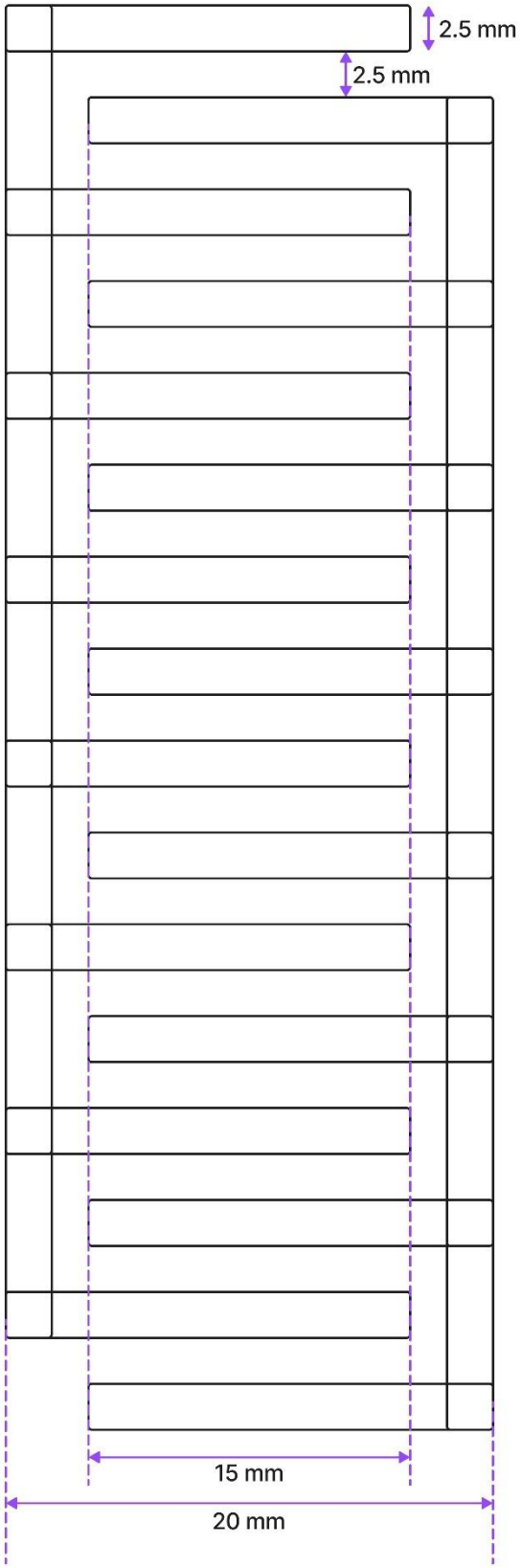
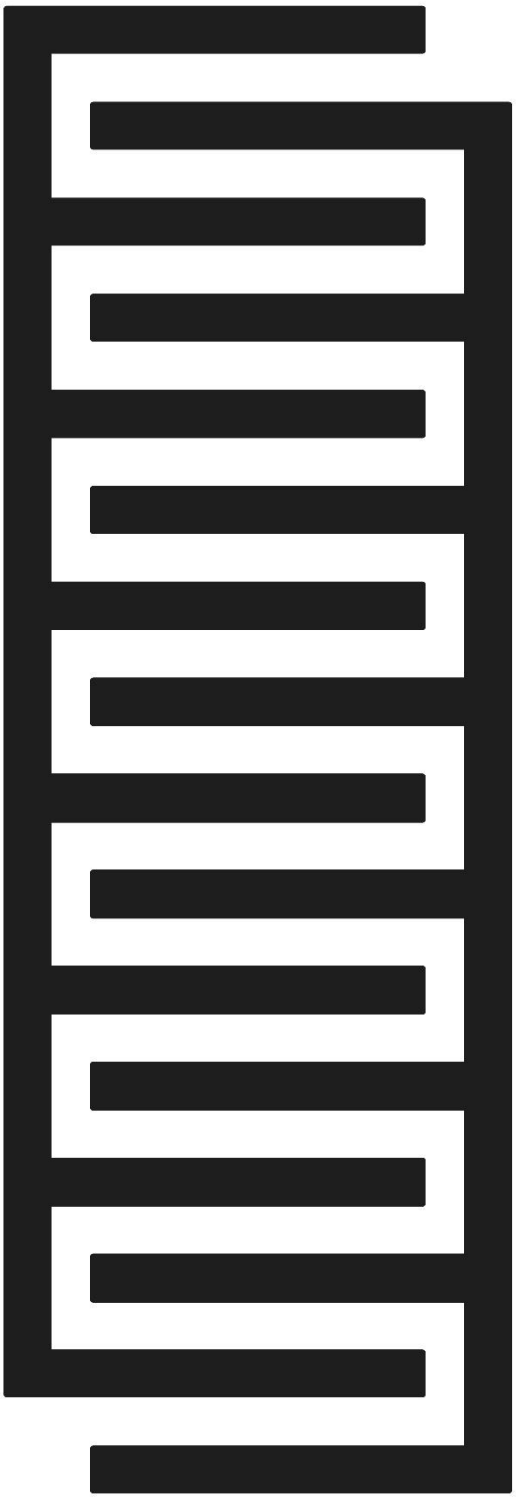
Paper Based Graphine Humidity sensor

Sensor Design:

(i) Dimensioning on the Paper.



