Tribe D Documentation

ELP305

Design and System Laboratory
Project 1

Week 2 Submission

Submitted to:
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Submitted by:
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Week 2 Report : Requirements and Specifications

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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

Table of contents

1 List of Tables

2 List of Figures

3 List of 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 5 – Abbreviations

4 Mind Map

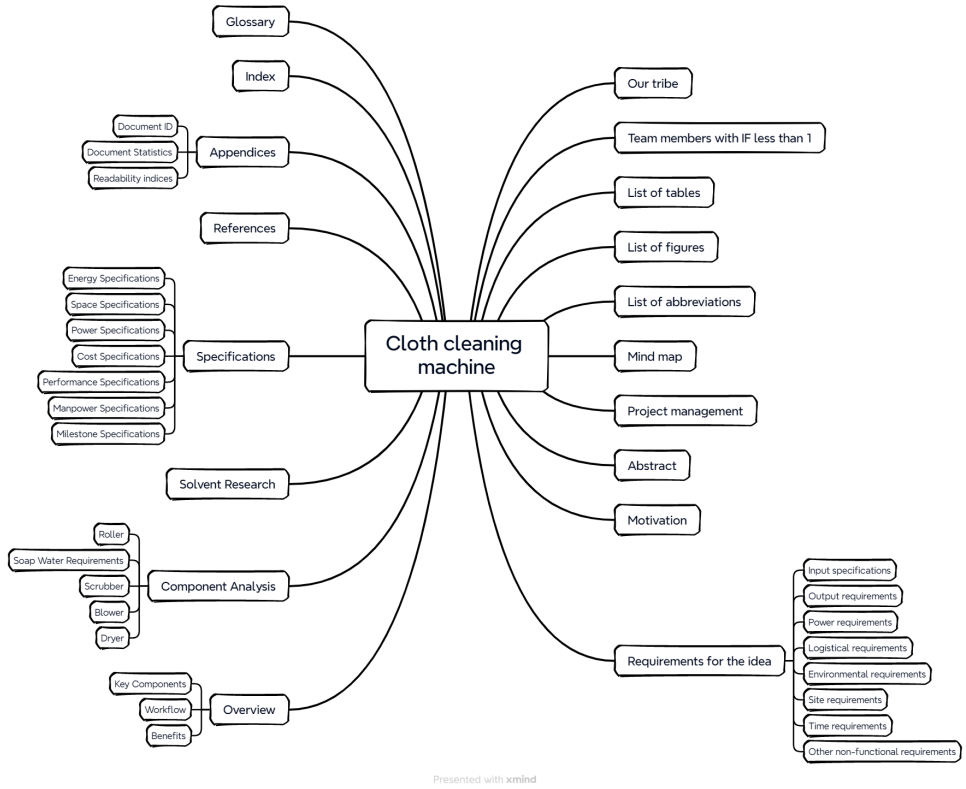


FIGURE 1 – Outline Mindmap

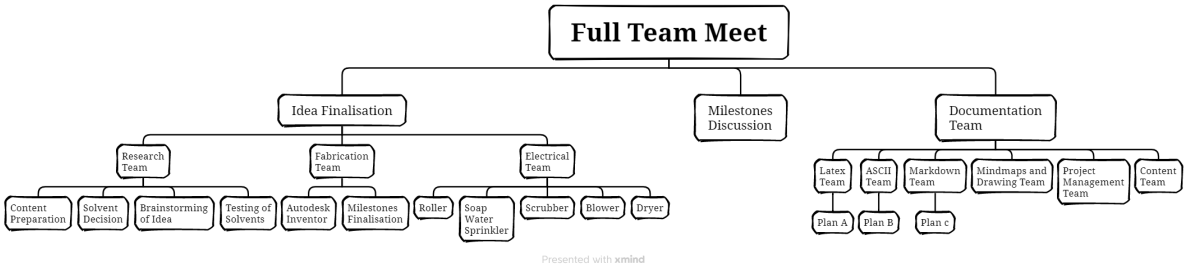


FIGURE 2 – Flowchart

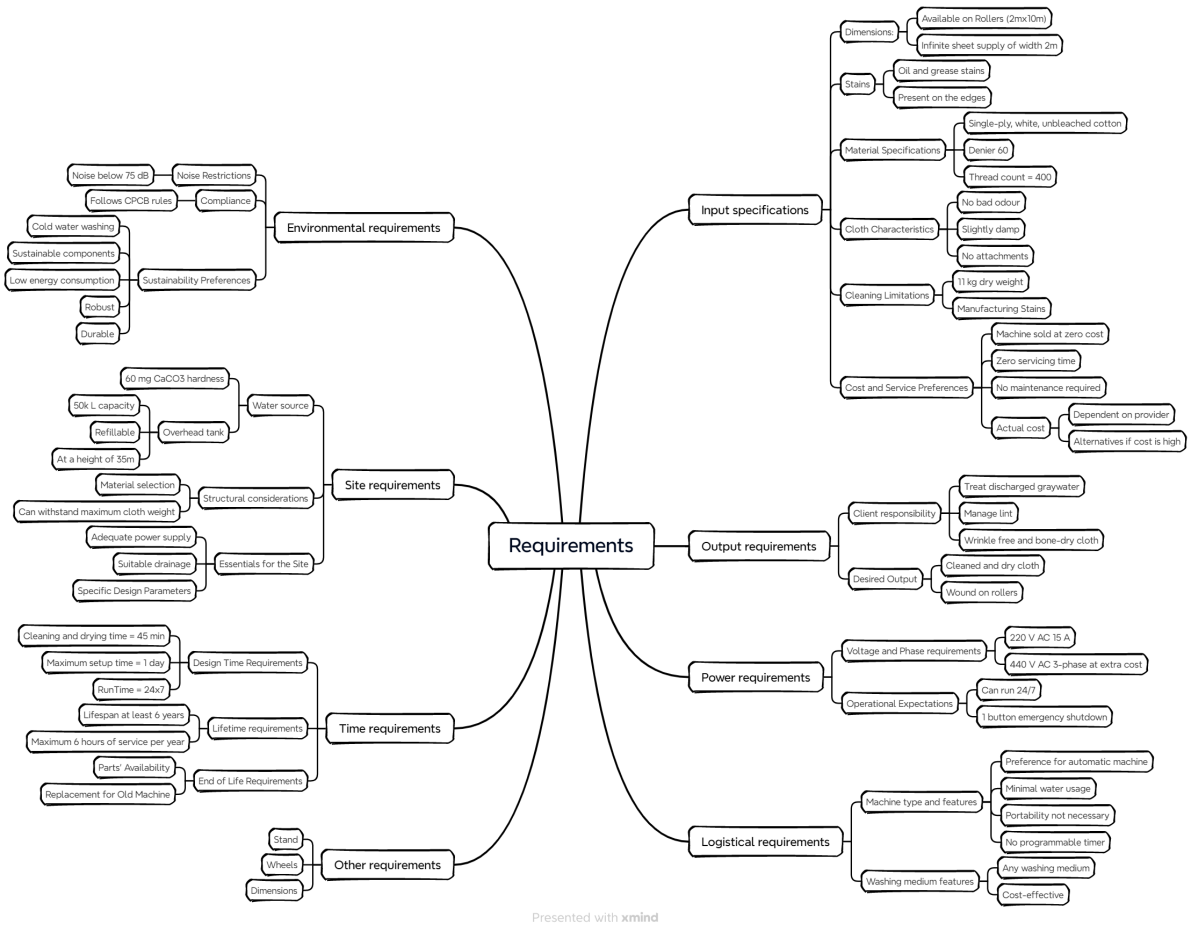


FIGURE 3 – Requirements MindMap

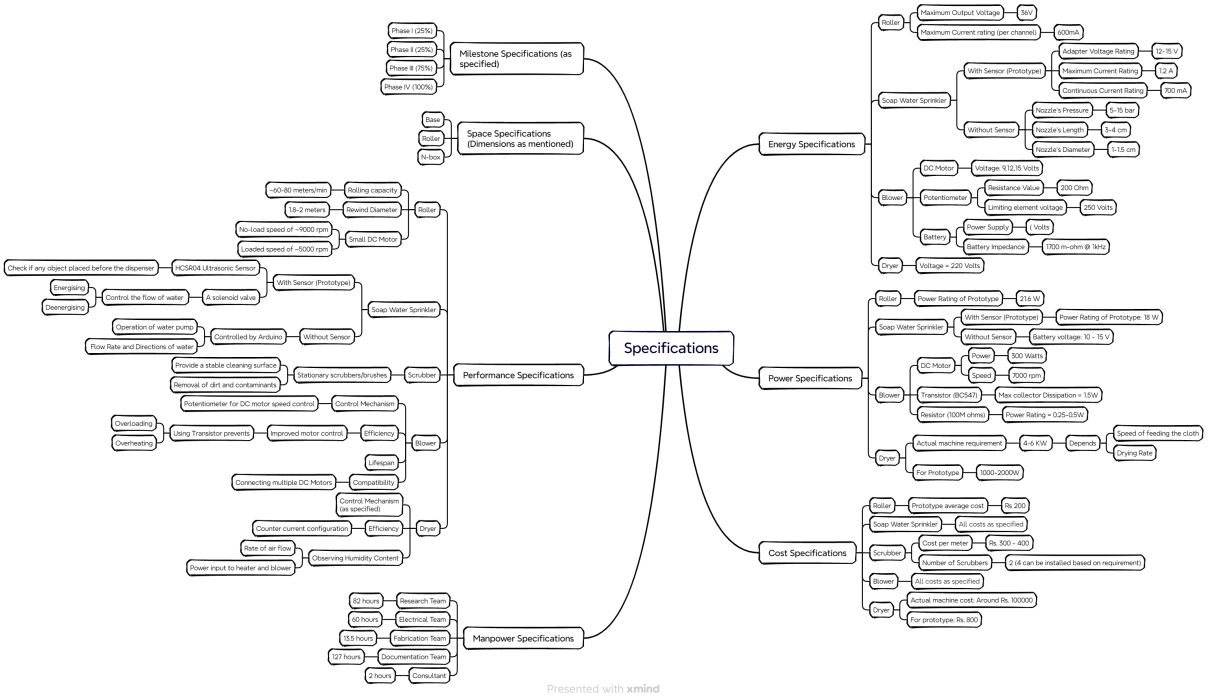


FIGURE 4 – Specifications Mind Map

5 Project Management

- Network Chart
- WBS
- Gantt Chart
- Resource Breakdown

6 Abstract

Cleaning Machine

This project revolves around developing a user-centric washing machine, which involves a comprehensive analysis of the features an average user looks for. Through extensive research, we will identify key elements that resonate with the needs and preferences of the general population when searching for a washing machine.

Our initial design focuses on building a basic model, which in further iterations, can incorporate more advanced features as a result of extensive surveys and research done across the course of the project to satisfy the contemporary users' needs.

7 Motivation

