ELP 305: Design and Systems Lab

Table of Contents

Week 2 Report

Submitted by: Tribe D (Demantors)

Submitted to: Prof. Subrat Kar

1. Week 2 Report: Requirements + Specifications

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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.

2. Body

2.1. List of Tables (to be updated)

2.2. List of Figures (to be updated)

2.3. List of Abbreviations (to be updated)

Table 1. Some Abbreviations

Abbreviation	**Stands for**
IF	Involvement Factor
ID	Identification
CPCB	Central Pollution Control Board
mg	milligram
AC	Alternating Current
dB	Decibels
Kg	Kilograms
ABS	Acrylonitrile Butadiene Styrene

2.4. Mind Map

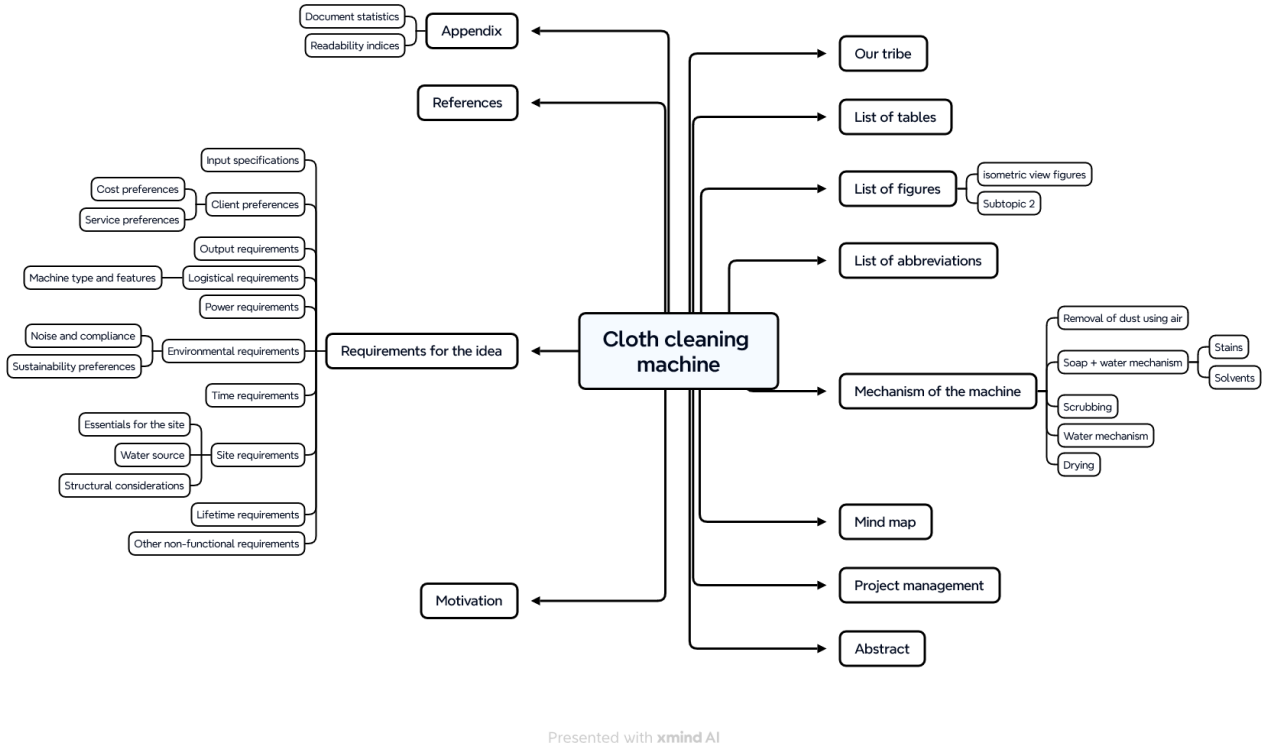


Figure 1. Outline Mind Map

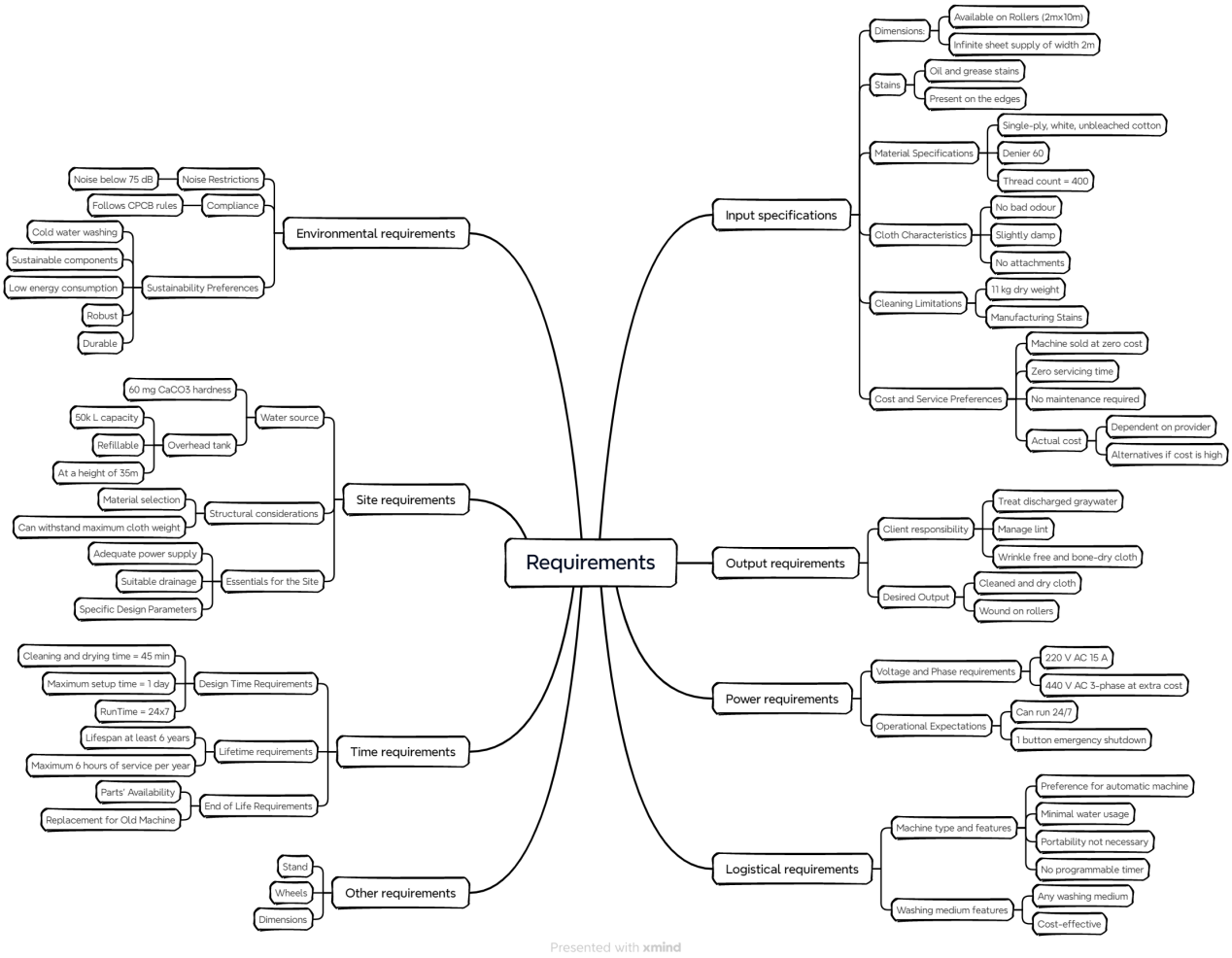


Figure 2. Requirements Mind Map

2.5. Project Management

- Network Chart
- WBS
- Gantt Chart
- Resource Breakdown

2.6. Abstract

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.

2.7. 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.

2.8. Requirements for the Idea

2.8.1. Input Specifications

- **Material Specifications:** Newly manufactured white unbleached cotton with single-ply, Denier 60, and a thread count 400.
- **Dimensions:** Cloth is either available on rollers(2m*10m) or it can be assumed as an infinite sheet supply of width 2 m.
- **Cloth Characteristics:** Free from foul odour, slightly damp, and without buttons, zippers, or attachments.
- **Stain Characteristics:** Only oil and grease stains present on the edges of the cloth need to be removed
- **Cleaning Limitations:** Maximum weight for cleaning is set at 11 kg dry, with stains limited to those occurring during manufacturing.
- **Cost and Service Preferences:** Preference for the washing machine to be offered at zero cost, requiring no servicing time and no maintenance. Actual prices are expected to depend on the provider, with alternatives considered if costs are excessively high.

2.8.2. Outputs Requirements

- **Desired Output:** A cleaned and dry cloth wound on rollers.
- **Client Responsibilities:** Treating discharged graywater, managing lint, and ensuring the returned cloth is wrinkle-free and bone-dry.

2.8.3. Power Requirements

- **Voltage and Phase Requirements:** The washing machine should operate on 220VAC 15A, with

the option for 440VAC 3-phase available at an additional cost.

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

2.8.4. Logistical Requirements

- **Machine Type and Features:** An automatic washing machine is preffered with minimal water usage and no need for portability or a programmable timer.
- **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.

2.8.5. Environmental Requirements

- **Noise Restrictions:** Noise levels should not exceed 75 dB.
- **Compliance:** Must comply with local regulations, including those set by the Central Pollution Control Board (CPCB).
- **Sustainability Preferences:** Preference for cold water washing, sustainable components, and optimization of energy consumption, robustness, and durability.

2.8.6. Site Requirements

- **Essentials for the Site:** Adequate power supply, suitable drainage, and specific design parameters.
- **Water Source:** 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:** Structural considerations include material selection and the ability to withstand the maximum cloth weight.