(ii) Filling it with graphite.



Maintained Standers:

1. Filter Paper type:
    - **Hand Made Paper**
      Thickness: **ranges from 0.12 to 0.5 mm.** (Exact thickness is not mentioned)
      Higher porosity and irregular fibre structure.
    - **Normal Paper**
      Thickness: **ranges from 0.17 to 1.00 mm.** (Exact thickness is not mentioned)
      Smoother surface and consistent fibre distribution.
2. Pencil Grade for graphite deposition: **10b**
3. Sensor Resistance: **Ranging between R_0 = 40k ohm to 70k ohm**
4. Heat Pad:
    - Material: **11 micron thick Aluminium Foil.**
    - Pattern: **Serpentine.**
    - Power: **5.12 volt /**
5. Circuit: **A voltage divider circuit kept in use with Arduino Uno to measure ADC values.**
6. Humidity Standers: **market available DHT 11 sensor working range between 40% to 100% RH.**
7. Graph Plotting Method:
    - **Normal DHT 11 data plots + Best Fit Curve.**
    - **Paper Sensor value → Reversed → Averaged of 10 values (to reduce the notice in the signal) → Plot + Best Fit Curve**

Findings:

1. Without heat pad:
    - It works properly 1 time, after that the paper starts deforming and the Resistance increased above 1M ohm which produce garbage value and error in the signal.
2. Paper Sensor with Heat pad:
    - Heats the paper while Humidity is decreasing 100% to 50%
    - It works properly around 3 time, after that the paper doesn't deform due to the applied heat but the Resistance still increased above 1M ohm which produce garbage value and error in the signal.
    - The Hand made paper giving a sharp humidity rise from 50 % to 100% (which drops the ADC value rapidly) also shows graphene deformation faster (increases resistance faster than the other one).
    - Normal Paper shows slow humidity increase rate from 50% to 80% as compared to the hand made paper after that touches 100% faster. shows slow graphene deformation compared to hand made one.
    - The Normal Paper is not capable of detecting slight increase in humidity at initial state which is important for measuring humidity from body (Nose).

Issues

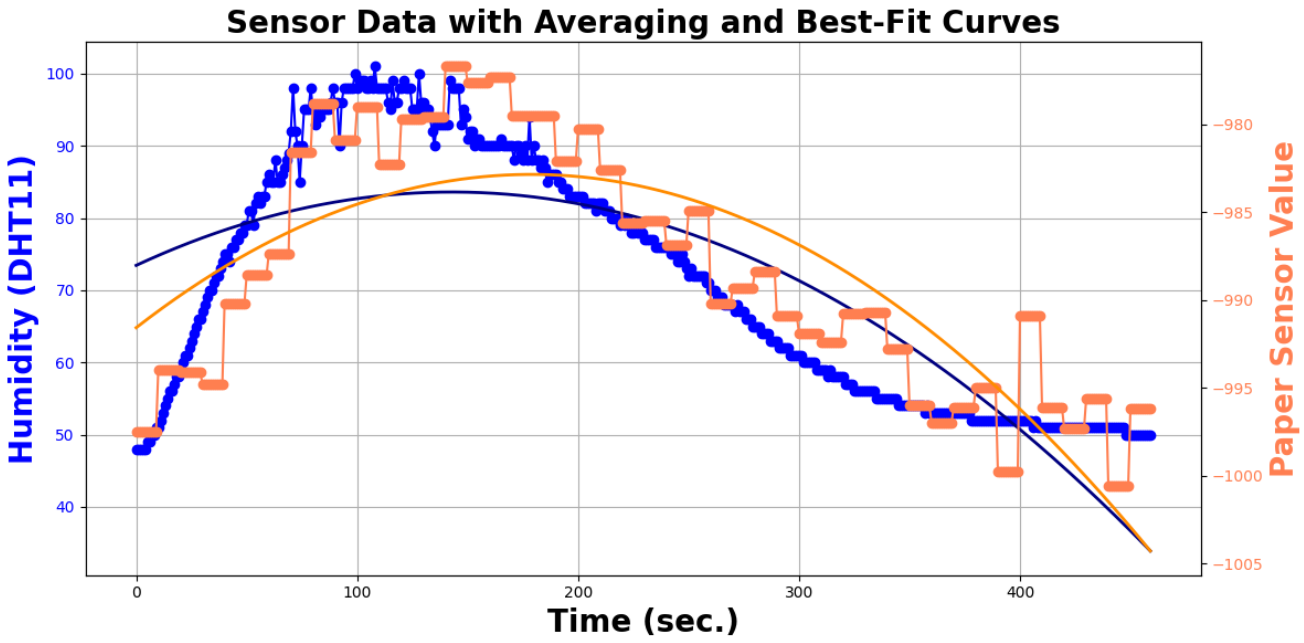
- Graphite trace degradation over time due to moisture absorption and physical breakdown.
- Paper deformation under repeated humidity cycles even with heat applied.
- Inadequate control over heating profile, leading to inconsistent recovery.