Our goal with this project is to create an advanced fabric-cleaning machine designed to wash oil stains, specifically those near the edges of manufactured cloth. This machine aims to improve the efficiency of cloth manufacturing by providing effective drying and cleaning processes while preserving the fabric. Our design's USP is its ability to leave the areas of the cloth that are already clean untouched, which preserves the fabric's quality and durability. Utilizing this approach helps ensure a straightforward process and reduces the resources required for drying. We currently have an Autodesk model of our machine and have researched various electrical parts and how they will be implemented practically. We have also tested various solvents in an attempt to find one which is most suitable. Finally, we intend to deliver a working model of this machine, which focuses on cleaning oil and grease stains left in cloth during the manufacturing process while focusing more on the edges of the cloth as there are higher chances of deterioration on the periphery.

8 Requirements for the idea

8.1 Input Specifications

8.1.1 Material Specifications :

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

8.1.2 Stains

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

8.1.3 Dimensions :

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

8.1.4 Cloth Characteristics :

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

8.1.5 Cleaning Limitations :

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

8.2 Outputs Requirement

8.2.1 Desired Output :

- A cleaned and dry cloth wound on rollers.

8.2.2 Client Responsibilities :

- Treating discharged greywater , managing lint, and ensuring the returned cloth is wrinkle-free and bone-dry.

8.3 Power Requirements

8.3.1 Voltage and Phase Requirements :

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

8.3.2 Operational Expectations :

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

8.4 Logistical Requirements

8.4.1 Machine Type and Features :

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

8.4.2 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.

8.5 Environmental Requirements

8.5.1 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).

8.5.2 Sustainability Preferences :

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

8.6 Site Requirements

8.6.1 Essentials for the Site :

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

8.6.2 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.

8.7 Time Requirements

8.7.1 Cleaning and Setup Times :

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

8.7.2 Design Time Requirements

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

8.7.3 Time to Market Requirements

8.7.4 LifeTime Requirements

- Expected Lifetime : The machine is expected to last atlest 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.

8.7.5 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.

8.8 Other Non-Functional Requirements

8.8.1 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*10m) or it can be assumed as an infinite sheet supply of width 2 m.

9 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 guiding frame (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.

9.1 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-> soap, next "y" cm-> water, next "x" cm-> 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 air blowers to blow hot air onto the cloth.
   - Ensures quick and effective drying.
7. **Guiding Fixtures**
   - Transition 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.

