Fabrication and Testing Coordinator	ee3210730@ee.iitd.ac.in	1
6	Abhas Porov	2021EE10781	Electrical and Simulation Coordinator	ee1210781@ee.iitd.ac.in	1
7	Tanisha	2021MT10927	Research	mt1210927@maths.iitd.ac.in	0.6
8	Shreyansh Jain	2021MT10930	Research	mt1210930@maths.iitd.ac.in	0.8
9	Rishika Arya	2021MT10926	Research	mt1210926@maths.iitd.ac.in	1
10	Sarmistha	2021MT10261	Research	mt1210261@maths.iitd.ac.in	1
11	Anshika Prajapati	2021MT60961	Research	mt6210961@maths.iitd.ac.in	1
12	Rupam Kumawat	2021MT60267	Research	mt6210267@maths.iitd.ac.in	1
13	Sakshi Magarkar	2021MT60965	Research	mt6210965@maths.iitd.ac.in	1
14	Aniket Pandey	2021MT60266	Research	mt6210266@maths.iitd.ac.in	1
15	Nancy Kansal	2021MT10905	Research	mt1210905@maths.iitd.ac.in	1
16	Diyvansh Agarwal	2021EE10035	Research	ee1210035@ee.iitd.ac.in	0.9
17	Mukund Aggarwal	2021MT60939	Research	mt6210939@maths.iitd.ac.in	1

Table 12: Team Members list 2

18	Tanishk Singh	2021EE10167	Research	ee1210167@ee.iitd.ac.in	0.6
19	Akshansh Rajora	2021MT10933	Research	mt1210933@maths.iitd.ac.in	0.6
20	Ayush Madhur	2021EE10161	Research	ee1210161@ee.iitd.ac.in	0.6
21	Keshvi Tomar	2021EE10682	Research	ee1210682@ee.iitd.ac.in	0.9
22	Kanak Kumar Singh	2021EE10163	Research	ee1210163@ee.iitd.ac.in	0.6
23	Aravind Udupa	2021MT60940	Research	mt6210940@maths.iitd.ac.in	1
24	Arpit Rathore	2021MT10920	Research	mt1210920@maths.iitd.ac.in	1
25	Vandit Srivastava	2021EE10640	Electrical	ee1210640@ee.iitd.ac.in	1
26	Ankita Meena	2021EE10173	Electrical	ee1210173@ee.iitd.ac.in	1
27	Aditya Gupta	2021EE30713	Electrical	ee3210713@ee.iitd.ac.in	1
28	Aditya Bhalotia	2021EE30698	Electrical	ee3210698@ee.iitd.ac.in	1
29	Ayush Shrivastava	2021EE10632	Electrical	ee1210632@ee.iitd.ac.in	1
30	Harshit Nagar	2021EE10155	Electrical	ee1210155@ee.iitd.ac.in	1
31	Shreyansh Jaiswal	2021EE10154	Electrical	ee1210154@ee.iitd.ac.in	1
32	Akshar Tripathi	2021EE10980	Electrical	ee1210980@ee.iitd.ac.in	1
33	Muskan Yadav	2021EE10686	Electrical	ee1210686@ee.iitd.ac.in	1
34	Pavan Bharadwaj	2021EE10630	Electrical	ee1210630@ee.iitd.ac.in	1
35	Aluka Mokshavi	2021MT10909	Electrical	mt1210909@maths.iitd.ac.in	1
36	Palle Sathvika	2021MT10928	Electrical	mt1210928@maths.iitd.ac.in	1
37	Shubham Anand	2021EE10674	Electrical	ee1210674@ee.iitd.ac.in	1
38	Kumar Sanu Singh	2021EE31213	Electrical	ee3211213@ee.iitd.ac.in	1
39	Rahul Kumar	2021MT10893	Fabrication	mt1210893@maths.iitd.ac.in	1
40	Manav Garg	2021EE30017	Fabrication	ee3210017@ee.iitd.ac.in	1
41	Kushagr Goyal	2021EE10634	Fabrication	ee1210634@ee.iitd.ac.in	1
42	Champak Swargiary	2021MT10263	Fabrication	mt1210263@maths.iitd.ac.in	1
43	Ajay Naik	2020MT60888	Fabrication	mt6200888@maths.iitd.ac.in	0.5
44	Aryan Sharma	2021EE10141	Fabrication	ee1210141@ee.iitd.ac.in	0.5