Questions:

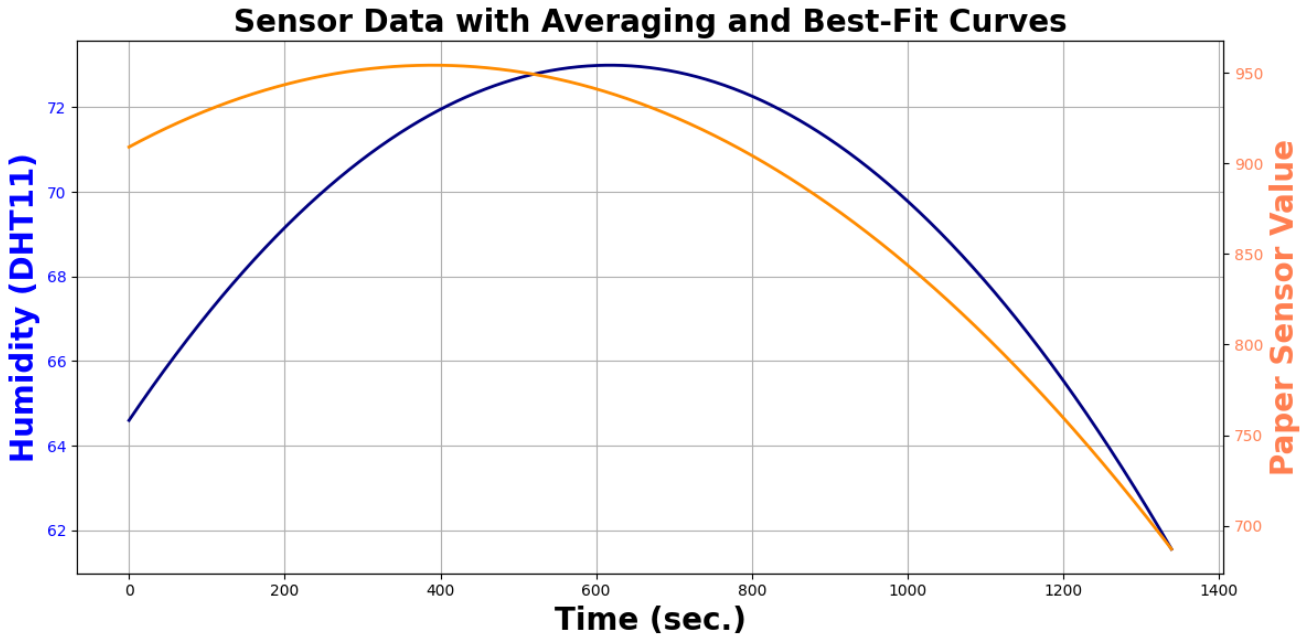
1. Changing paper thickness, ranging between the hand made and the normal one.
2. Using metallic ink or graphene ink to reduce the deformation rate to use the sensor for long time.
3. Changing the ration of NaCl solution.
4. Apply the heat in a measured way to control it.
5. Changing the heat pad material paper to Kapton tape. Helps to apply more heat
6. Changing the heat pad pattern or changing the material to increase the resistance.
7. Reducing the gap between the paper sensor geometry.

Graphs:

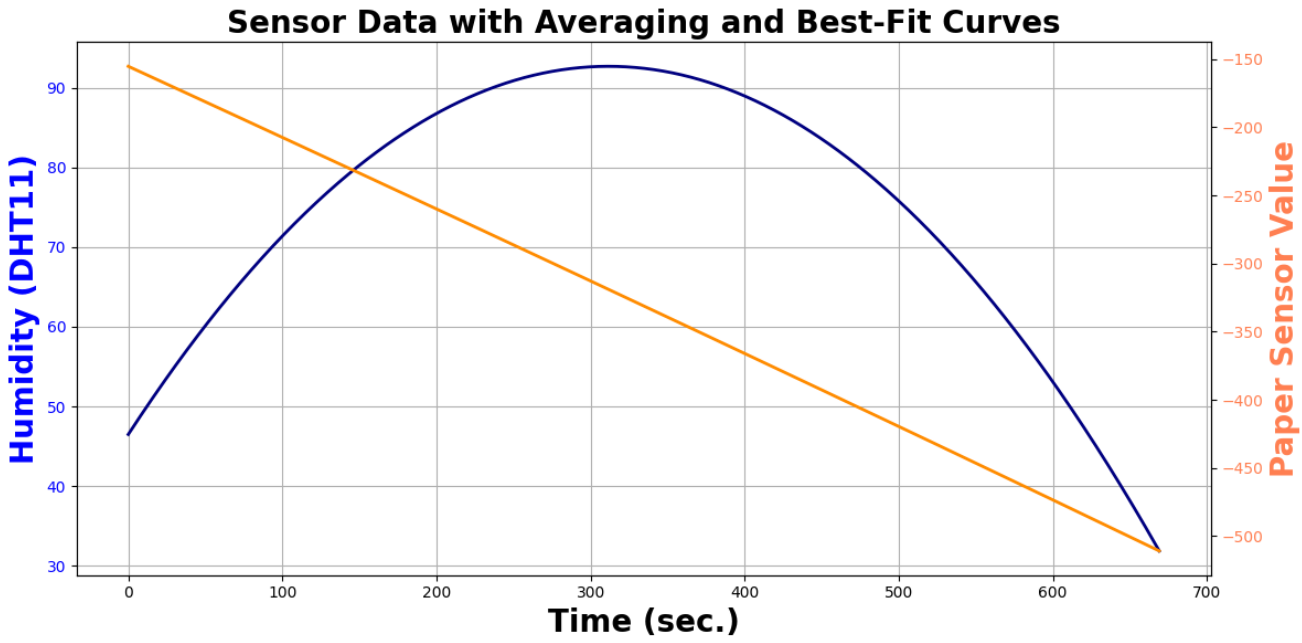
1. **Without Heat Pad:**
    - **Test 1: (Normal Paper)**