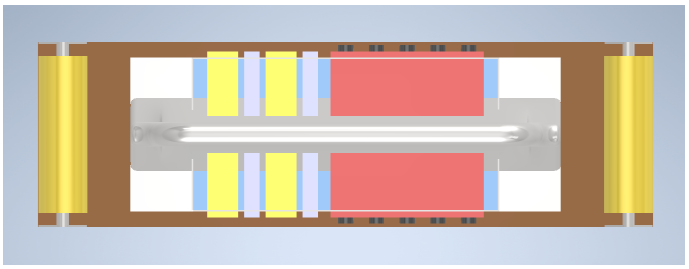


FIGURE 5 – Top View

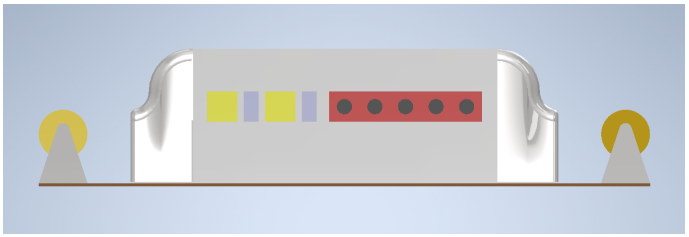


FIGURE 6 – side view

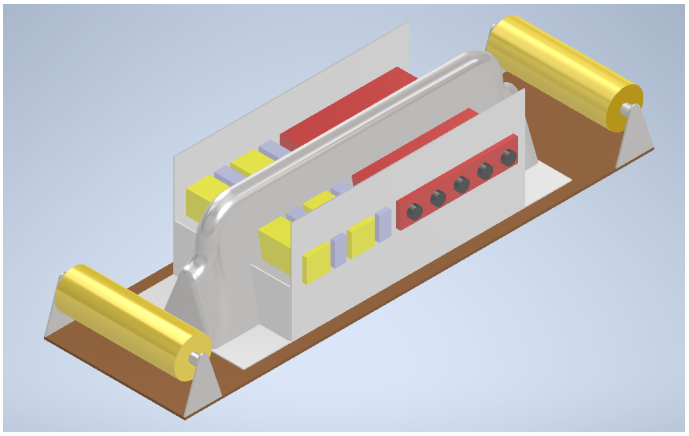


FIGURE 7 – Isometric View

9.2 WorkFlow

- Cloth is loaded onto input rollers over the guiding frame, through the guiding fixtures, 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 as long as the machine 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 to the demonstration but very relevant 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.
- 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.

9.3 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
- 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

10 Component Analysis

10.1 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 8 – (A textile rewinding machine)

10.1.1 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. The higher

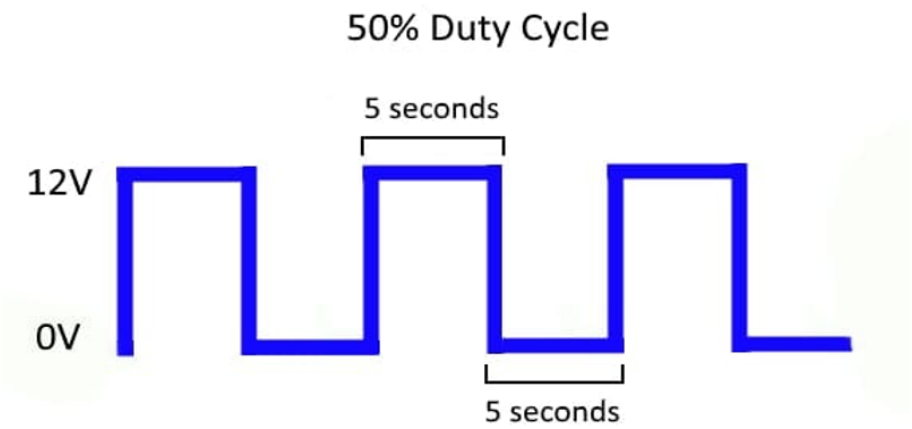


FIGURE 9 – (A square wave with 50% duty cycle)

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).

10.1.2 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.

Click here for arduino code

10.2 Soap Water Requirements

10.2.1 A. For splitted cloth pieces using sensor

Click here for the code reference

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

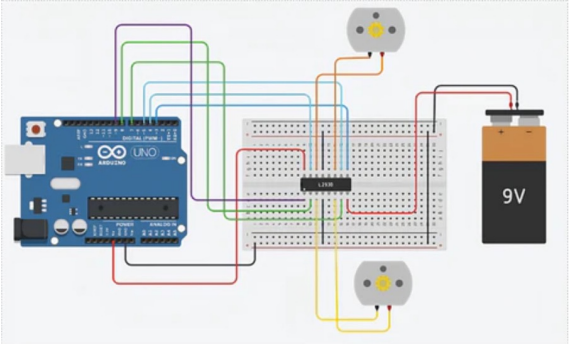


FIGURE 10 – (Sample circuit diagram of motor control)

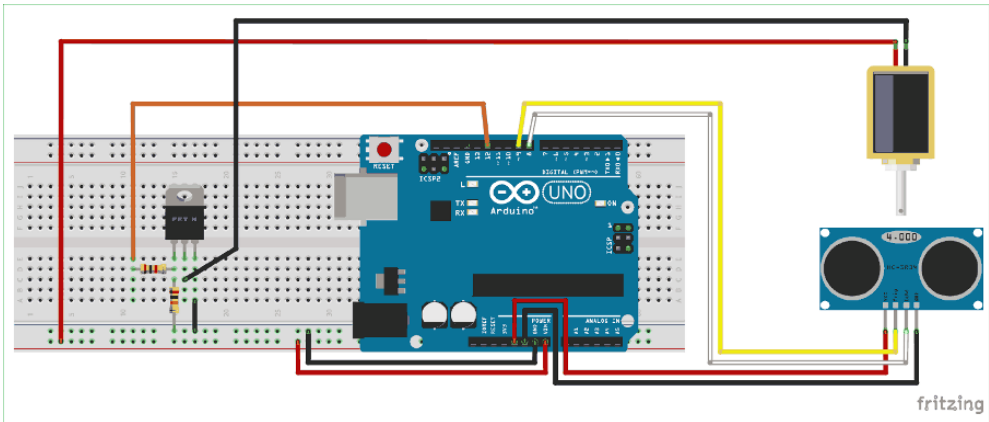


FIGURE 11 – For splitted cloth pieces using sensor

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.