Table 13: Team Members list 3

45	Vadlapudi Manoj	2021MT10245	Documentation	mt1210245@maths.iitd.ac.in	1
46	Bhavik Garg	2021EE10657	Documentation	ee1210657@ee.iitd.ac.in	1
47	Ishu	2021EE30735	Documentation	ee3210735@ee.iitd.ac.in	1
48	Alvakonda Sashidhar	2021EE30744	Documentation	ee3210744@ee.iitd.ac.in	1
49	Harshdeep Shakya	2021EE30745	Documentation	ee3210745@ee.iitd.ac.in	1
50	Abhinava Anwesha Mohanty	2021EE10136	Documentation	ee1210136@ee.iitd.ac.in	1
51	Atishay Aggarwal	2021MT60941	Documentation	mt6210941@maths.iitd.ac.in	1
52	Srinath K S	2021MT10912	Documentation	mt1210912@maths.iitd.ac.in	1
53	Kshitij K Gautam	2021MT60269	Documentation	mt6210269@maths.iitd.ac.in	1
54	Chandan Kumar	2021MT60268	Documentation	mt6210268@maths.iitd.ac.in	1
55	Naunidh Singh	2021MT60956	Documentation	mt6210956@maths.iitd.ac.in	1
56	Vipul	2021EE30731	Documentation	ee3210731@ee.iitd.ac.in	1
57	Amit Singh	2021MT10921	Documentation	mt1210921@maths.iitd.ac.in	1
58	Sumanth Mandala	2021EE10153	Documentation	ee1210153@ee.iitd.ac.in	1
59	Prabhat Babu	2021MT10255	Documentation	mt1210255@maths.iitd.ac.in	1

Tribe Members with IF less than 1

Table 14: Team Members with IF <1

1	Tanisha	2021MT10927	Research	mt1210927@maths.iitd.ac.in	0.6
2	Shreyansh Jain	2021MT10930	Research	mt1210930@maths.iitd.ac.in	0.8
3	Diyvansh Agarwal	2021EE10035	Research	ee1210035@ee.iitd.ac.in	0.9
4	Tanishk Singh	2021EE10167	Research	ee1210167@ee.iitd.ac.in	0.6
5	Akshansh Rajora	2021MT10933	Research	mt1210933@maths.iitd.ac.in	0.6
6	Ayush Madhur	2021EE10161	Research	ee1210161@ee.iitd.ac.in	0.6
7	Keshvi Tomar	2021EE10682	Research	ee1210682@ee.iitd.ac.in	0.9
8	Kanak Kumar Singh	2021EE10163	Research	ee1210163@ee.iitd.ac.in	0.6
9	Ajay Naik	2020MT60888	Fabrication	mt6210888@maths.iitd.ac.in	0.5
10	Aryan Sharma	2021EE10141	Fabrication	ee1210141@ee.iitd.ac.in	0.5

Reason: Assigned tasks were not completed, Low participation in most of the meetings even after multiple reminders on the group. No inputs were given for the research stage. No role in CAD model designing