2.8.7. Time Requirements

Design Time Requirements

- **Cleaning and Drying time:** Atmost 45 minutes.
- **Use Rate:** 24 hours a day 7 days a week with maximum downtime of 6 hours per year
- **Setup Time:** As little time as possible, no more than 1 day.

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.

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.

2.8.8. Other Non-Functional Requirements

- **Miscellaneous Considerations:** Dimensions and the inclusion of a stand or wheels are left to the designer’s discretion.

2.9. 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 surfaces (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 than other approaches.

2.9.1. Key Components:

Rollers with Motor Control:

- Two rollers placed on either side of the machine.
- Motor-controlled to regulate the speed of the cloth movement.

Cloth Attachment:

- Cloth is securely attached to the rollers upon loading in batches, ensuring uniform tension.

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. (This helps in dispensing soap on the edge stains from the top with targeted and precise positioning)
- 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. (Please note, the top of the frame is not a dome kept on top of a rectangular sheet. It is a rectangular sheet that is cut to the guiding geometry and filleted and smoothened)
- 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 pulls 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 roller

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 onto 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.

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 remove soap from the cloth.
- Ensures proper cleaning of the cloth during the process.

Drying Chamber:

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

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.

Waste Tub:

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

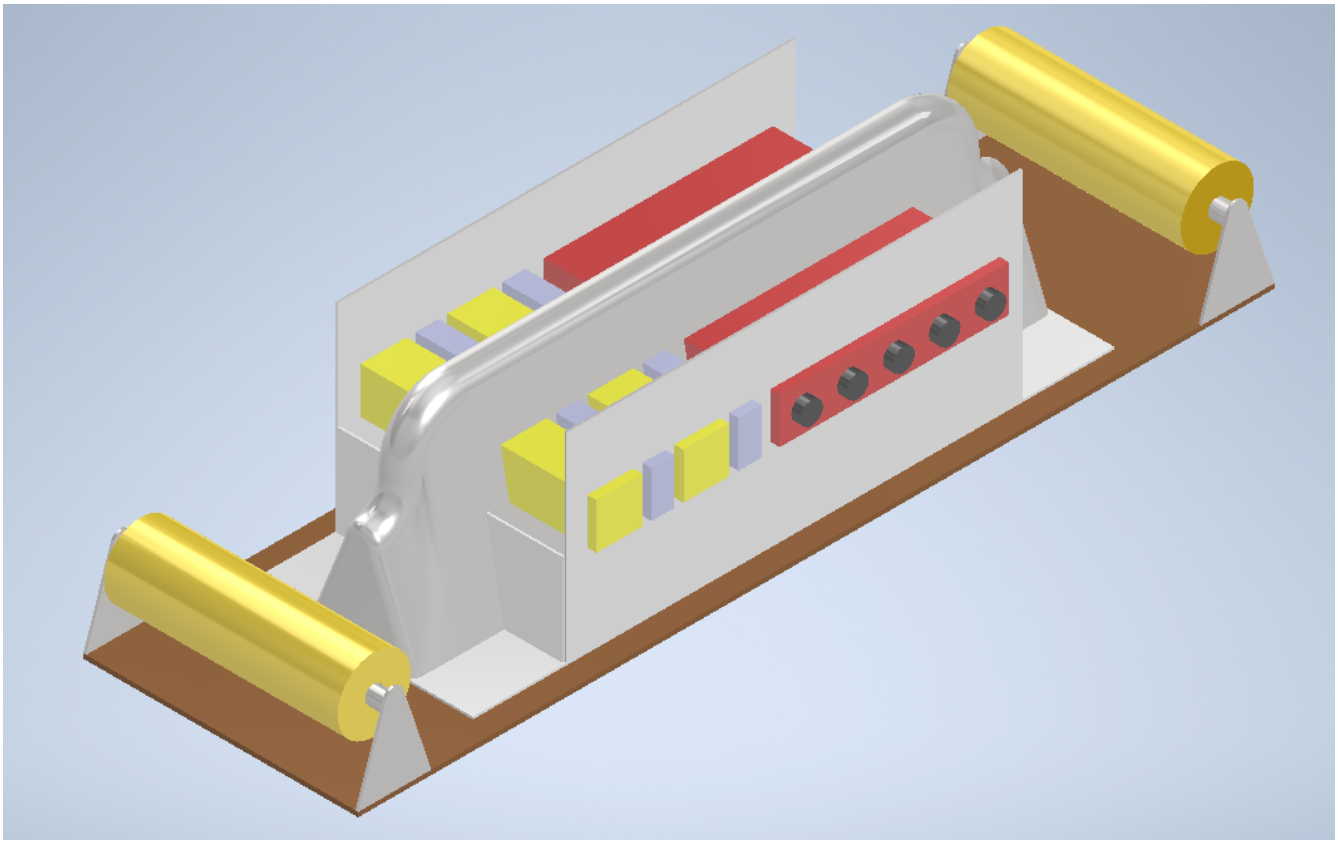


Figure 3. Proposed model isometric view

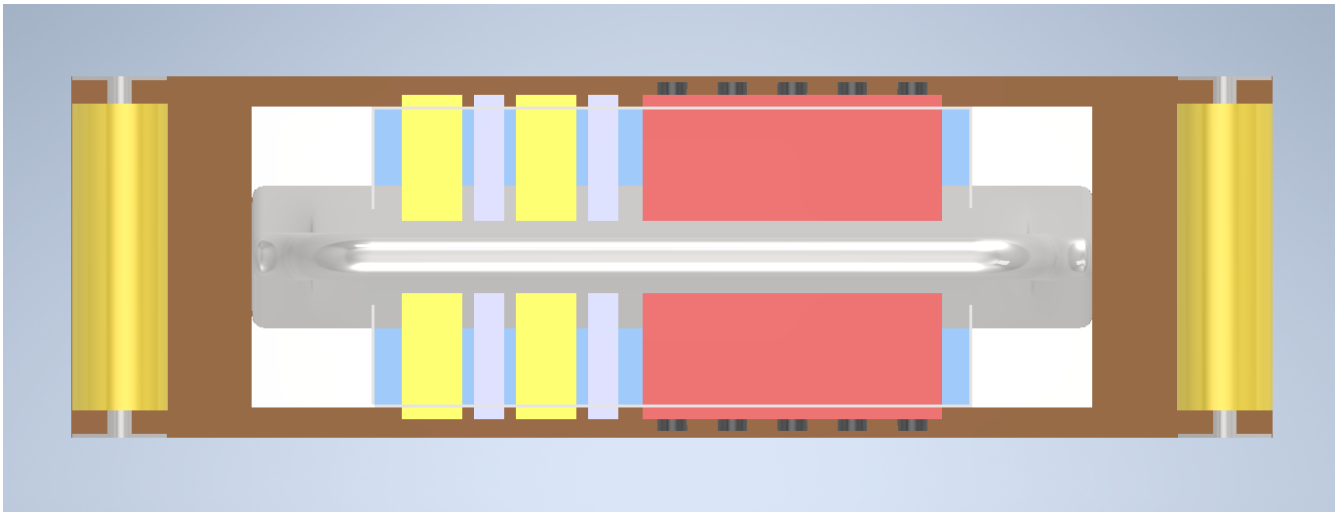


Figure 4. Proposed model top view

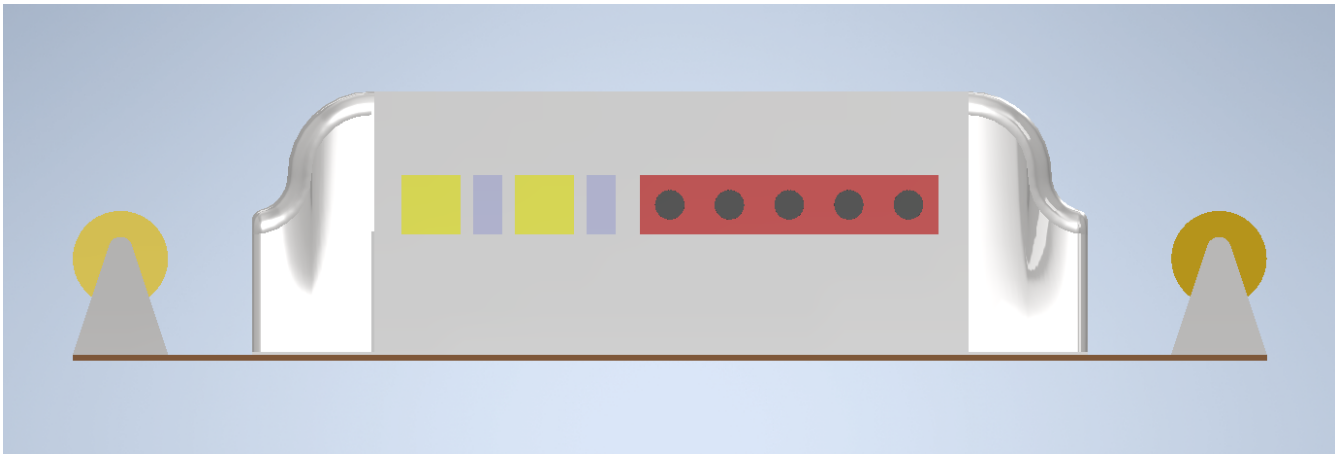


Figure 5. Proposed model side view

2.9.2. Workflow

- Cloth is loaded onto input rollers over the guiding frame, through them 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 to 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.