10.2.2 B. Without Sensor, using push button :

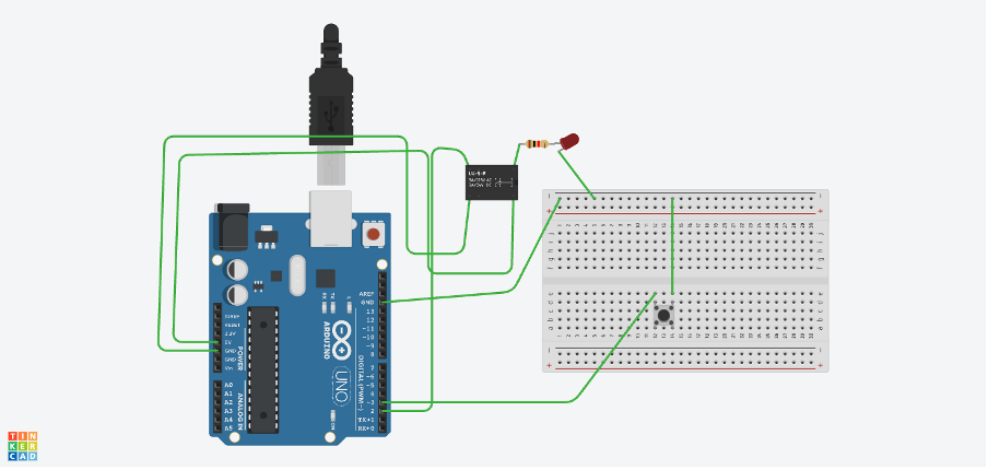
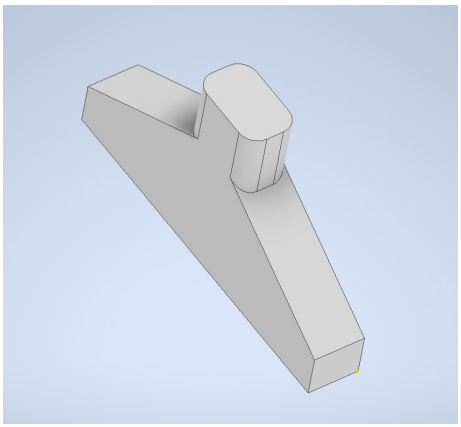


FIGURE 12 – circuit for Using push button

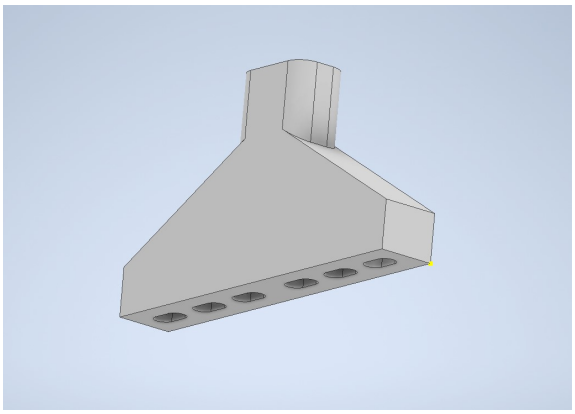
Click here for code reference

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.



(a) Isometric View



(b) Isometric View2

FIGURE 13 – Sprinkler

10.3 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.
- Stattonary brushes would be used near the edges of the cloth.
- Static cleaning mechanism
- Zero power requirement

10.4 Blower

- We will be controlling the speed of the DC motor using a potentiometer for the purpose of a blower in our washing machine to remove heavy dust particles from the cloth piece.
- Potentiometer has three terminals. Outer two terminals are for power supply, and the middle terminal is the output.
- As we rotate the knob of the potentiometer, the resistance between the middle terminal and one of the outer terminals changes. This change in resistance controls the voltage supplied to the motor, which in turn controls its speed.
- We can connect multiple DC motors in our system by making slight modifications in the wiring.
- A Transistor is used for more efficient control of the motor speed. By controlling the current flow to the motor, transistors can prevent overloading and overheating, enhancing the motor's lifespan .