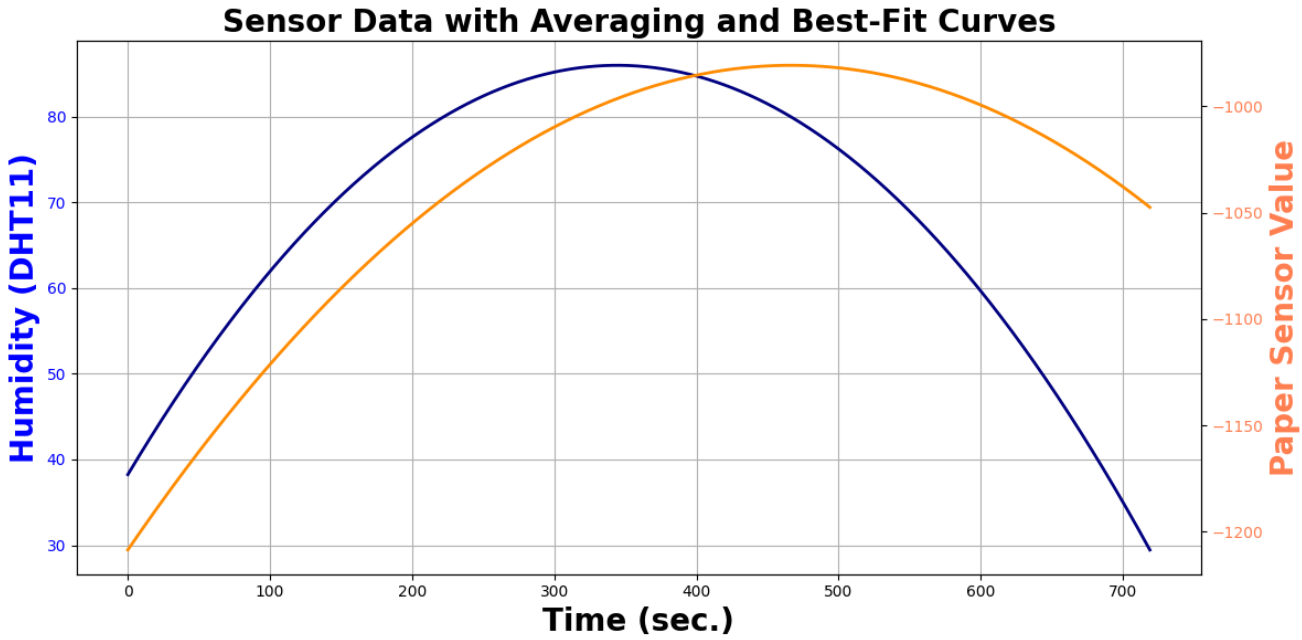
    - **Test 2: (Normal paper)**



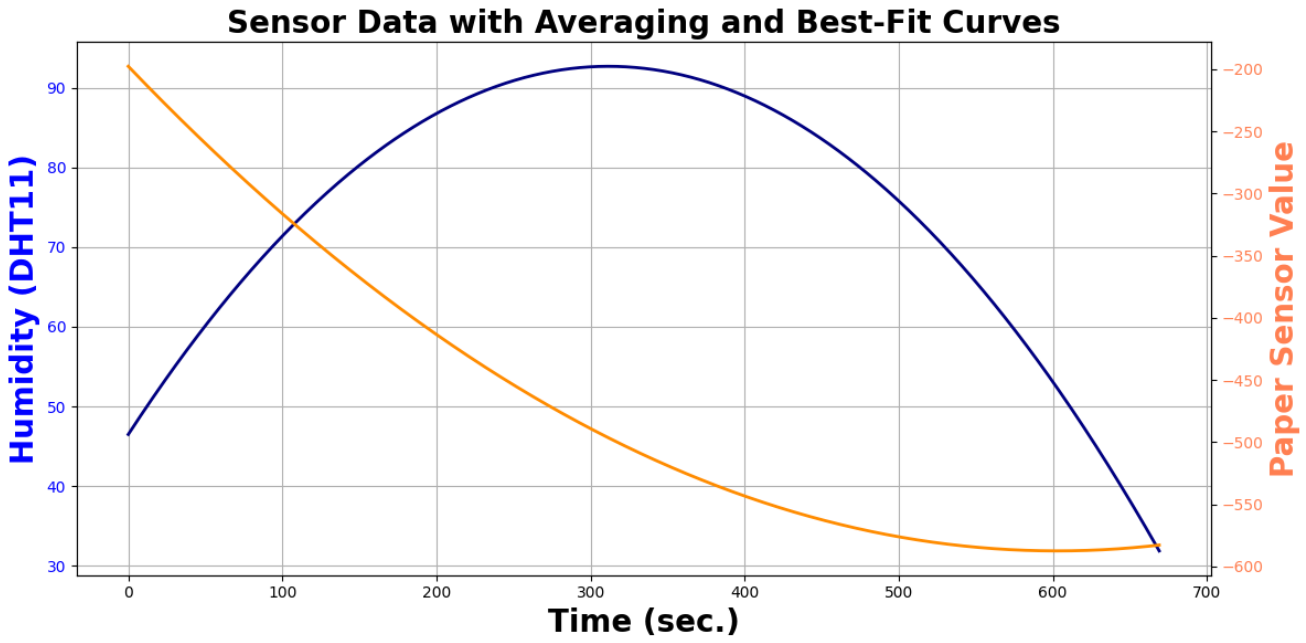