Project Management

Network Chart

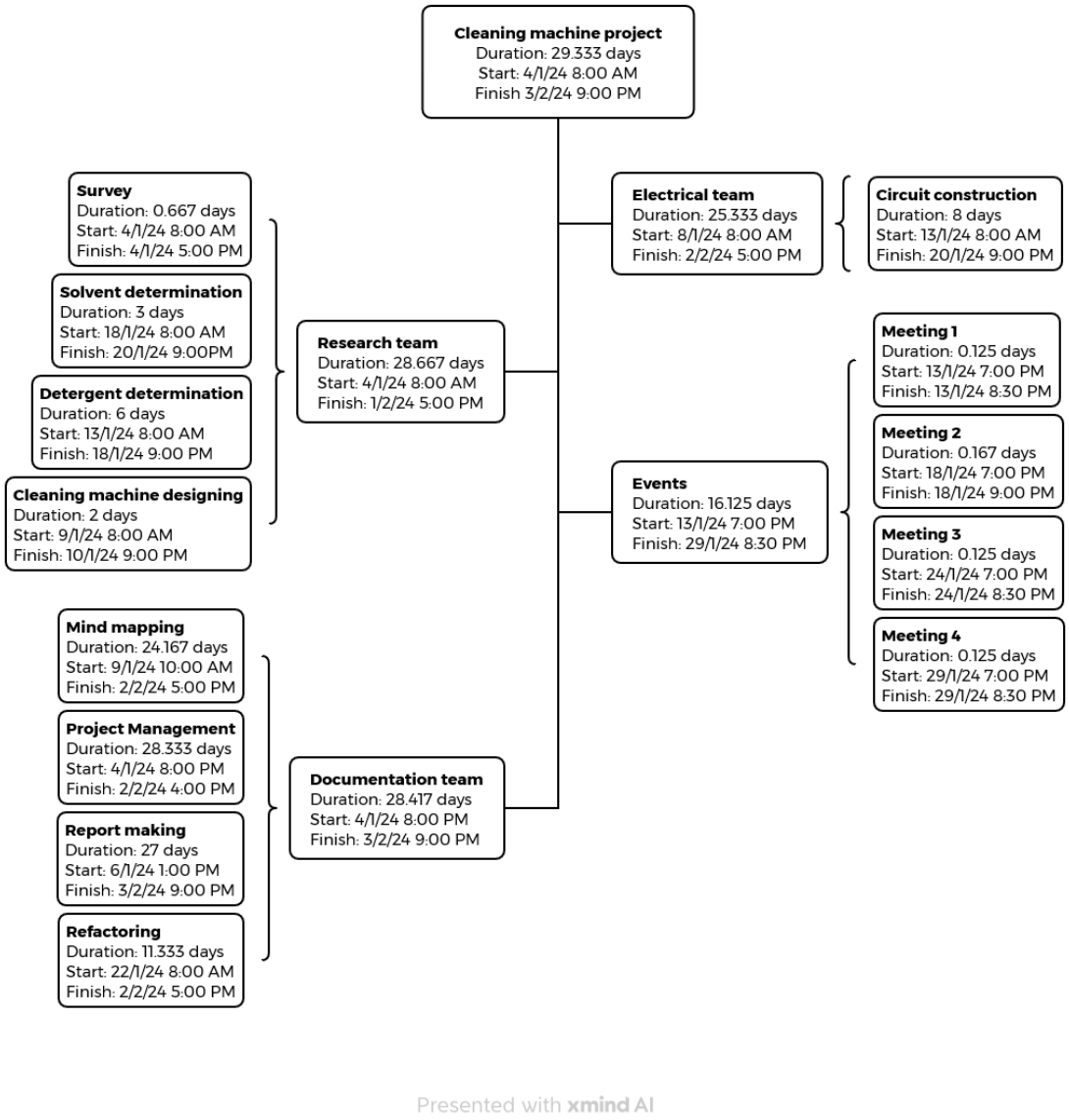