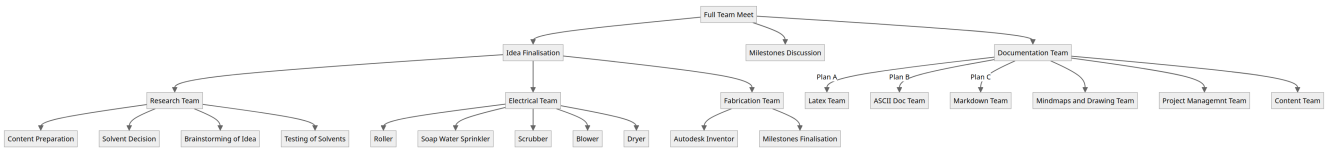


Figure 6. Workflow

2.9.3. Benefits:

- Improved cloth cleaning efficiency.
- Minimised impact on the fabric during the cleaning process.
- Streamlined manufacturing workflow.
- Enhanced drying capabilities for increased production speed. This innovative cloth making machine promises to revolutionise the textile industry by automating and optimising the cloth cleaning and drying processes.

2.9.4. Calculation of order of magnitude of the length of the chamber:

Suppose the cleaning and drying part of the machine is ‘l’ inches long. The cloth needs to be in the cleaning environment for about 90 seconds to get cleaned and dried (experimental estimate using soap, hair dryer and napkin).

- 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

Calculation:

```
l = \frac{(90 * 11)}{(0.18 * 2 * 45 * 60)} = 1  m (approx) = 40 inches (approx)
```

Note Varying soaps changes the time cloth needs to spend in the chamber, which increases/decreases the length of the machine.

2.10. Component Analysis

2.10.1. Roller

i. The roller will roll the washed cloth, coming through the conveyor belt.

ii. A controlled DC motor will be used to drive the roller.

iii. Appropriately select the dimensions of the roller, like the diameter of the roller and its length, based on the conveyor width.

iv. Choose a proper outer covering for the roller, which can provide a better grip and friction for the cloth.

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. Industrial Roller

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**.

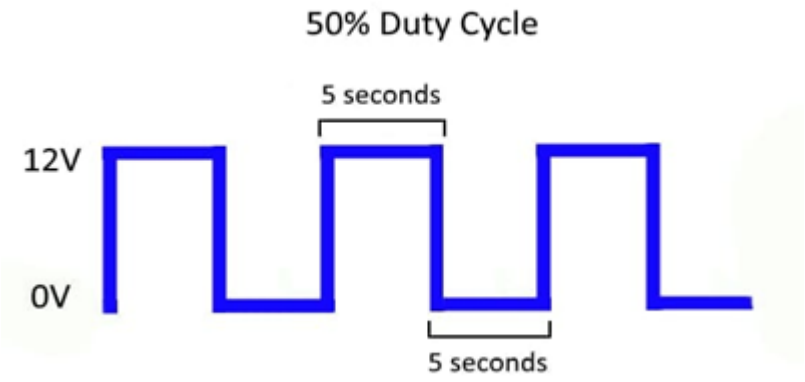


Figure 8. Duty Cycle

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).

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.

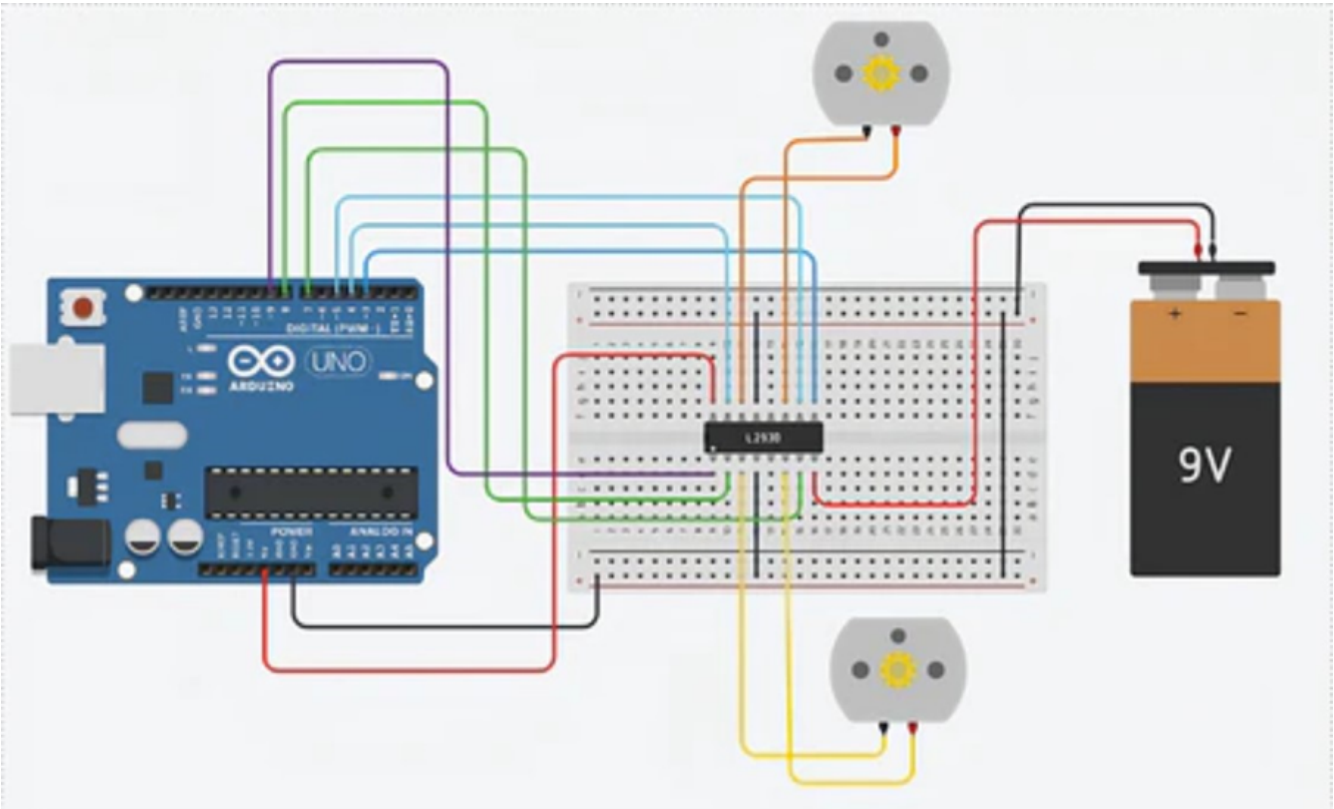


Figure 9. Circuit for Roller

▼ *Click Here to See the Code*

Arduino Code

```
// Motor A connections
int enA = 9;
int in1 = 8;
int in2 = 7;
// Motor B connections
int enB = 3;
int in3 = 5;
int in4 = 4;

void setup() {
  // Set all the motor control pins to outputs
  pinMode(enA, OUTPUT);
  pinMode(enB, OUTPUT);
  pinMode(in1, OUTPUT);
  pinMode(in2, OUTPUT);
  pinMode(in3, OUTPUT);
  pinMode(in4, OUTPUT);

  // Turn off motors - Initial state
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4, LOW);
}

void loop() {
  directionControl();
  delay(1000);
  speedControl();
  delay(1000);
}

// This function lets you control the spinning direction of motors
void directionControl() {
  // Set motors to maximum speed
  // For PWM maximum possible values are 0 to 255
  analogWrite(enA, 255);
  analogWrite(enB, 255);

  // Turn on motor A & B
  digitalWrite(in1, HIGH);
  digitalWrite(in2, LOW);
  digitalWrite(in3, HIGH);
  digitalWrite(in4, LOW);

  delay(2000);

  // Now change motor directions
```

```
  digitalWrite(in1, LOW);
  digitalWrite(in2, HIGH);
  digitalWrite(in3, LOW);
  digitalWrite(in4, HIGH);

  delay(2000);

  // Turn off motors
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4, LOW);
}

// This function lets you control the speed of the motors
void speedControl() {
  // Turn on motors
  digitalWrite(in1, LOW);
  digitalWrite(in2, HIGH);
  digitalWrite(in3, LOW);
  digitalWrite(in4, HIGH);

  // Accelerate from zero to maximum speed
  for (int i = 0; i < 256; i++) {
    analogWrite(enA, i);
    analogWrite(enB, i);
    delay(20);
  }

  // Decelerate from maximum speed to zero
  for (int i = 255; i >= 0; --i) {
    analogWrite(enA, i);
    analogWrite(enB, i);
    delay(20);
  }

  // Now turn off motors
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4, LOW);
}
```