    - **Test 3: (Normal paper)**



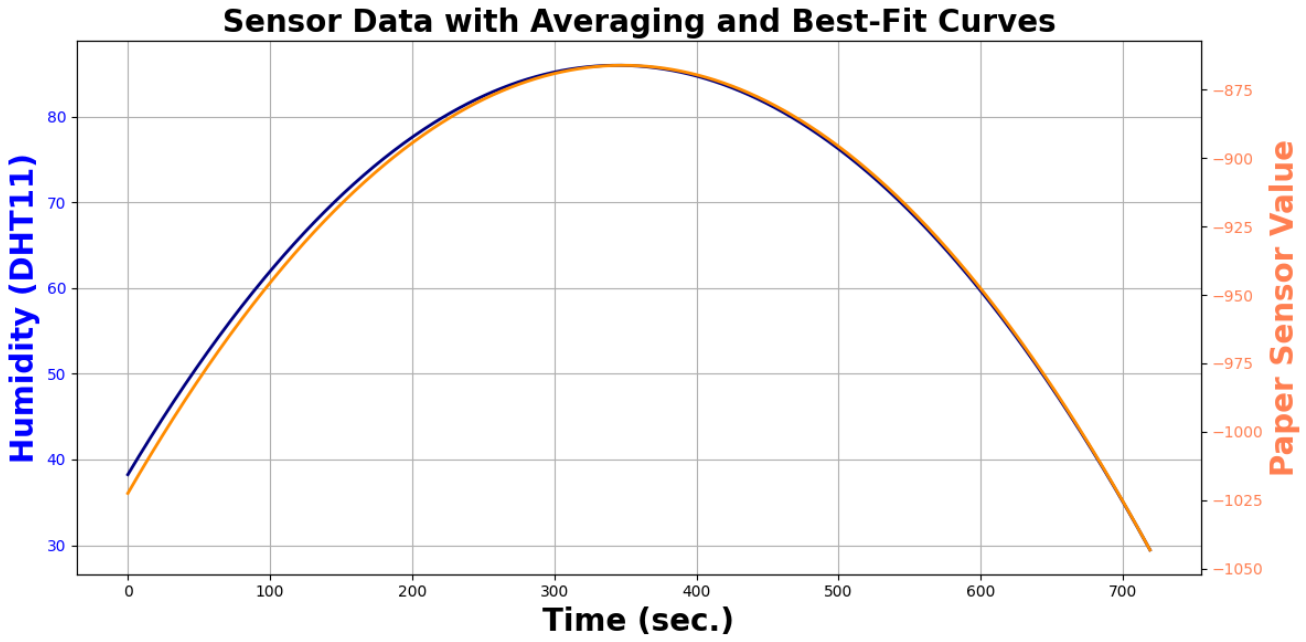
- **Test 1: (Hand Made paper)**



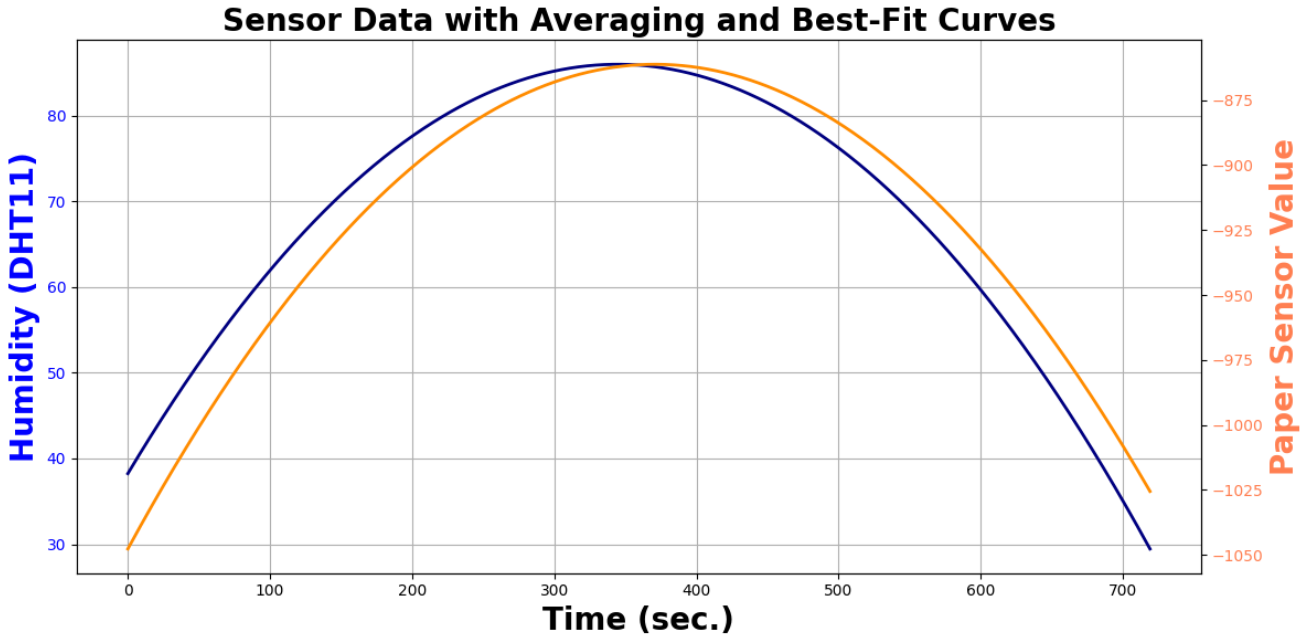