10.4.1 Tinkercad :

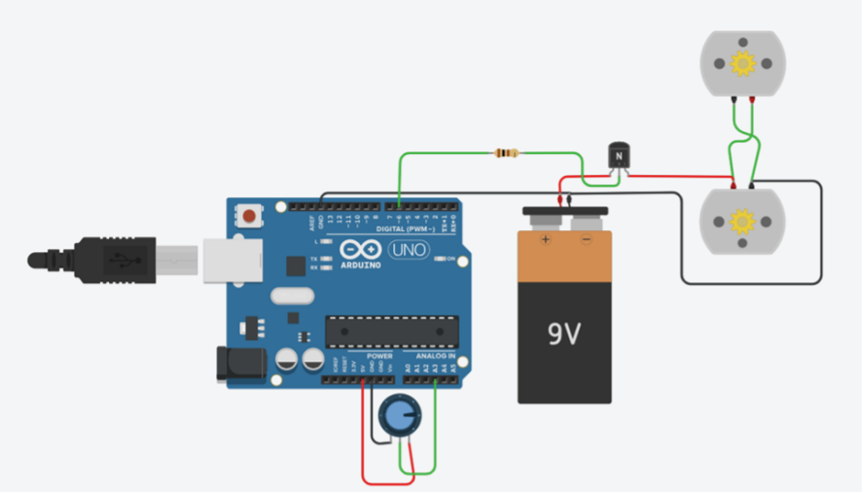


FIGURE 14 – Tinkercad model for blower based on DC motor speed control using potentiometer