2.10.2. Soap Water Sprinkler

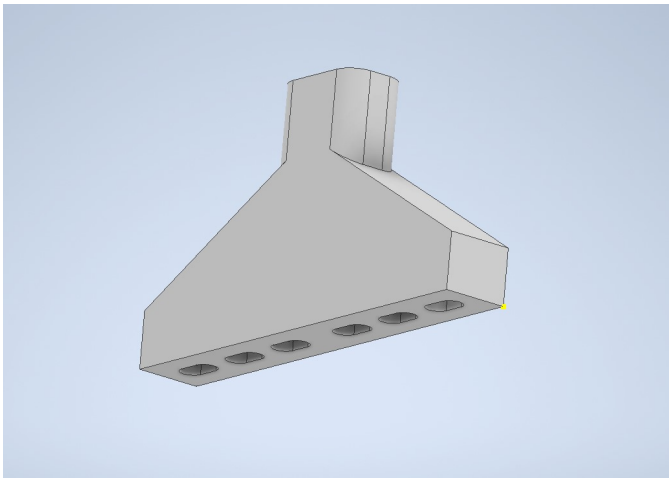


Figure 10. Isometric view of Sprinkler

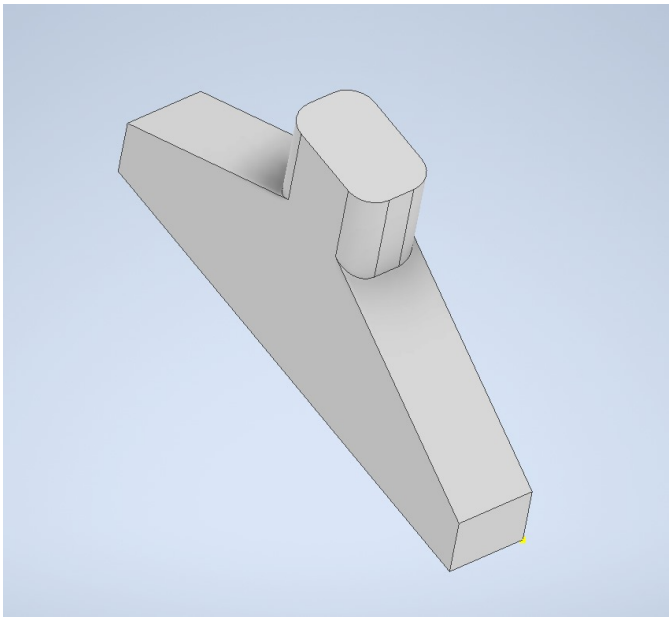


Figure 11. Isometric view of Sprinkler

For splitted cloth pieces using sensor

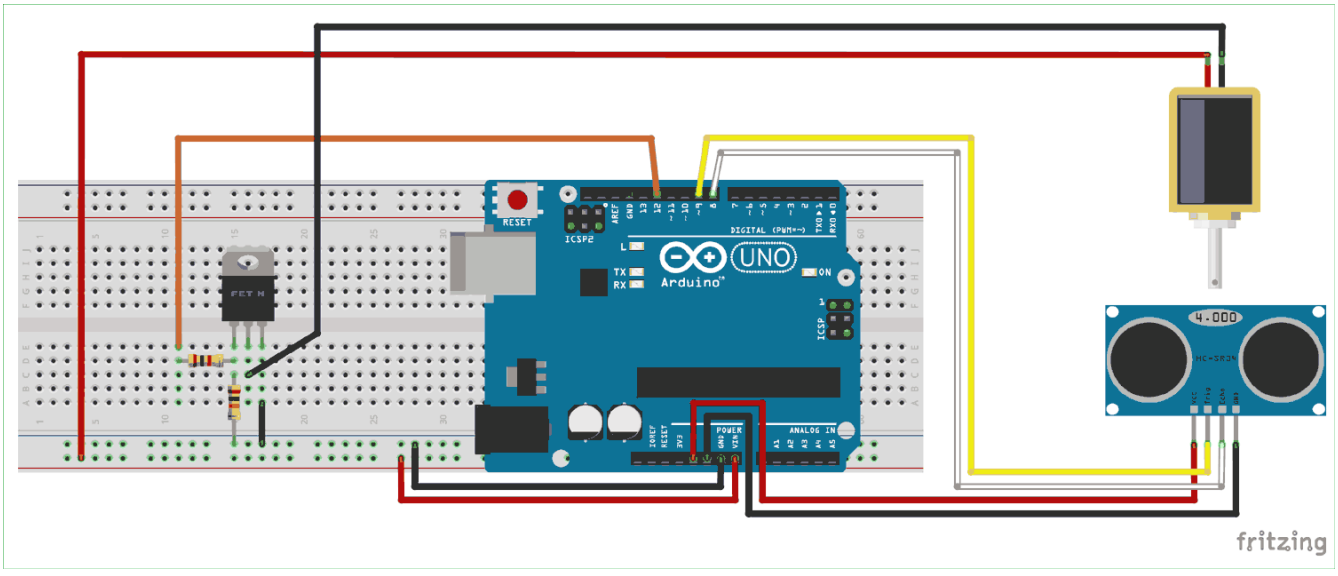


Figure 12. Circuit for Water Sprinkler

▼ *Click Here to See the Code*

```
void setup() {
  Serial.begin(9600);
  pinMode(trigger, OUTPUT);
  pinMode(echo, INPUT);
  pinMode(LED, OUTPUT);
  pinMode(MOSFET, OUTPUT);
  delay(2000);
}

void loop() {
  measure_distance();
  Serial.println(distance);

  if (distance < 10) {
    digitalWrite(LED, HIGH);
    digitalWrite(MOSFET, HIGH);
  } else {
    digitalWrite(LED, LOW);
    digitalWrite(MOSFET, LOW);
  }

  delay(500);
}

void measure_distance() {
  digitalWrite(trigger, LOW);
  delayMicroseconds(2);
  digitalWrite(trigger, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigger, LOW);
  delayMicroseconds(2);
  time = pulseIn(echo, HIGH);
  distance = time * 340 / 20000;
}
```

- Explanation:
  - When the distance is less than 10cm we have to turn on the MOSFET and else 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 turned on or 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 and if the value is less than 10cm we make the MOSFET and LED to go high, in the following else statement we make the MOSFET and LED to go low