Figure 20: Network Chart

WBS

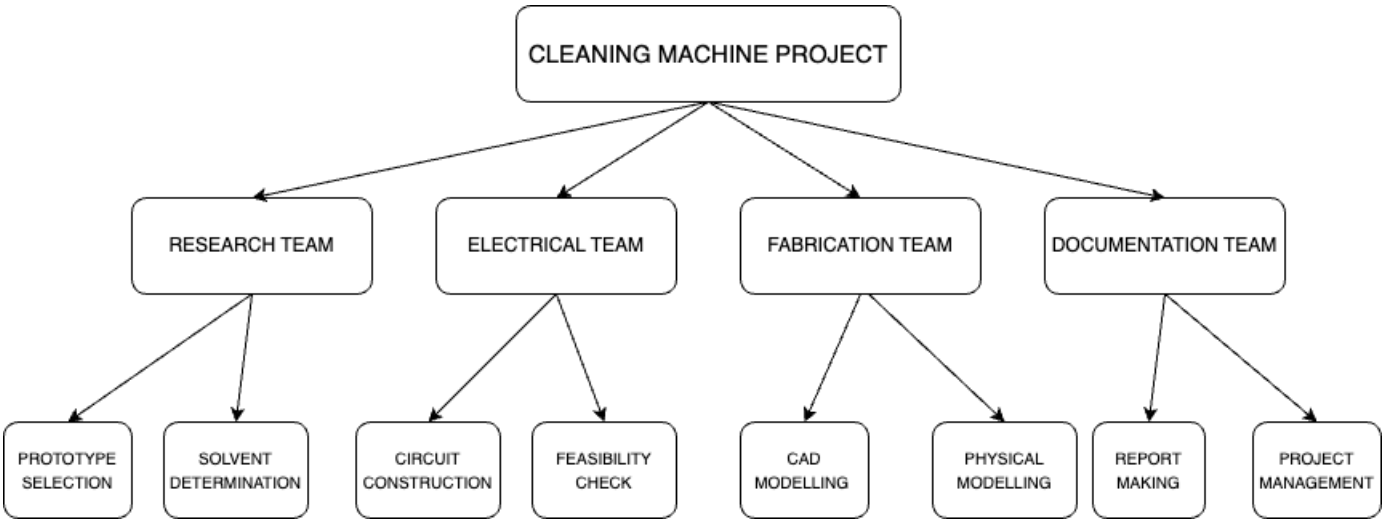
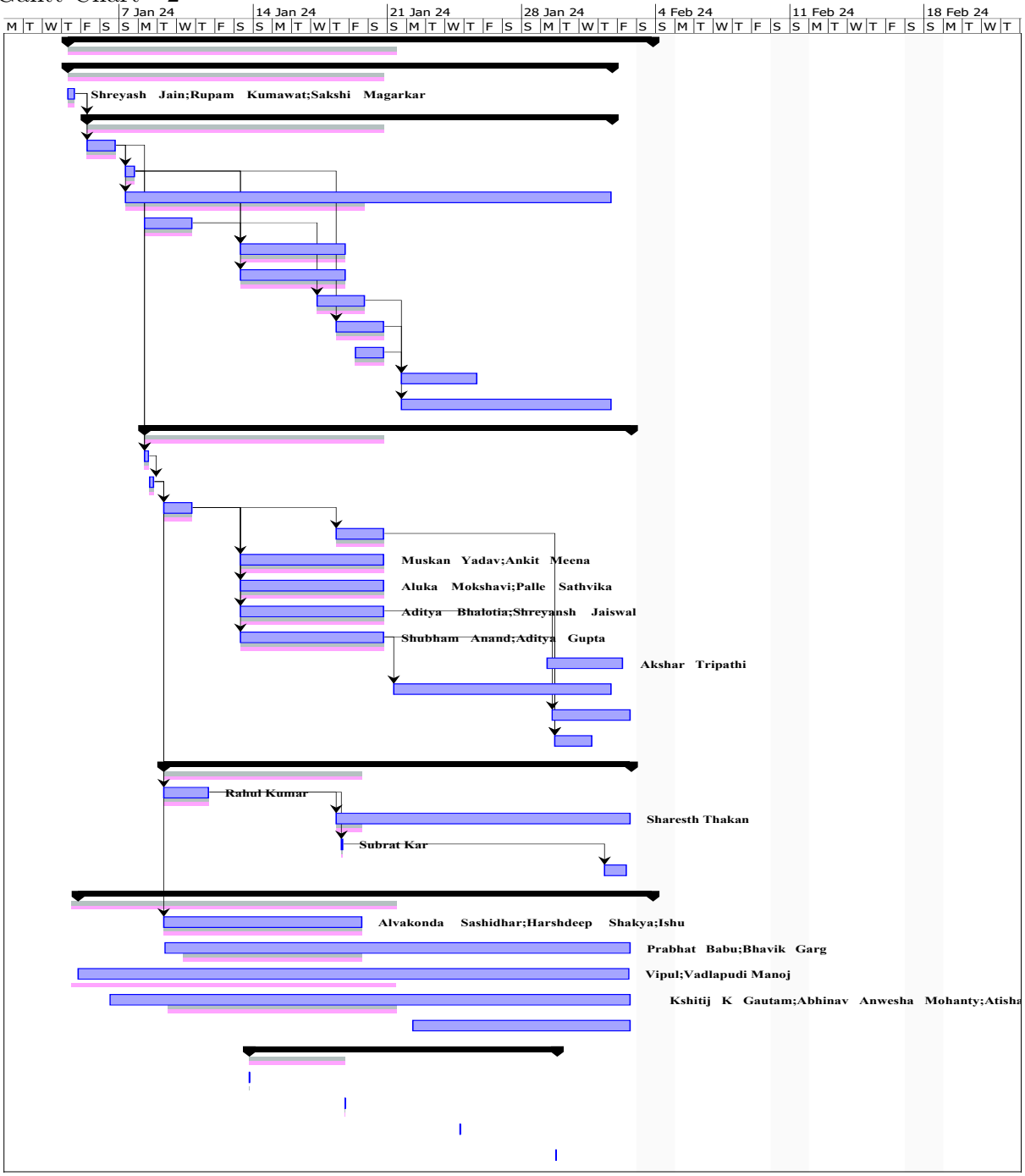