Click here for code references

10.5 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

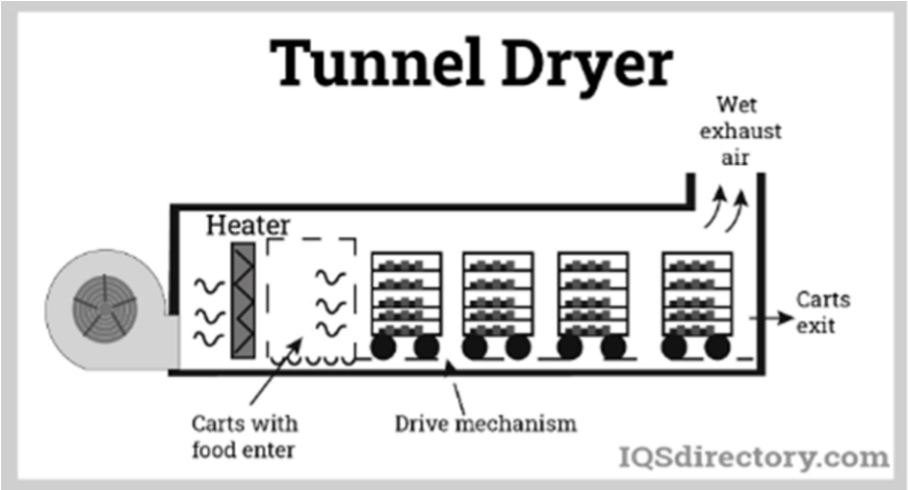


FIGURE 15 – Tunnel Dryer

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

Click here for code reference

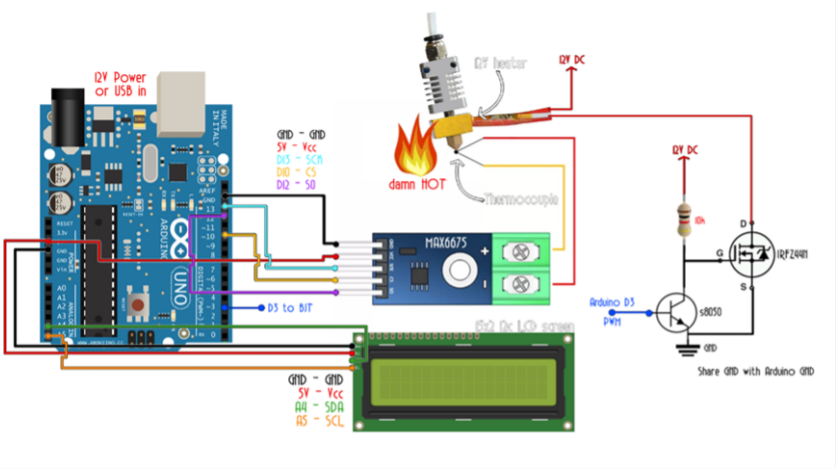


FIGURE 16 – Control circuit for heater

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

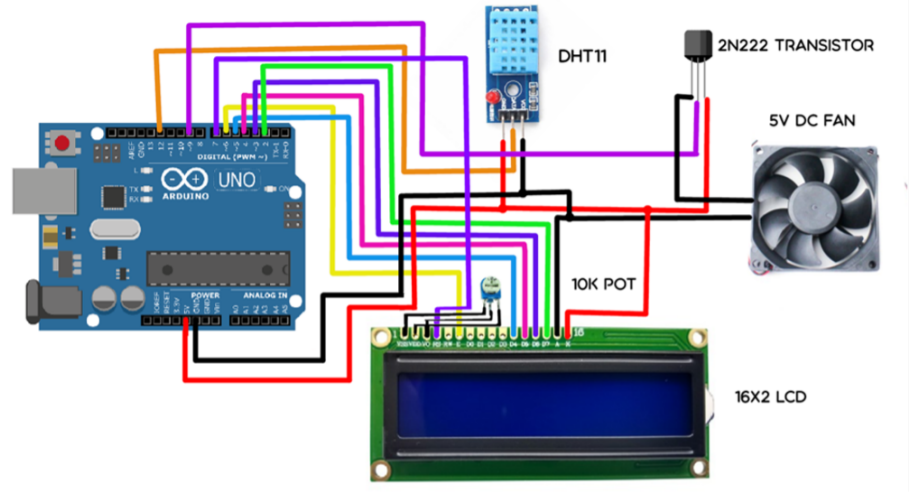


FIGURE 17 – Control Circuit for a DC motor/fan.

Click here for Code references

11 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

11.1 We tested many solvents and the results are as follows :

- **WD-40**

(a) Before (b) After

FIGURE 18 – Application of WD-40

- **Acetone**

(a) Before

(b) After

FIGURE 19 – Application of acetone

- **Dishwash(Vim)**

(a) Before

(b) After

FIGURE 20 – Application of dishwasher(vim)

- **Some more applications**

(a) after applying isopropyl

(b) after using detergent

FIGURE 21 – Image of grease

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 6 – Comparison of Different Solvents for Stain Removal

12 Specifications

12.1 Energy Specifications

Roller

Maximum Operating Voltage	36 V
Maximum Current rating (per channel)	600 mA

Sprinkler

Adapter Voltage Rating	12-15 V
Maximum Current Rating	1.2 A
Continuous Current Rating	700 mA

Blower

DC Motor Voltage	9,12,15 V
Potentiometer Resistance	200 Ohm
Potentiometer Limiting Element Voltage	250 V
Battery Power Supply	1700 mOhm
Battery Frequency	1kHz
Battery Impedance	9 V

Dryer

Voltage	220V

12.2 Space Specifications

Base

Length	100 units
Breadth	30 units

Roller

Diameter	8 units
Length	25 units

N-Box

Length	70 units
Breadth	25 units

12.3 Power Specifications

Roller

Power rating of Prototype	21.6 W

Sprinkler

Wattage	18W

Blower

DC Motor Power	300W
DC Motor Speed	7000RPM
BC547 Max collector Dissipation	1.5W
Resistor (100M ohms) Power Rating	0.25-0.5W

Dryer

Actual machine requirement	4-6 KW
For Prototype	1000-2000W

12.4 Cost Specifications

Roller

Prototype Average Cost	200 Rs

Sprinkler

Arduino	2500 Rs
Nozzle	500 Rs
Resistors	10-20 Rs
Breadboard	90 Rs
Sensors	200 Rs
Connecting Wires	150 Rs
NMOS	70 Rs
Solvent Pump	200 Rs

Scrubber

Cost per meter	300-400 Rs
No of scrubbers	200 Ohm

Blower

Arduino	2550 Rs
Resistor(100 Ohms)	1 Rs
Transistor	1 Rs
Potentiometer	17 Rs
9V battery	300 Rs
DC Motor	260 Rs

Dryer

Actual Machine Cost	100,000 Rs
Prototype cost	800 Rs

12.5 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.

Blower

- Control Mechanism : Potentiometer for DC motor speed control
- Efficiency : Improved motor control using a transistor to prevent overloading and overheating
- Lifespan : Enhanced motor lifespan due to efficient control using the transistor
- Compatibility : Multiple DC motors can be connected with slight wiring modifications