Without Censor, using push button

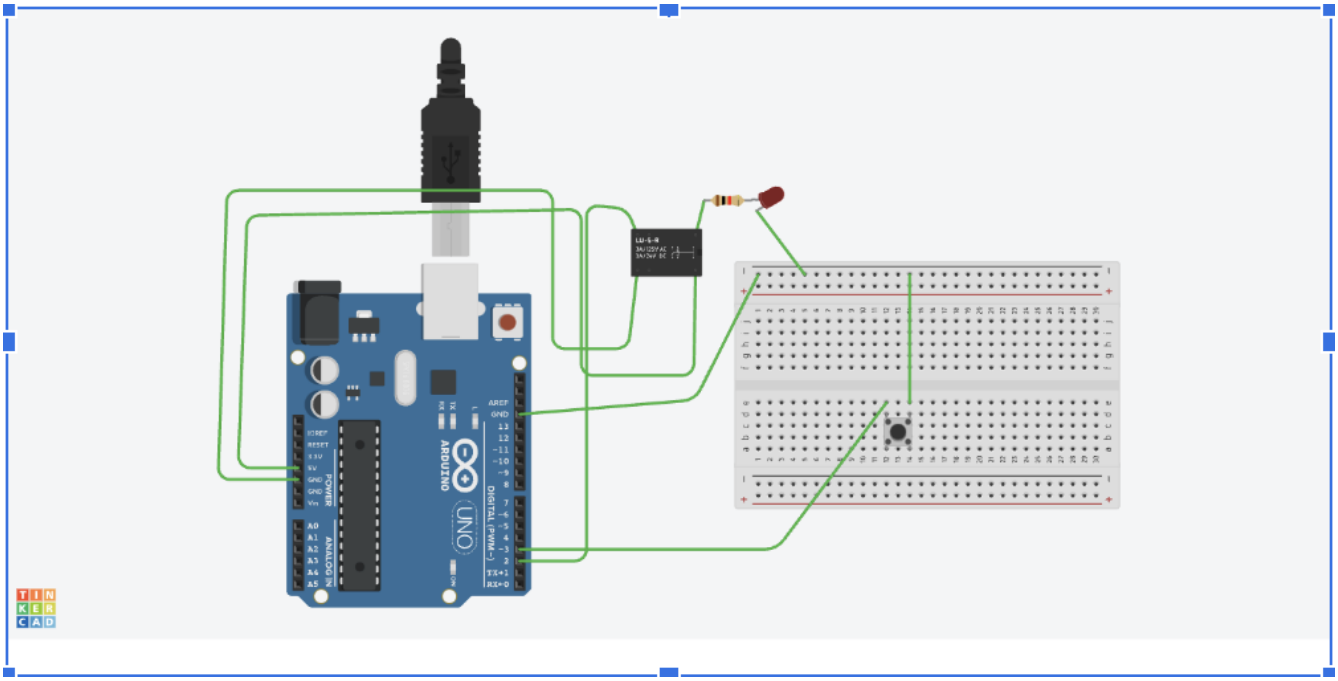


Figure 13. Circuit using Push button

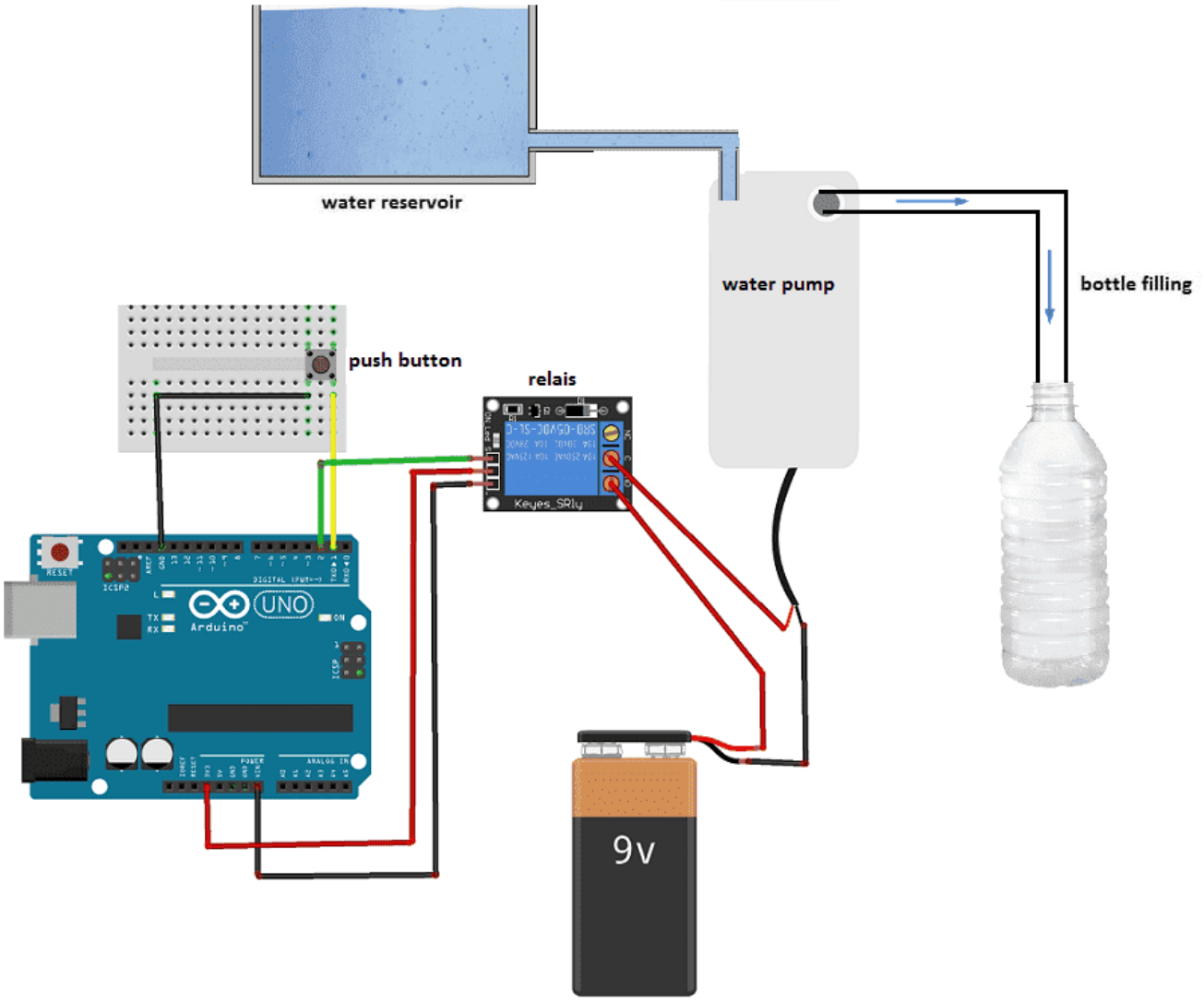


Figure 14. Full Circuit without Sensor

▼ *Click Here to See the Code*

Arduino Relay Control with Button

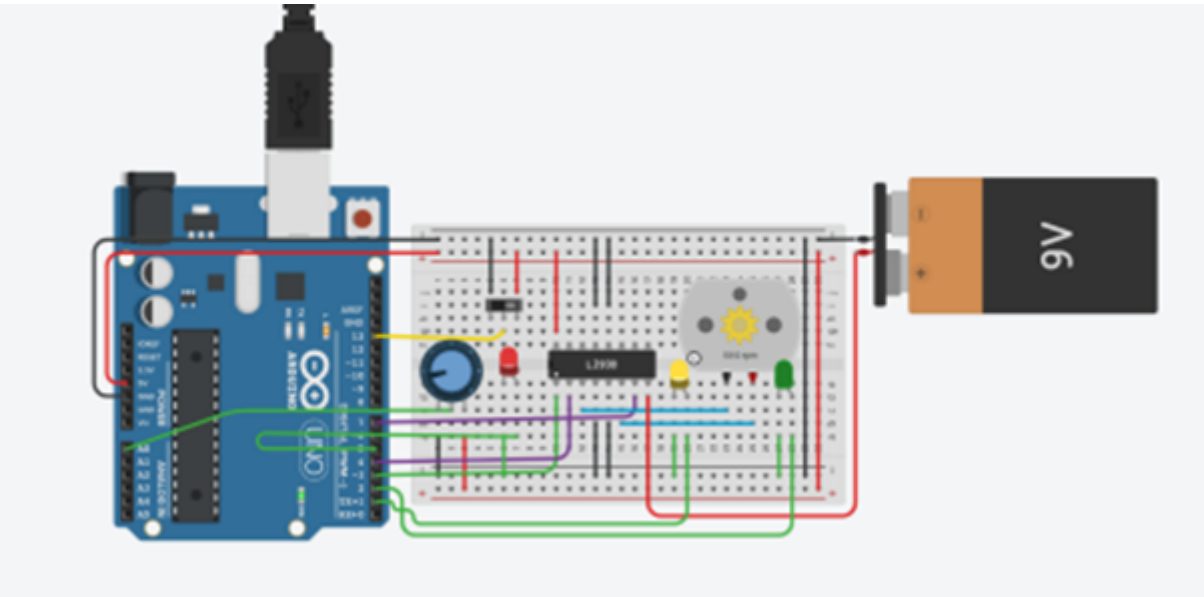
```
const int relayPin = 2;
const int buttonPin = 3;

void setup() {
  pinMode(relayPin, OUTPUT);
  pinMode(buttonPin, INPUT_PULLUP);
  Serial.begin(9600);
  digitalWrite(relayPin, LOW);
}

void loop() {
  int buttonState = digitalRead(buttonPin);
  Serial.println(buttonState);

  if (buttonState == LOW) {
    digitalWrite(relayPin, HIGH);
  } else {
    digitalWrite(relayPin, LOW);
```

```
  }
}
```

- Explanation:
  - Push button is used to on/off the relay which controls the pump
  - The relay is turned on and off at regular intervals, simulating the control of a device (solvent pump) through the relay. The relay pin (control pin) is set HIGH to activate the relay and LOW to deactivate it.

2.10.3. Scrubber

- Scrubbing will occur in circular motion [clockwise/anticlockwise]
- Speed is controlled using electric signals (based on the voltage of a potentiometer)
- Direction (clockwise/ anticlockwise) can be controlled based on a digital logic [1 or 0]
- The L293D motor driver is used. It is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V.
- Multiple scrubbers/ scrubbing mode patterns can be defined on this model further based on the design specifications.



▼ *Click Here to See the Code*

```
#define BTN_DIR 13
#define POT 0
#define EN1 3
#define M1A 4
#define M1B 7
#define LED_GREEN 2
#define LED_RED 5
#define LED_YELLOW 1

int pos, veloc, oldpos=-1, Speed;
```

```
void setup() {
  pinMode(M1A, OUTPUT);
  pinMode(M1B, OUTPUT);
  pinMode(LED_GREEN, OUTPUT);
  pinMode(LED_RED, OUTPUT);
  pinMode(LED_YELLOW, OUTPUT);
  pinMode(BTN_DIR, INPUT);
}

void loop() {
  pos = analogRead(POT);
  Speed = analogRead(POT);

  if (pos != oldpos) {
    veloc = map(pos, 0, 1023, 0, 255);
    Speed = map(pos, 0, 1023, 0, 255);
    analogWrite(EN1, veloc);
    analogWrite(LED_RED, Speed);
    oldpos = pos;
  }

  if (digitalRead(BTN_DIR) == LOW) {
    digitalWrite(M1A, HIGH);
    digitalWrite(M1B, LOW);
    digitalWrite(LED_GREEN, HIGH);
    digitalWrite(LED_YELLOW, LOW);
  } else {
    digitalWrite(M1A, LOW);
    digitalWrite(M1B, HIGH);
    digitalWrite(LED_YELLOW, HIGH);
    digitalWrite(LED_GREEN, LOW);
  }

  delay(200);
}
```

2.10.4. Blower

- We will be controlling the speed of the DC motor using a potentiometer for the purpose of 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.