Figure 21: WBS

Gantt Chart

	Name	Duration	Start	Finish	Resource Names
1	**CLeaning Machine Project**	**29.333 day...**	**4/1/24 8:00 AM**	**3/2/24 9:00 PM**	
2	**Research Team**	**28.667 day...**	**4/1/24 8:00 AM**	**1/2/24 5:00 PM**	
3	Survey	0.667 days?	4/1/24 8:00 AM	4/1/24 5:00 PM	Shreyash Jain;Rupam Kuma...
4	**Research**	**27.667 days**	**5/1/24 8:00 AM**	**1/2/24 5:00 PM**	
5	Prototype Selection	2 days	5/1/24 8:00 AM	6/1/24 9:00 PM	
6	Prototype Finalization	1 day	7/1/24 8:00 AM	7/1/24 9:00 PM	
7	Information Exchange	25.667 days	7/1/24 8:00 AM	1/2/24 5:00 PM	
8	Requirement Doc Creation	3 days	8/1/24 8:00 AM	10/1/24 9:00 PM	
9	Detergent Determination	6 days	13/1/24 8:00 AM	18/1/24 9:00 PM	
10	Scrub Determination	6 days	13/1/24 8:00 AM	18/1/24 9:00 PM	
11	Glossary Prep	3 days	17/1/24 8:00 AM	19/1/24 9:00 PM	
12	Solvent Determination	3 days	18/1/24 8:00 AM	20/1/24 9:00 PM	
13	Time Determination Experiment	2 days	19/1/24 8:00 AM	20/1/24 9:00 PM	
14	Finalization of Solvent	4 days	21/1/24 5:00 PM	25/1/24 5:00 PM	
15	Dimension Finalization	11 days	21/1/24 5:00 PM	1/2/24 5:00 PM	
16	**Electrical Team**	**25.333 day...**	**8/1/24 8:00 AM**	**2/2/24 5:00 PM**	
17	Feasability Check	0.5 days	8/1/24 8:00 AM	8/1/24 3:00 PM	
18	Modification	0.5 days	8/1/24 3:00 PM	8/1/24 9:00 PM	
19	Cleaning Machine Designing	2 days	9/1/24 8:00 AM	10/1/24 9:00 PM	
20	Moters Circuit Construction	3 days	18/1/24 8:00 AM	20/1/24 9:00 PM	
21	Blower Circuit Construction	8 days	13/1/24 8:00 AM	20/1/24 9:00 PM	Muskan Yadav;Ankit Meena
22	Sprinkler Circuit Construction	8 days	13/1/24 8:00 AM	20/1/24 9:00 PM	Aluka Mokshavi;Palle Sathvika
23	Dryer Circuit Construction	8 days	13/1/24 8:00 AM	20/1/24 9:00 PM	Aditya Bhalotia;Shreyansh J...
24	Roller Circuit Construction	8 days	13/1/24 8:00 AM	20/1/24 9:00 PM	Shubham Anand;Aditya Gupta
25	Static Scrubber Finalization	2.667 days	29/1/24 8:00 AM	2/2/24 8:00 AM	Akshar Tripathi
26	Rolling Scrubber Finalization	11.667 days?	21/1/24 8:00 AM	1/2/24 5:00 PM	
27	Dryer Finalization	3.833 days?	29/1/24 3:00 PM	2/2/24 5:00 PM	
28	Roller Finalization	2 days	29/1/24 5:00 PM	31/1/24 5:00 PM	
29	**Fabrication Team**	**24.333 days**	**9/1/24 8:00 AM**	**2/2/24 5:00 PM**	
30	3D Software Modelling	2 days	9/1/24 8:00 AM	11/1/24 5:00 PM	Rahul Kumar
31	CAD Model	8 days	18/1/24 8:00 AM	2/2/24 5:00 PM	Sharesth Thakan
32	Consulatancy	0.167 days	18/1/24 3:00 PM	18/1/24 5:00 PM	Subrat Kar
33	Physical Modelling	1 day	1/2/24 8:00 AM	2/2/24 1:00 PM	
34	**Documentation Team**	**28.417 days**	**4/1/24 8:00 PM**	**3/2/24 9:00 PM**	
35	Content Creation	10.667 days	9/1/24 8:00 AM	19/1/24 5:00 PM	Alvakonda Sashidhar;Harsh...
36	Mind Mapping	24.167 days	9/1/24 10:00 AM	2/2/24 5:00 PM	Prabhat Babu;Bhavik Garg
37	Project Management	28.333 days	4/1/24 8:00 PM	2/2/24 4:00 PM	Vipul;Vadlapudi Manoj
38	Report Making	27 days	6/1/24 1:00 PM	3/2/24 9:00 PM	Kshitij K Gautam;Abhinav An...
39	Refactoring of Previous Doc	11.333 days	22/1/24 8:00 AM	2/2/24 5:00 PM	
40	**Events**	**16.125 days**	**13/1/24 7:00 PM**	**29/1/24 8:30 PM**	
41	Meeting 1	0.125 days	13/1/24 7:00 PM	13/1/24 8:30 PM	
42	Meeting 2	0.167 days	18/1/24 7:00 PM	18/1/24 9:00 PM	
43	Meeting 3	0.125 days	24/1/24 7:00 PM	24/1/24 8:30 PM	
44	Meeting 4	0.125 days	29/1/24 7:00 PM	29/1/24 8:30 PM	