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

12.6 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

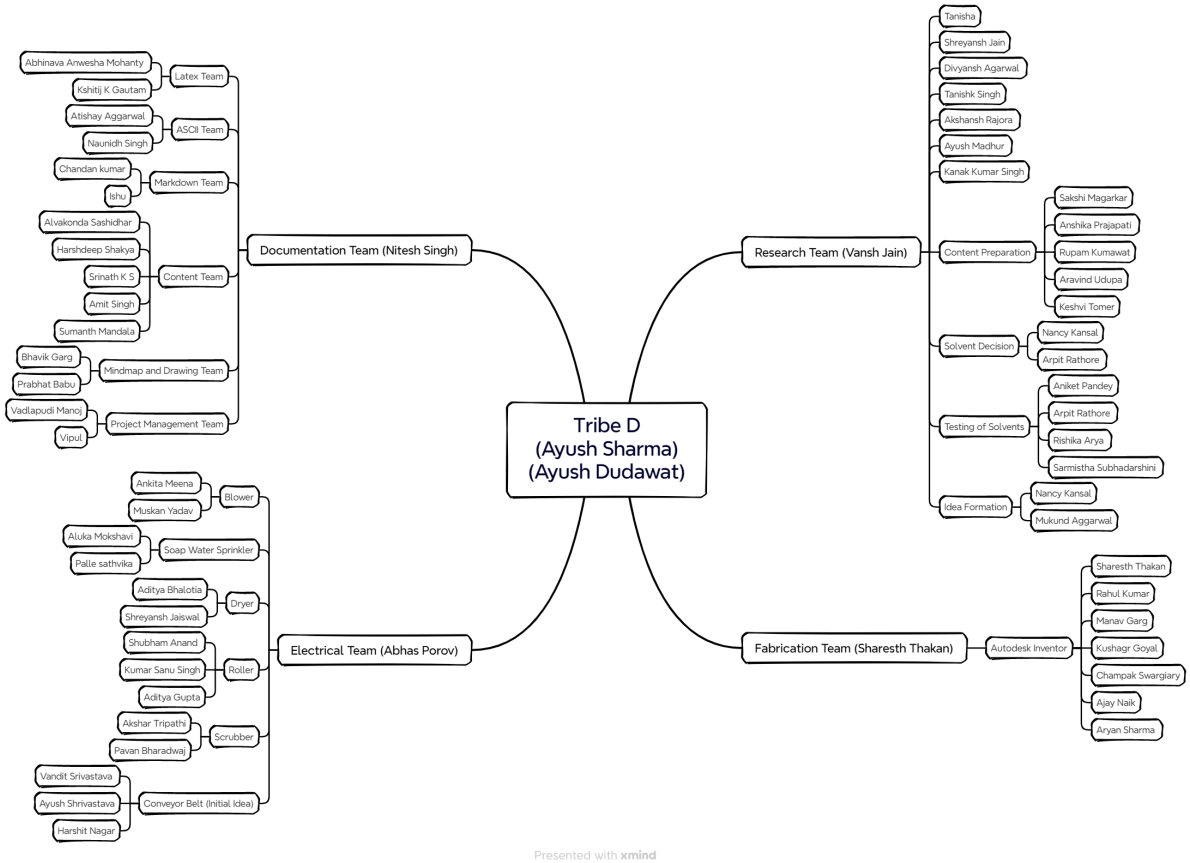


FIGURE 22 – work distribution mind map

12.7 Milestone Specifications

Phase 1 (25%)

1. Outline and ideation of the proposed design.
2. Learning the skills required for the project.
3. Formation and organization of a team for the project.
4. Empirical research on the idea and feasibility of the project.
5. Visualization of the initial theorized model through basic diagrams on AutoCAD.

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 (50%)

1. Realization of the components required in the design.
2. Trial and error checks on the code for the mechanisms.
3. Purchasing the required chemicals and inventory to realize the mechanisms.
4. Testing the chemicals used on the cloth.
5. Finalized design of the visualized model using FreeCAD.

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 (75%)

1. Showing some individual components, which are completely ready and are in working condition, to the client.
2. Finalizing component circuits and codes.
3. Including details (dimensions and location) of all the small parts in the model.

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 (100%)

1. Assembling all the different components together to make a full working prototype.
2. Live demonstration to the client by using a sample cloth with edges stained with oil and grease, to mimic a just-manufactured cotton cloth.
3. Assessment of the model by the quality of cleaning and the time taken.

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, signaling a mature state.

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Index

Glossary

Adapter Voltage Rating This specifies the voltage range for the adapter that provides power to the soap water sprinkler. . 33

Arduino Arduino is an open-source electronics platform used for creating interactive electronic projects. . 41

Areal density mass per unit area. 41

Bone-Dry Completely dry, with no moisture remaining.. 41

Compatibility The ability of the system to work with other components.. 41

Control Mechanism The method used to regulate or manipulate the operation of the system.. 41

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.. 41

Denier A unit of measurement for the linear mass density of fibers. It is the mass in grams per 9000 meters of the fiber.. 41

Efficiency The effectiveness of the system in converting input power to useful output power.. 41

Filleted Somewhat stuck to the side or attached to side walls.. 41

Graywater Domestic wastewater that does not contain fecal matter, often reused for irrigation or other non-potable purposes.. 41

Isometric View A three-dimensional representation of an object, showing all three spatial dimensions in one view.. 41

Lifespan The duration for which the system is expected to operate.. 41

Lipase An enzyme the body uses to break down fats.. 41

Nozzle A device for controlling the direction or flow of a fluid.. 34

Prototype An initial version or model of a product that is used to test and develop the design.. 41

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.. 41

User-Centric Designed with a primary focus on meeting the needs and preferences of users.. 41

Appendix

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Document Authorised by	Ayush Sharma
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Table 7 – Document ID

Word Count :	3453
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Number of Characters(Without Spaces)	19288

Table 8 – Document Statistics

Readability (0-100)	62.5
Gunning Fog Index (0-20)	13.9
Flesch Reading Ease (0-100)	52
Coleman Liau Index (0-17+)	14.33

TABLE 9 – Readability Indices

Readibility
Score Range : 0-100
Explanation : The Readability (0-100) score, specifically the Flesch Reading Ease 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.
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).
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.
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.