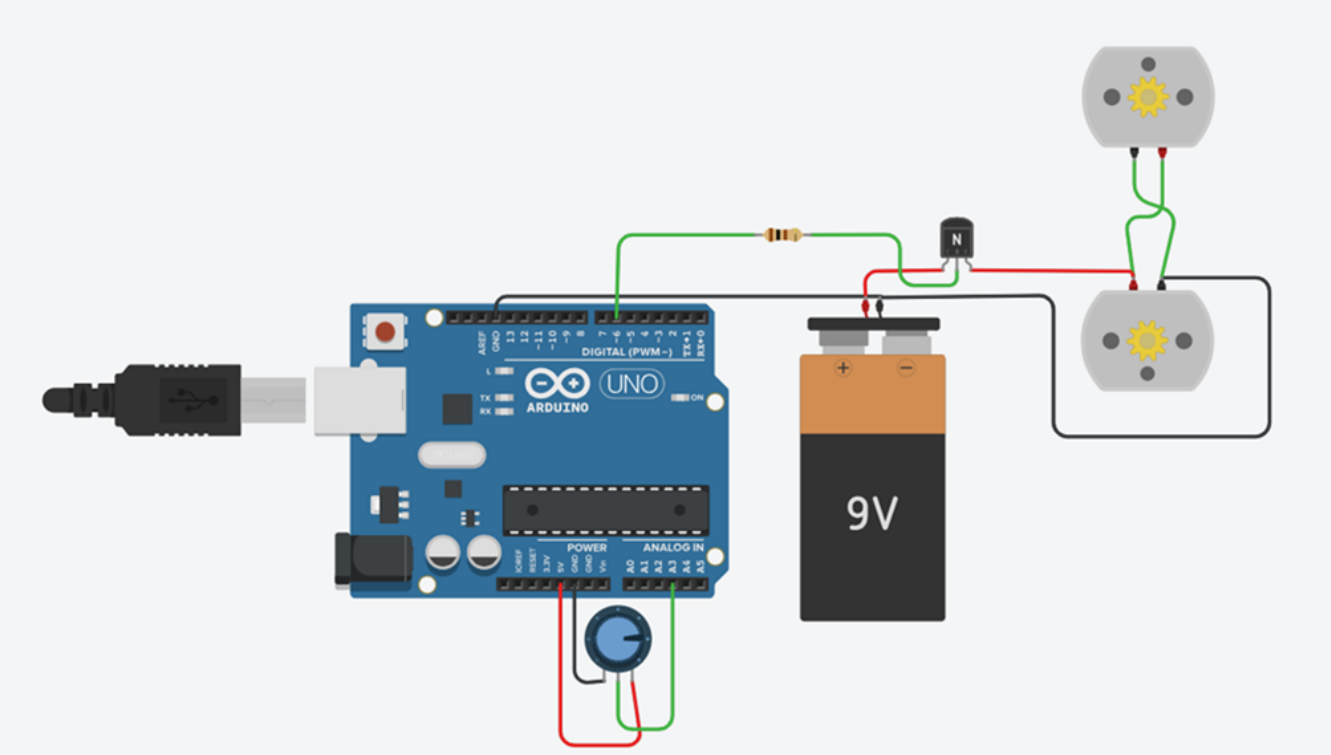


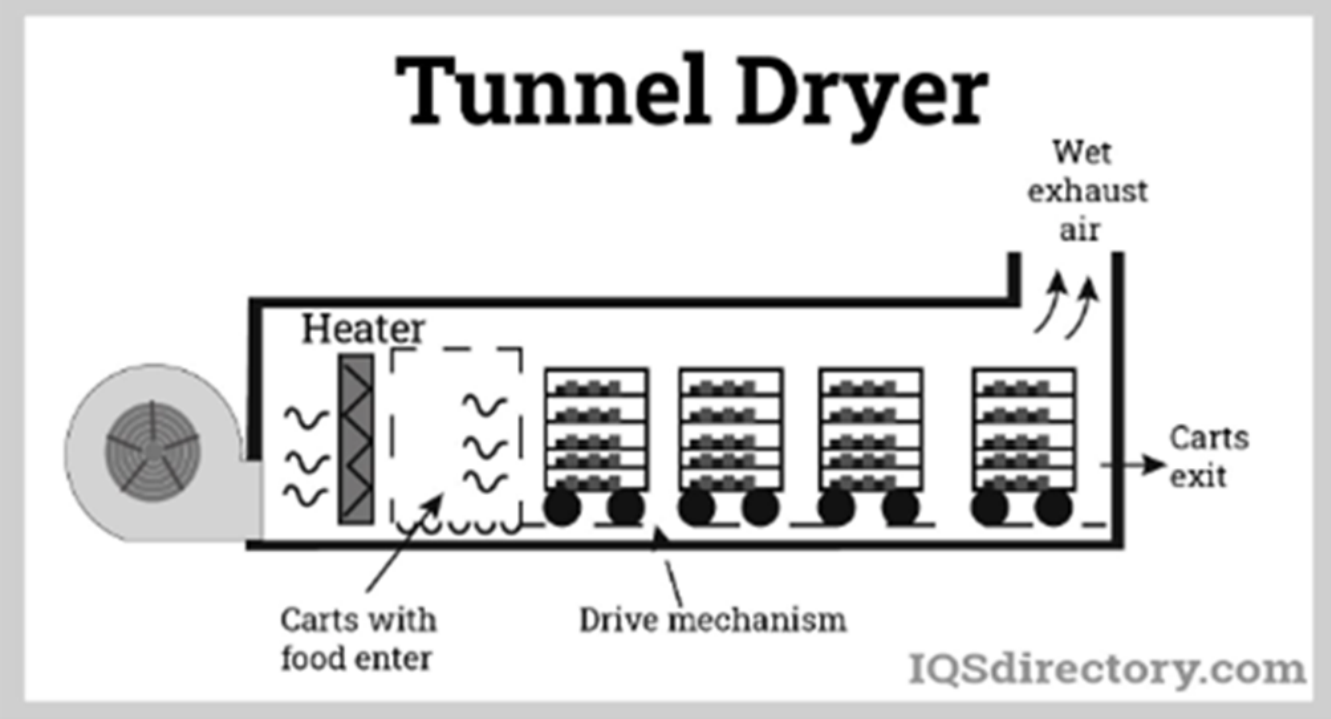
Figure 15. TinkerCAD circuit for Blower

▼ *Click Here to See the Code*

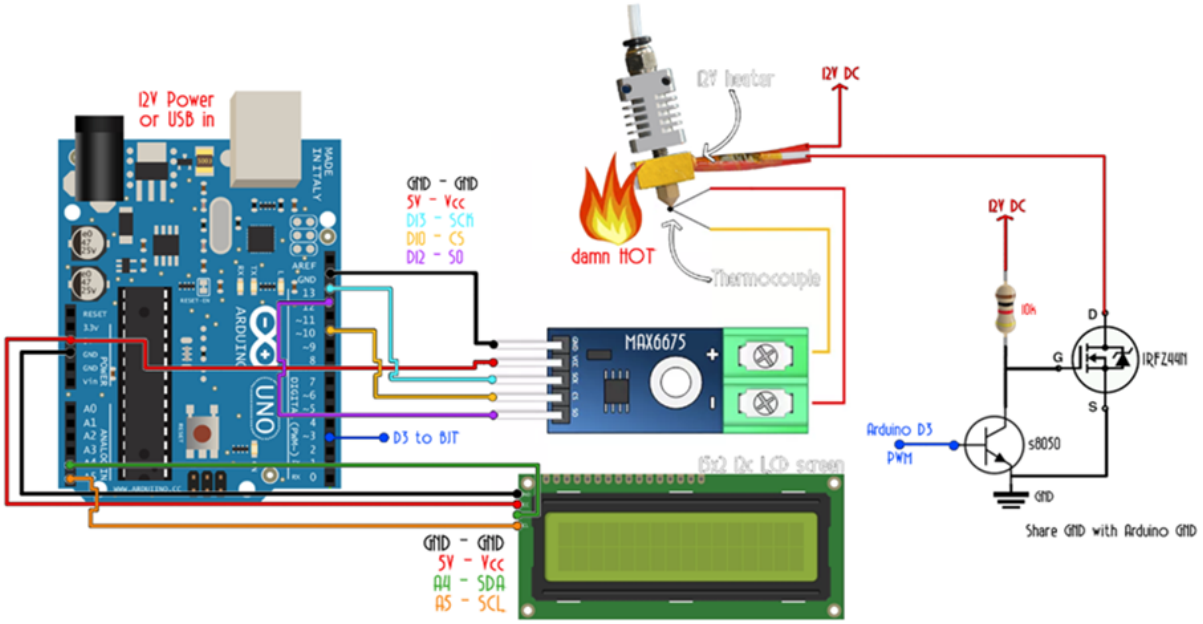
```
const int poten = A3;
int var;

void setup() {
  pinMode(6, OUTPUT);
}

void loop() {
  var = analogRead(poten);
  analogWrite(6, var);
}
```

2.10.5. 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.



Optimization 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:



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

▼ *Click Here to See the Code*

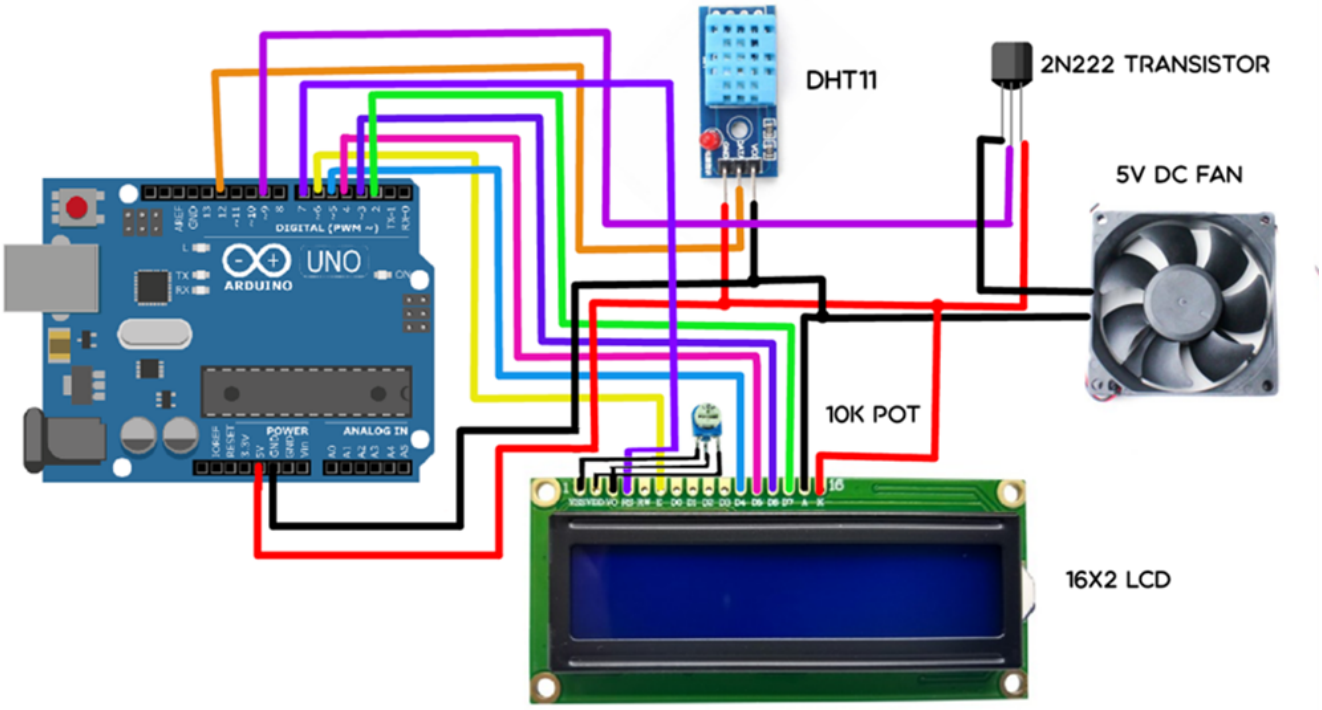
```
/* Max6675 Module  ==> Arduino
 * CS            ==> D10
```

```
 * SO            ==> D12
 * SCK           ==> D13
 * Vcc           ==> Vcc (5v)
 * Gnd           ==> Gnd
 */

// LCD config (i2c LCD screen, you need to install the LiquidCrystal_I2C if you
don't have it)
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x3f, 20, 4);  // sometimes the address is not 0x3f. Change to
0x27 if it doesn't work.

/* i2c LCD Module  ==> Arduino
 * SCL           ==> A5
 * SDA           ==> A4
 * Vcc           ==> Vcc (5v)
 * Gnd           ==> Gnd
 */
#include <SPI.h>
// We define the SPI pins
#define MAX6675_CS   10
#define MAX6675_SO   12
#define MAX6675_SCK  13

// Pins
int PWM_pin = 3;

// Variables
float temperature_read = 0.0;
float set_temperature = 100;
float PID_error = 0;
float previous_error = 0;
float elapsedTime, Time, timePrev;
int PID_value = 0;

// PID constants
int kp = 9.1;   int ki = 0.3;   int kd = 1.8;
int PID_p = 0;  int PID_i = 0;  int PID_d = 0;

void setup() {
  pinMode(PWM_pin, OUTPUT);
  TCCR2B = TCCR2B & B11111000 | 0x03;  // pin 3 and 11 PWM frequency of 980.39 Hz
  Time = millis();
  lcd.init();
  lcd.backlight();
}

void loop() {
  // First, we read the real value of temperature
  temperature_read = readThermocouple();
```

```
  // Next, we calculate the error between the setpoint and the real value
  PID_error = set_temperature - temperature_read;
  // Calculate the P value
  PID_p = kp * PID_error;
  // Calculate the I value in a range of +-3
  if (-3 < PID_error < 3) {
    PID_i = PID_i + (ki * PID_error);
  }

  // For derivative, we need real-time to calculate speed change rate
  timePrev = Time;                            // the previous time is stored before the
actual time read
  Time = millis();                            // actual time read
  elapsedTime = (Time - timePrev) / 1000;
  // Now we can calculate the D value
  PID_d = kd * ((PID_error - previous_error) / elapsedTime);
  // Final total PID value is the sum of P + I + D
  PID_value = PID_p + PID_i + PID_d;
  // We define PWM range between 0 and 255
  if (PID_value < 0) {
    PID_value = 0;
  }
  if (PID_value > 255) {
    PID_value = 255;
  }
  // Now we can write the PWM signal to the MOSFET on digital pin D3
  analogWrite(PWM_pin, 255 - PID_value);
  previous_error = PID_error;     // Remember to store the previous error for the
next loop.

  delay(300);
  // lcd.clear();

  lcd.setCursor(0, 0);
  lcd.print("PID TEMP control");
  lcd.setCursor(0, 1);
  lcd.print("S:");
  lcd.setCursor(2, 1);
  lcd.print(set_temperature, 1);
  lcd.setCursor(9, 1);
  lcd.print("R:");
  lcd.setCursor(11, 1);
  lcd.print(temperature_read, 1);
}

double readThermocouple() {
  uint16_t v;
  pinMode(MAX6675_CS, OUTPUT);
  pinMode(MAX6675_SO, INPUT);
  pinMode(MAX6675_SCK, OUTPUT);
```

```
  digitalWrite(MAX6675_CS, LOW);
  delay(1);

  // Read in 16 bits,
  // 15 = 0 always
  // 14..2 = 0.25 degree counts MSB First
  // 2  = 1 if thermocouple is open circuit
  // 1..0  = uninteresting status

  v = shiftIn(MAX6675_SO, MAX6675_SCK, MSBFIRST);
  v <<= 8;
  v |= shiftIn(MAX6675_SO, MAX6675_SCK, MSBFIRST);

  digitalWrite(MAX6675_CS, HIGH);
  if (v & 0x4) {
    // Bit 2 indicates if the thermocouple is disconnected
    return NAN;
  }
  // The lower three bits (0,1,2) are discarded status bits
  v >>= 3;
  // The remaining bits are the number of 0.25 degree (C) counts
  return v * 0.25;
}
```

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



▼ *Click Here to See the Code*

```
#include "DHT.h"
#include <LiquidCrystal.h>
```

```
LiquidCrystal lcd(7, 6, 5, 4, 3, 2);
#define DHTPIN 12  // Pin connected to the DHT sensor

#define DHTTYPE DHT11  // DHT 11

#define pwm 9  // PWM pin for fan speed control

byte degree[8] =
{
  0b00011,
  0b00011,
  0b00000,
  0b00000,
  0b00000,
  0b00000,
  0b00000,
  0b00000
};

// Initialize DHT sensor for normal 16mhz Arduino
DHT dht(DHTPIN, DHTTYPE);

void setup() {
  lcd.begin(16, 2);
  lcd.createChar(1, degree);
  lcd.clear();
  lcd.print("   Fan Speed  ");
  lcd.setCursor(0, 1);
  lcd.print("  Controlling ");
  delay(2000);
  analogWrite(pwm, 255);
  delay(2000);
  Serial.begin(9600);
  dht.begin();
}

void loop() {
  // Wait a few seconds between measurements.
  delay(2000);

  // Reading temperature or humidity takes about 250 milliseconds!
  // Sensor readings may also be up to 2 seconds 'old' (it's a very slow sensor)
  float h = dht.readHumidity();
  // Read temperature as Celsius
  float t = dht.readTemperature();
  // Read temperature as Fahrenheit
  float f = dht.readTemperature(true);

  // Check if any reads failed and exit early (to try again).
  if (isnan(h) || isnan(t) || isnan(f)) {
```

```
    Serial.println("Failed to read from DHT sensor!");
    return;
  }

  // Compute heat index
  // Must send in t in Fahrenheit!
  float hi = dht.computeHeatIndex(f, h);

  Serial.print("Humidity: ");
  Serial.print(h);
  Serial.print(" %\t");
  Serial.print("Temperature: ");
  Serial.print(t);
  Serial.print(" *C ");
  Serial.print(f);
  Serial.print(" *F\t");
  Serial.print("Heat index: ");
  Serial.print(hi);
  Serial.println(" *F");

  lcd.setCursor(0, 0);
  lcd.print("Temp: ");
  lcd.print(t);   // Printing temperature on LCD
  lcd.print(" C");
  lcd.setCursor(0, 1);

  // Fan Speed Control based on Temperature
  if (t > 29) {
    analogWrite(9, 0);
    lcd.print("Fan OFF         ");
    delay(100);
  } else if (t == 29) {
    analogWrite(pwm, 51);
    lcd.print("Fan Speed: 20%   ");
    delay(100);
  } else if (t == 28) {
    analogWrite(pwm, 102);
    lcd.print("Fan Speed: 40%   ");
    delay(100);
  } else if (t == 24) {
    analogWrite(pwm, 153);
    lcd.print("Fan Speed: 60%   ");
    delay(100);
  } else if (t == 20) {
    analogWrite(pwm, 204);
    lcd.print("Fan Speed: 80%   ");
    delay(100);
  } else if (t < 20) {
    analogWrite(pwm, 255);
    lcd.print("Fan Speed: 100%   ");
    delay(100);
```

```
  }

  delay(3000);
}
```

2.11. Solvent

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

2.11.1. Lipase Enzyme

- Pros: Lipase is an enzyme that breaks down oil and thus was thought of as a solution to clean oil and grease stains.
- Cons: The idea was rejected as we require the water to be slightly warm(~40-50 C) for the optimal enzyme action, and maintaining warm water is not so easy.

2.11.2. Spot Remover(such as Shout) and Hot Water

- Pros: It can remove both oil and grease stains. Spraying the stain remover and then followed by brushing in hot water can remove the results.
- Cons: Increases the energy requirement of the model as hot water is required. Using spot removers increases the cost.

2.11.3. Spot Lifters(such as K2R spot lifter) followed by dry brushing

- Pros: It overcomes the drawback of scrubbing in hot water(mentioned in the previous method). After application, keeping it for 10-15 minutes lifts the stain and only a brush off is required in the end.
- Cons: It is very costly(~3300 Rs for 150 ml) and availability may become an issue when required in large amounts, as it is manufactured in the USA.

2.11.4. Baby powder/ Cornstarch/ Salt/ Vinegar followed by washing

- Pros: Effective in cleaning oil and grease stain significantly
- Cons: Requires soaking and multiple iterations to remove the stains, therefore time consuming

2.11.5. WD-40 or Lighter Fluid

- Pros: Effective in cleaning oil and grease stain significantly
- Cons: Takes 20 min soaking time and hot water is required for washing.

Figure 16. Grease stain before using WD-40

Figure 17. Grease stain after using WD-40

2.11.6. PCE(perchloroethylene):

- Pros: Tetrachloroethylene (PCE) is a nonflammable, liquid solvent widely used in dry cleaning and is effective in removing oil and grease stains..In small quantities.
- Cons: Extended exposure to large quantities of PCE could cause irritation to eyes, skin, throat, nose, and respiratory system.

2.11.7. Handwash(Dettol):

Tested hand wash to clean oil stain with gentle brushing and it successfully cleaned the oil stain.

- Pros: Handwashes are biodegradable and environmentally friendly and can be washed and reused multiple times. They are soft and less abrasive
- Cons: Depending on the material and color, handwashes may be more prone to staining, which could affect the appearance and cleanliness of cloth

2.11.8. Dishwasher (Vim Drop)

- Pros: Effective in removing both oil and grease stains by scrubbing with vim drop and water with normal pressure.