Gantt Chart - 2



Resource Breakdown

	Name	RBS	E-mail Address	Standard Rate
1	**Research Team**			Rs.0.00/hour
2	Vansh Jain		mt1210234@iitd.ac.in	Rs.0.00/hour
3	Shreyash Jain	koreascience.kr	mt1210231@iitd.ac.in	Rs.0.00/hour
4	Rupam Kumawat	textilelearner.net	mt6210267@iitd.ac.in	Rs.0.00/hour
5	Sakshi Magarkar	techjut.com	mt6210965@iitd.ac.in	Rs.0.00/hour
6	Tanisha		mt1210927@iitd.ac.in	Rs.0.00/hour
7	Rishika Arya		mt1210926@iitd.ac.in	Rs.0.00/hour
8	Sarmistha Subhadharshini		mt1210261@iitd.ac.in	Rs.0.00/hour
9	Anshika Prajapati		mt6210961@iitd.ac.in	Rs.0.00/hour
10	Nancy Kansal		mt1210905@iitd.ac.in	Rs.0.00/hour
11	Divyansh Agarwal	tinkercad.com	ee1210035@iitd.ac.in	Rs.0.00/hour
12	Mukund Aggarwal		mt6210939@iitd.ac.in	Rs.0.00/hour
13	Tanishk Singh		ee1210167@iitd.ac.in	Rs.0.00/hour
14	Akshansh Rajora		mt1210933@iitd.ac.in	Rs.0.00/hour
15	Aniket Pandey		mt6210266@iitd.ac.in	Rs.0.00/hour
16	Ayush Madhur		ee1210161@iitd.ac.in	Rs.0.00/hour
17	Keshvi Tomer		ee1210682@iitd.ac.in	Rs.0.00/hour
18	Kanak Kumar Singh		ee1210163@iitd.ac.in	Rs.0.00/hour
19	Aravind Uduapa		mt6210940@iitd.ac.in	Rs.0.00/hour
20	Arpit Rathore		mt1210920@iitd.ac.in	Rs.0.00/hour
21	**Electrical Team**			Rs.0.00/hour
22	Abhas Porov		ee1210781@iitd.ac.in	Rs.0.00/hour
23	Muskan Yadav	tinkercad.com	ee1210686@iitd.ac.in	Rs.0.00/hour
24	Ankit Meena	tinkercad.com	ee1210173@iitd.ac.in	Rs.0.00/hour
25	Aluka Mokshavi	circuitdigest.com	mt1210909@iitd.ac.in	Rs.0.00/hour
26	Palle Sathvika	www.instructables.com	mt1210928@iitd.ac.in	Rs.0.00/hour
27	Aditya Gupta	robocraze.com	ee3210713@iitd.ac.in	Rs.0.00/hour
28	Shubham Anand	docs.arduino.cc	ee1210674@iitd.ac.in	Rs.0.00/hour
29	Aditya Bhalotia	zotero.org	ee3210698@iitd.ac.in	Rs.0.00/hour
30	Shreyansh Jaiswal	tandfonline.com	ee1210154@iitd.ac.in	Rs.0.00/hour
31	Vandit Srivastava		ee1210640@iitd.ac.in	Rs.0.00/hour
32	Ayush Shrivastava		ee1210632@iitd.ac.in	Rs.0.00/hour
33	Harshit Nagar		ee1210155@iitd.ac.in	Rs.0.00/hour
34	Akshar Tripathi	polymagtek.com, portescap...	ee1210980@iitd.ac.in	Rs.0.00/hour
35	Pavan Bharadwaj		ee1210630@iitd.ac.in	Rs.0.00/hour
36	Kumar Sanu Singh		ee3211213@iitd.ac.in	Rs.0.00/hour
37	**Fabrication Team**			Rs.0.00/hour
38	Sharesth Thakan	Autocad Inventor	ee3210730@iitd.ac.in	Rs.0.00/hour
39	Rahul Kumar	Autodesk	mt1210893@iitd.ac.in	Rs.0.00/hour
40	Manav Garg	www.rdworkslab.com	ee3210017@iitd.ac.in	Rs.0.00/hour
41	Kushagr Goyal	www.rdworkslab.com	ee1210634@iitd.ac.in	Rs.0.00/hour
42	Champak Swargiary		mt1210263@iitd.ac.in	Rs.0.00/hour
43	Ajay Naik		mt6200888@iitd.ac.in	Rs.0.00/hour
44	Aryan Sharma		ee1210141@iitd.ac.in	Rs.0.00/hour
45	Subrat Kar		subrat@iitd.ac.in	Rs.1200.00/hour
46	**Documentation Team**			Rs.0.00/hour
47	Nitesh Singh	Github	mt1210250@iitd.ac.in	Rs.0.00/hour
48	Vipul	ProjectLibre	ee3210731@iitd.ac.in	Rs.0.00/hour
49	Prabhat Babu	Xmind	mt1210255@iitd.ac.in	Rs.0.00/hour
50	Bhavik Garg	Xmind	ee1210257@iitd.ac.in	Rs.0.00/hour
51	Kshitij K Gautam	overleaf	mt6210269@iitd.ac.in	Rs.0.00/hour
52	Abhinav Anwesha Mohanty	overleaf	ee1210136@iitd.ac.in	Rs.0.00/hour
53	Atishay Aggarwal	AsciiDoc	mt6210941@iitd.ac.in	Rs.0.00/hour
54	Naunidh Singh	AsciiDoc	mt6210956@iitd.ac.in	Rs.0.00/hour
55	Ishu	Vscode	ee3210735@iitd.ac.in	Rs.0.00/hour
56	Alvakonda Sashidhar	Microsoft Word	ee3210744@iitd.ac.in	Rs.0.00/hour
57	Harshdeep Shakya	Microsoft Word	ee3210745@iitd.ac.in	Rs.0.00/hour
58	Vadlapudi Manoj		mt1210245@iitd.ac.in	Rs.0.00/hour
59	Amit Singh		mt1210921@iitd.ac.in	Rs.0.00/hour
60	Srinath K S		mt1210912@iitd.ac.in	Rs.0.00/hour