- **Test 2: (Hand Made paper)**



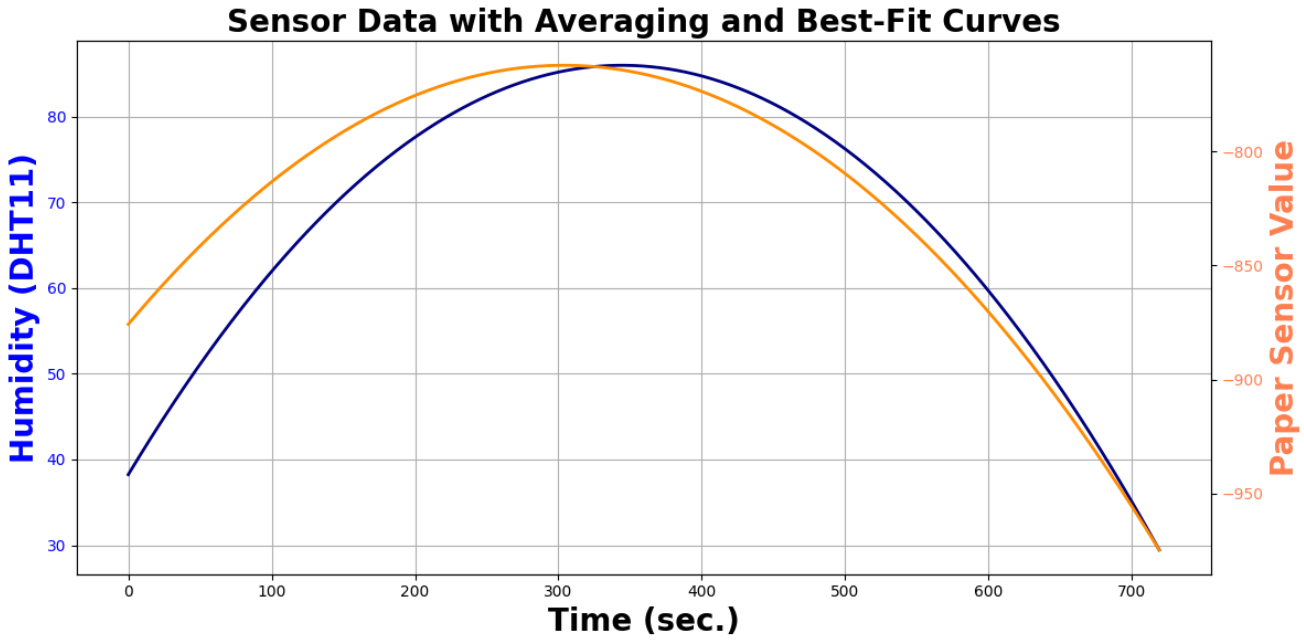
2. **With Heat pad:**
    - **Test 1: (Normal paper)**