Figure 18. Grease stain before using dishwasher(Vim)

Figure 19. Grease stain after using dishwasher(Vim)

2.11.9. Trichloroethylene (TCE): chlorinated solvent

- Pros: Stain remover and degreaser. TCE evaporates quickly, leaving behind a dry surface.TCE can act quickly to break down and dissolve stains or contaminants, making it effective for rapid cleaning processes.
- Cons: TCE exposure has been linked to various health risks, including respiratory, neurological,

and reproductive effects. Prolonged or repeated exposure can lead to serious health problems, and it is considered a potential human carcinogen. TCE has been restricted or banned in many countries for certain applications. TCE is flammable, posing a fire hazard. Special precautions are needed when handling and storing TCE to prevent accidents. It is also persistent in the environment and can contaminate soil and groundwater, posing risks to ecosystems.

2.11.10. Isopropyl(Rubbing alcohol 68-72%)

- Pros: Isopropyl alcohol, also known as rubbing alcohol, is a natural degreasing agent sold in most department stores. Based on the theoretical searches it was suggested a volatile solvent to remove oil and grease stains
- Cons: The idea was rejected after practically experimenting on the grease and oil stained cotton cloth by scrubbing and even soaking the cloth in it for 5 min didn't remove oil and Grease stain. May be effective after a longer time of soaking, and thus not efficient because of time constraints.

Figure 20. Grease stain after applying isopropyl(rubbing alcohol 68-72%)

2.11.11. Detergent (Surf Excel)

- Pros: Was effective on oil stains with slight scrubbing
- Cons: The idea was rejected because it was not effective on Grease stain, even after hard scrubbing

Figure 21. Grease stain after using detergent and scrubbing

2.11.12. 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 stain

Figure 22. Grease stain before using acetone

Figure 23. Grease stain after using acetone

2.12. Specifications

2.12.1. Energy Specifications

1. Roller

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

2. Soap Water Sprinkler

- With Sensor (Prototype)

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

- Without Sensor

Nozzle’s Pressure	5-15 bar
Nozzle’s Length	3-4 cm
Nozzle’s Diameter	1-1.5 cm

3. Blower

- DC Motor:
  - Voltage: 9,12,15 Volts
- Potentiometer:

Resistance Value	200 Ohm
Limiting element voltage	250 Volt

- Battery :

Power Supply	9-volt
Battery Impedance	1700 m-ohm @ 1 kHz

4. Dryer

- Voltage: 220 Volts

2.12.2. Space Specifications

proposed model specifications:

- **Base:**
  - length = 100cm
  - breadth = 30cm
- **Roller:**
  - diameter = 8cm
  - length = 25cm
- **N-box:**
  - length = 70cm
  - breadth = 25cm

2.12.3. Power Specifications

1. Roller

Power Rating of Prototype	21.6 W

2. Soap Water Sprinkler

- With Sensor (Prototype)
  - Power Rating of Prototype: 18 W
- Without Sensor
  - Battery voltage: 10 - 15 V

4. Blower

- DC Motor:

Power	300 Watts
Speed	7000 RPM

- Transistor (BC547): Max collector Dissipation | 1.5W
- Resistor (100M ohms): Power Rating:0.25-0.5W

5. Blower

- Actual machine requirement: 4-6 KW depending on the speed of feeding the cloth and drying rate
- For Prototype: 1000-2000W

2.12.4. Cost Specifications

1. Roller

- Prototype average cost: Rs. 200.

2. Soap Water Sprinkler

Arduino	Rs.2500
Nozzle	Rs.500
Resistors	Rs. 10-20
Breadboard	Rs. 90
Sensor	Rs. 200
Connecting wires	Rs.150
NMOS	Rs. 70
solvent pump	Rs. 200

3. Scrubber

Cost per meter	Rs. 300 - 400
Number of Scrubbers	2 (4 can be installed based on requirement)

4. Blower

Arduino	Rs.2550
Resistor(100 ohms)	Rs.1
Transistor	Rs. 1
Potentiometer	Rs.17
9 volt Battery	Rs.300
DC motor	Rs. 260

5. Dryer

- Actual machine cost: Around Rs. 100000
- For prototype: Rs. 800

2.12.5. Performance Specifications

1. 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.

2. Soap Water Sprinkler

a. With Sensor: 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.

b. Withour Sensor: Arduino controls the operation of water pump. It also controls the flow rate and directions of water.

3. 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.

4. 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

5. 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

2.12.6. Manpower Specifications

Table 2. Manpower Specs

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

2.12.7. Milestone Specifications

Phase I (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 auto CAD mode.

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 II (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 Free CAD.

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 III (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 IV (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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3. Index(with pageno.)??

Glossary

ABS (Acrylonitrile Butadiene Styrene)

A strong and durable thermoplastic polymer used in manufacturing.

Adapter Voltage Rating

This specifies the voltage range for the adapter that provides power to the soap water sprinkler.

Affix

Securely attach or fasten.

Areal density

mass per unit area

Arduino

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

Blower

A device used to create a flow of air or gas.

carcinogen

potential to cause cancer

Central Pollution Control Board (CPCB)

A regulatory body in India that sets standards for environmental pollution control.

chlorinated

state of having chlorine

Coil-based heating

This implies the use of a heating element made in the form of a coil. Electricity passing through the coil generates heat, and this method is often used in appliances like room heaters.

Compatibility

The ability of the system to work with other components.

Control Mechanism

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

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.

Controlled and targeted cleaning

This describes the method of cleaning where the scrubbers are designed to clean fabrics in a precise and controlled manner. The goal is to ensure uniform and effective removal of dirt and contaminants from the surfaces being cleaned.

CPCB (Central Pollution Control Board)

A regulatory body in India that sets standards for environmental pollution control.

DC Motor

A motor that operates on direct current (DC) electricity.

Denier

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

Desizing

The removal of sizing agents, such as starch or other chemicals, from fabrics to prepare them for further processing. driving motors: Motors powering the movement of the cloth fabric

Efficiency

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

filleted

Somewhat stuck to the side or attached to side walls

fixtures

a fixed frame

Gantt Chart

A visual representation of a project schedule that shows the start and finish dates of various elements of the project.

Graywater

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

Guiding frame

a frame used to fold the cloth in half vertically

HCSR04 Ultrasonic Sensor

A specific ultrasonic sensor used in the prototype to detect objects in front of the dispenser.

Infrared based heating

This refers to a method of heating using infrared radiation. Infrared radiation is a type of electromagnetic radiation that heats objects directly without heating the surrounding air. It's commonly used in appliances like heaters and dryers.

Isometric View

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

KW (Kilowatts)

Kilowatts are a unit of power.

Lifespan

The duration for which the system is expected to operate.

Limiting element voltage

The maximum voltage the potentiometer can handle.

Lipase

an enzyme the body uses to break down fats Mathematical modeling and simulations: This refers to the use of mathematical equations and computer simulations to analyze and predict the behavior of the system.

Maximum Current Rating

Indicates the maximum current the device can draw from the power source.

Maximum Current Rating (per channel)

This indicates the maximum amount of electrical current that can flow through each channel (a

path for electric current) without causing damage. The limit is set at 600 milliamperes (mA).

Maximum Operating Voltage

This is the highest voltage at which the roller or the associated system can safely operate.

Mercerizing

A textile finishing process that increases the luster and strength of fabric, typically cotton, by treating it with a caustic soda solution.

Nozzle

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

Nozzle mechanism

The nozzle and flapper mechanism are a displacement type detector that converts mechanical movement into a pressure signal by covering the opening of a nozzle with a flat plate called the flapper. This restricts fluid flow through the nozzle and generates a pressure signal.

Petroleum-based cleaning agents

Solvents effective for oil-based stains (e.g., mineral spirits, naphtha).

Pretreatment

Applying cleansing agent before washing.

Prototype

A prototype is an initial version or model of a product that is used to test and develop the design.

Resource Breakdown

A breakdown of resources required for a project, often detailing labor, equipment, and materials.

Robust Scrubbing

Strong, sturdy, and effective scrubbing.

Rust stains

Formed by oxidation of iron.

Scour

To clean or rub using a stiff brush or abrasive.

Setup Time

The time required to prepare the washing machine for operation.

Singeing

The process of burning off protruding fibers or impurities from the surface of a fabric, often using a flame or hot surface.

Solvent

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

Spot Lifters

A unique cleaning aid that removes oil and grease spots and stains from several types of fabrics and clothing.

Syrup

In the context of the report, it may refer to a concentrated solution of sugar or a sugar substitute in water.

Tannin

A bitter, astringent substance found in plants.

Testing Phase

A stage in the development process where the functionality and performance are evaluated.

Thermoplastic Polymer

A type of polymer that becomes pliable or moldable when heated and solidifies upon cooling.

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.

traces

Small amounts or remnants.

Turpentine

Solvent used for thinning, cleaning paint and varnish removal.

User-Centric

Designed with a primary focus on meeting the needs and preferences of users.

USP

Unique selling point

Voltage

Voltage is a measure of electrical potential difference.

waste tub

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

water compartment

A compartment to store water

A: Appendix (to be changed)

A.1. Document ID

Table 3. Document ID

Document type	
Document Authorised by	
Publication Date	
Version No.	
GitHub Repo Details	

A.2. Document Statistics

Table 4. Document Stats

Number of words	2318
Average Word Length	5
Average number of words per sentence	15
Total Number of characters with spaces	17,983
Total Number of character without spaces	14,254
Total Number of Letter characters	11,719
Total Number of Sentences	141
Number of Unique Words	940
Number of Repeat Words	2087
Number of Syllables	3874

A.3. Readability Indices ? explain a bit about ranges? add max range in denom

Table 5. Readability Stats

Readibility Index	Score	Difficulty
Flesch Reading Ease	63/100	Standard
Gunning Fog Readibility	11.3	Fairly Difficult
Coleman Liau Readibility Index	10.51	Fairly Difficult
Flesch Kincaid Grade Level	6.96	Average
Automated Readibility Index	11.01	Fairly Difficult