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Index

Glossary

Arduino Arduino is an open-source electronics platform used for creating interactive electronic projects. . 8

Areal density mass per unit area. 7

Bone-Dry Completely dry, with no moisture remaining.. 1

carcinogen potential to cause cancer.. 18

Controller In this context, a controller is a device that regulates or manages the operation of the dryer. It could involve setting and maintaining specific conditions such as temperature and drying time.. 9

Current The flow of electric charge through a conductor. 29

Denier A unit of measurement for the linear mass density of fibers. It is the mass in grams per 9000 meters of the fiber.. 1

Efficiency The effectiveness of the system in converting input power to useful output power.. 24

Filleted Somewhat stuck to the side or attached to side walls.. 4

Lipase An enzyme the body uses to break down fats.. 17

microcontroller A small computer on a single integrated circuit. 8

Nozzle A device for controlling the direction or flow of a fluid.. 23

Prototype An early model of a product to test concepts. 28, 29

Scrubber A device used for cleaning. 28

Solvent A substance, typically a liquid, capable of dissolving other substances.. i

Sustainable Avoiding depletion of natural resources to maintain ecological balance. 2

Thread Count The number of threads woven together per square inch in a fabric. A higher thread count is generally associated with a finer and more luxurious fabric.. 1

Appendix

Word Count	9749
Number of Sentences	453
Number of Characters(Without Spaces)	51438

Table 15: Document Statistics

Readability (0-100)[1]	72.5
Gunning Fog Index (0-20)[2]	10.2
Flesch Reading Ease (0-100)[3]	53.7
Coleman Liau Index (0-17+)[4]	10.8

Table 16: Readability Indices

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1. Readibility
Score Range: 0-100
Explanation: The Readability (0-100) score, measures how easy or difficult a piece of text is to read. The higher the score, the easier the text is to understand. The score is calculated based on the average sentence length and the average number of syllables per word in the text.
2. Gunning Fog Readability
Score Range: 0-20
Explanation: The Gunning Fog Index estimates the years of formal education needed to understand a piece of text. The higher the index, the more difficult the text is to comprehend. It considers the average sentence length and the percentage of complex words (words with three or more syllables).
3. Flesch Reading Ease
Score Range: 0-100
Explanation: The Flesch Reading Ease score is a measure of how easy or difficult a piece of text is to read. The higher the score, the easier the text is to understand. The formula takes into account the average sentence length and the average number of syllables per word.
4. Coleman Liau Readability Index
Score Range: 0-17+
Explanation: The Coleman Liau Index determines the readability of a text by using characters per word and words per sentence. It provides an estimate of the U.S. school grade level required to comprehend the text. Higher scores indicate more difficult readability.