Thermistor Response and Thermal Contraction (Report #1)

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Introduction

The purpose of this experiment is to determine how a thermistor's resistance alters in response to temperature change and to test the mechanical properties of an Aluminum-6061 bar.

Two different frequencies are tested to compare the efficiency and accuracy of collecting data; one frequency is chosen to analyze the thermal contraction and temperature change in the aluminum bar at room temperature and ice water temperature. Interpreting the observations, graphs, and calculations will be incorporated to analyze how temperature alters the physical properties of Al-6061. This report will also document the procedures and equipment used to illustrate these experiments through qualitative and quantitative data.

Methodology and Procedures

1. Set up the lab station to record thermistor measurements; an Arduino Uno is connected to a laptop and a breadboard, of which the latter also has two resistors and thermistors clipped within. Once the coding “Sketch 4” is uploaded onto the Arduino and the software CoolTerm is receiving the correct port, recording can begin by selecting “Connect”.
2. Aside from the assembled circuit, a bucket with ice water was prepared as well as a steel bucket with an upright and measured Al-6061 bar submerged in water inside. The bar had the plunger of a dial indicator touching it at a 90 degree angle and was zeroed out via dial . When the time came, thermistors were attached to the top and bottom of the bar with insulating tape.
3. While waiting for thermistor readings to stabilize each time a change was made, separate text files were made for when:
    a. A thermistor was grasped by a hand in a sampling rate of 0.25 Hz and 200 Hz
    b. A thermistor was submerged in and swirled around in ice water
    c. Ice was gently added to the steel bucket

    For each smaller procedure, connection was stopped and captured using time stamps.

Results

<u>Lab 2 Data</u>

Sampling Rate .25Hz (°C)	Sampling Rate 200Hz (°C)
27.5	22.07
27.37	22.01
27.27	21.97
27.17	21.97
27.07	21.87
26.89	21.87
26.76	21.87
26.64	21.87
26.52	21.85
26.46	21.85
26.36	22.07
26.26	22.31
26.18	22.47
26.08	22.56
25.97	22.66
25.95	22.76
25.85	22.78
25.69	22.86
25.25	22.96
24.91	22.96
24.65	22.96
24.55	22.94
24.45	22.88
24.35	22.86
24.35	22.94
24.35	22.96
24.35	22.98
24.29	23
24.31	23.06
24.29	23.06
24.29	23.08
24.27	23.1
24.29	23.12
24.31	23.16
24.27	23.16
24.27	23.14
24.27	23.16
24.29	23.14
24.21	23.18
24.25	23.2
24.23	23.2
24.25	23.22
24.19	23.22
24.21	23.22
24.19	23.22
24.17	23.2
24.15	23.2

26.36	22.07
26.26	22.31
26.18	22.47
26.08	22.56
25.97	22.66
25.95	22.76
25.85	22.78
25.69	22.86
25.25	22.96
24.91	22.96
24.65	22.96
24.55	22.94

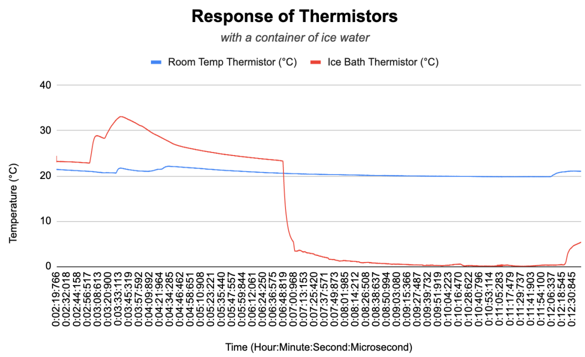
24.45	22.88
24.35	22.86
24.35	22.94
24.35	22.96
24.35	22.98
24.29	23
24.31	23.06
24.29	23.06
24.29	23.08
24.27	23.1
24.29	23.12
24.31	23.16
24.27	23.16

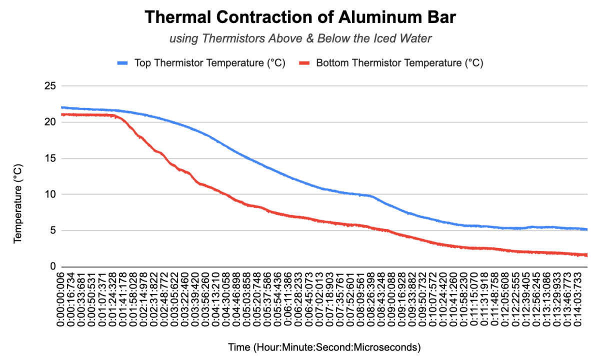
24.27	23.14
24.27	23.16
24.29	23.14
24.21	23.18
24.25	23.2
24.23	23.2
24.25	23.22
24.19	23.22
24.21	23.22
24.19	23.22
24.17	23.2
24.15	23.2

<u>Table 1:</u> Displays the thermistors range of temperatures when fingers were rapidly opened and closed on both thermistors at 0.25Hz and 200Hz sampling rates (SR). The SR value determines the amount of times per second a sample is recorded. Consequently, the 200Hz SR data logged temperature every second faster, providing more continuous data compared to the 0.25Hz SR data. The 0.25Hz data documented at a slower pace and had a larger pause between each recorded sample, shown on Serial Plotter.