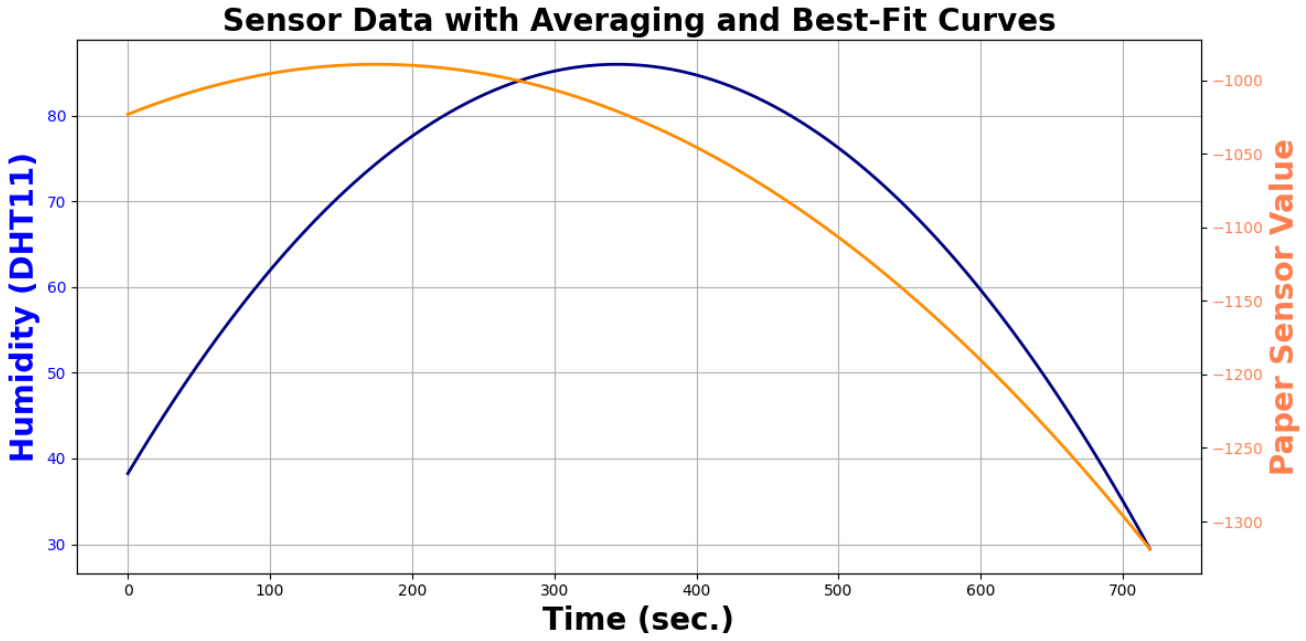
- **Test 2: (Normal paper)**



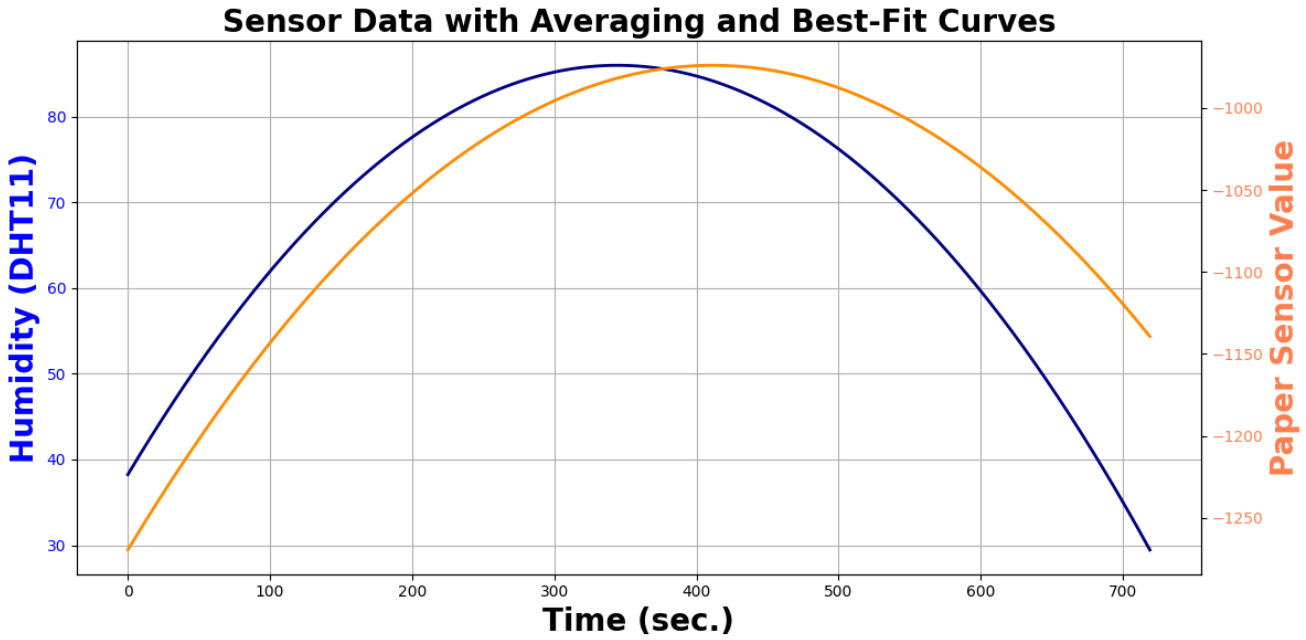
- **Test 3: (Normal paper)**



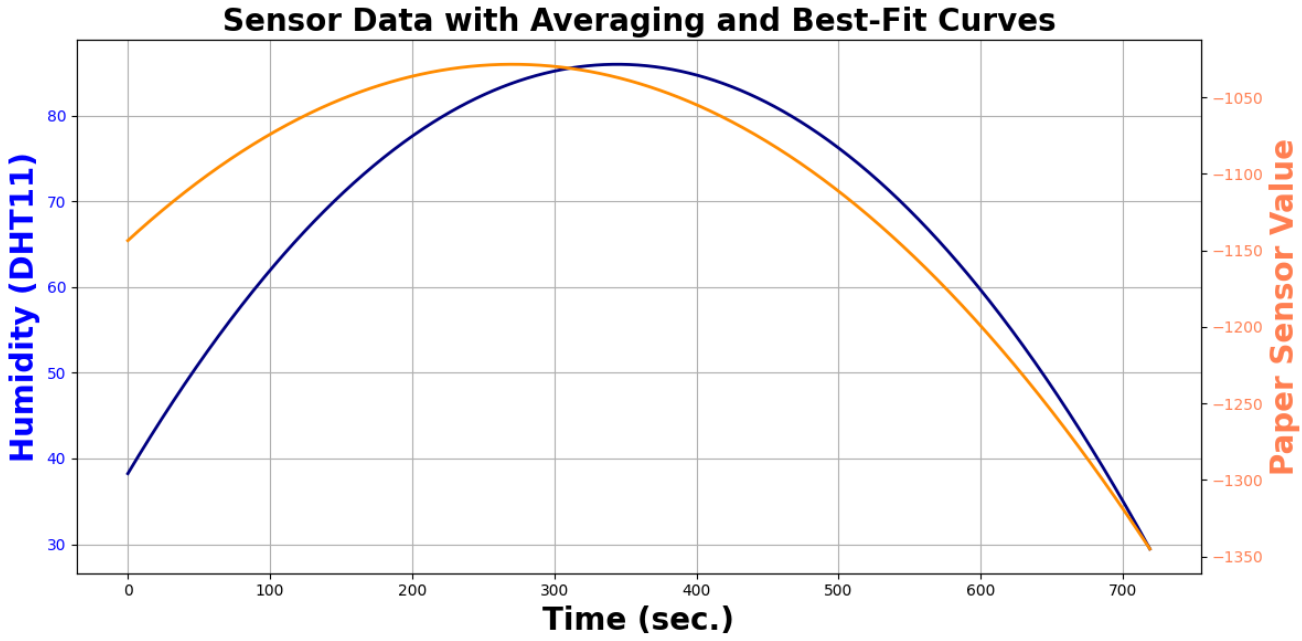
- **Test 4: (Normal paper)**



- **Test 1: (Hand Made paper)**



- **Test 2: (Hand Made paper)**



- **Test 3: (Hand Made paper)**