Maximum Temperature for 0.25 Hz: 27.5°C | Maximum Temperature for 200 Hz: 22.07°C

Lab 3 Data





Graph 1 (Left): The intersection at which the ice bath thermistor crosses below the room temp thermistor displays a sharp decrease in temperature. Stabilized temperature for the ice bath thermistor was 1.5°C while the room temperature thermistor remained close to constant at 20°C.

Graph 2 (Right): Both thermistors exhibit an overall decrease in temperature when the aluminum bar is submerged in the ice bath.

Formulae:

Thermistor Resistance & Temperature Relationship:

The direct relationship between resistance and temperature can be seen as the thermistor temperature increases, so does the resistance (resistance ∝ temperature).

(1)

where B = coefficient of the thermistor, T_0 = initial temperature, T = final temperature, R_0 = initial resistance, and R = final thermistor resistance.

Linear Thermal Contraction Equation:

(2),

where, ΔL = change in length of Al bar measured by the dial indicator (in.), $\alpha_{act.}$ and α_{exp} = theoretical/experimental value of the thermal contraction coefficient of Al-6061 (/°C) respectively, ΔT = change in stabilized temperature (°C), = $(T_2 - T_1)$, and L_0 = original length of Al bar before contraction (in.).

{Known Values}:= 7.03 in., = 0.0027 in., $\alpha_{act.} = 24\times10^{-6}$/ °C, T_1 = 22.07 °C, T_2= 1.5 °C

Percent Error for Coefficient of Thermal Expansion:

(3) = % Error,

Time Constant for Temperature:

(4) $T(\tau)$ = -, Time Constant = 5 seconds

Ice Water TS (TS = time for stabilization) = 7 minutes

Aluminum Contraction TS = 11 minutes and 30 seconds

Average TS = 9 minutes and 15 seconds = 9.25

Calculations:

(2) → α_{exp} = , = $(T_2 - T_1)$ →= (22.07 °C - 1.5 °C) →= 20.57 °C

∴ α_{exp} = (0.0027 in) / [(20.57 °C) * (7.03 in)] → $\alpha_{exp} = 1.87\times10^{-5}$/°C

(3) → [|(1.87×10^{-5}/℃ - 24×10^{-6}/℃)| / (24×10^{-6}/℃)] × 100% = Percent Error = 22.1%

(4) T(τ) = - =22.07- (.632)(20.57 °C) = 9.06976. This occurs after an interval of 4.715 seconds. τ=4.715 seconds.

Discussion

From (1), its evident that the thermistor is a PTC (Positive Thermistor Coefficient), since temperature increases as resistance increases, demonstrated through the experiment of holding the thermistor between a set of fingers. Using (2) and (3), the percent error calculated is 22.1%. The results show a large percent error since the data from the the top thermistor came from another group. There could have been erroneous data since the tape didn't fully stick the top thermistor and the bar together. For Lab 3's ice water temperature, the time for stabilization is 7 minutes, while for the aluminum bar contraction, the time for stabilization is 11 minutes and 30 seconds, resulting in an average time of 9 minutes and 15 seconds. This discrepancy arises as a consequence of time needed to cool the bar. From (4), Given the time constant for this system is 4.715 seconds, temperature changes should be measured multiple times per second, in order to generate a meaningful data set. Increasing the temperature would increase the time constant, thus increasing the interval at which one could measure temperature changes and preserve accuracy. However, so long as noise is not dominating the signal, a faster sampling rate is preferential. A 22% error for the determination of constant of thermal expansion is very large. However, the thermistor was not flush with bar, meaning that the temperature measured was not very accurate.. To improve results, more attention should be paid to the attachment of the thermistor. Further accuracy could be obtained by insulating the thermistor from ambient temperature.

Conclusion

This lab required a PTC thermistor and from (1) it can be seen that the thermistor resistance is proportional to the temperature because when the thermistor temperature increase so does the resistance. The optimal sampling rate was found to be 200hz ,as indicated by Table 1, more frequent sampling of cycles gives a larger, continuous range of data with an average stabilization of 9.25. Furthermore, the system was found to have a time constant of 4.715s, meaning that a sampling rate of .25 hz would miss the majority of the temperature change. The thermal contraction of the bar was .0027in, indicating a coefficient of thermal expansion of α_{exp} = 1.87×10^{-5}/℃.