ASEN 2012 Project 1: Calorimetry

Andrew Logue
University of Colorado Boulder, Boulder, CO, 80309

The goal of this project is to use error propagation, the first law of thermodynamics, least squares extrapolation method, and provided temperature measurements to determine the specific heat of a sample material. By these methods the material from which the sample is made can be determined. The specific heat of the material was calculated to be 1.154 J/(gC), which matches most similarly to Aluminium 6061. Therefore it was concluded that the material undergoing the calorimeter experiment was most likely Aluminium 6061 based off of the provided specific heat capacity data.

Nomenclature

m_c	=	mass of calorimeter
m_s	=	mass of sample
c_c	=	specific heat capacity of calorimeter
c_s	=	specific heat capacity of sample
T_0	=	initial temperature of the calorimeter
T_1	=	initial temperature of sample
T_2	=	final temperature of the calorimeter and sample at equilibrium

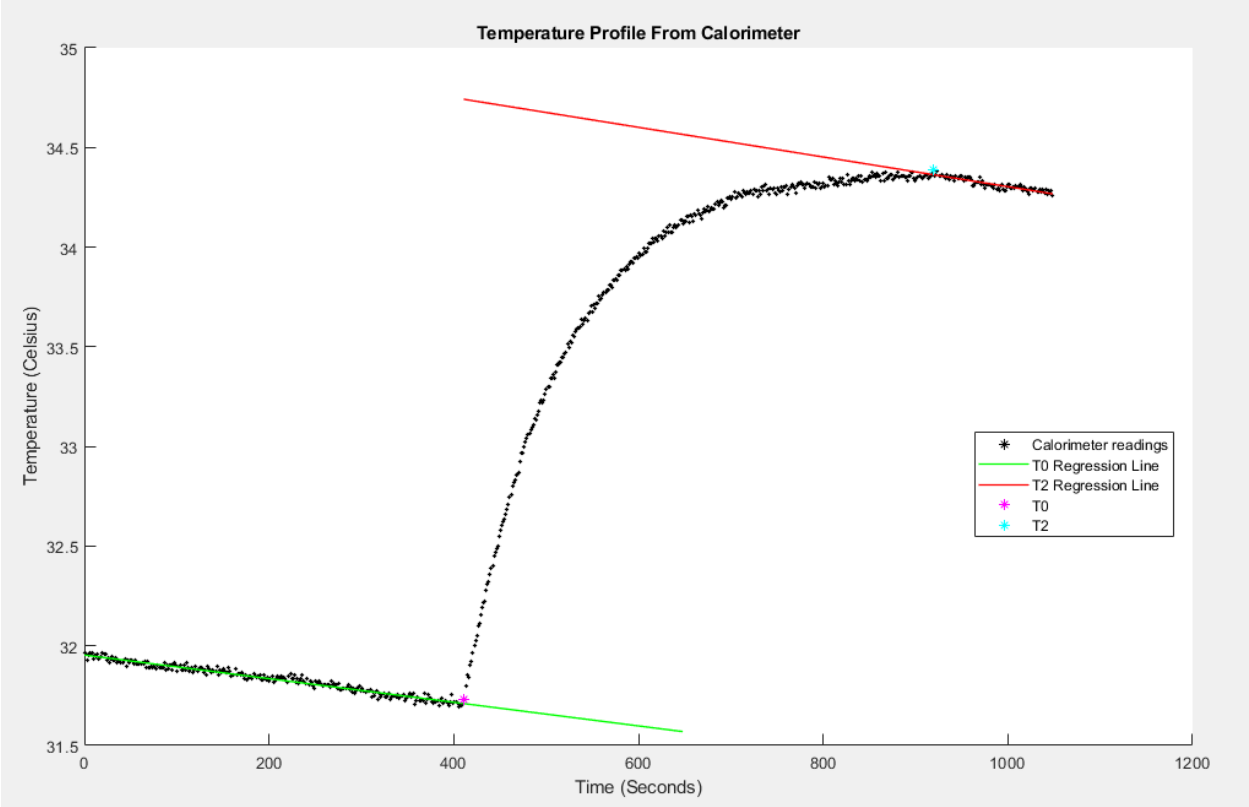
I. Introduction

The significance of this experiment is that Calorimeter readings can be used to identify unknown materials. Since calorimetry can be used to measure heat capacity and the approximate the amount of energy released/absorbed during a reaction, calorimetric methods and analyses are useful to us as engineers as they allow us to observe the first law of thermodynamics. Thus we are able to physically record and subsequently compare the amount of heat lost to the amount of heat gained by the two bodies. This system is helpful as it allows us to analyze the thermodynamic properties of different substances, and consequently what they are made of. This is done by determining the specific heat of the substance based off of the following equation:

$$C_{s,av} = \frac{m_c C_{c,av}(T_2 - T_0)}{m_s(T_1 - T_2)}$$

II. Experimental Method

The experimental method was applied to set up this project in order to identify the provided sample. First the properties of the calorimeter used were determined. The calorimeter is made of Aluminium 6061, with a specific heat of 0.895 J/(gC). The calorimeter was weighed to determine it had a mass of 510 grams, while the sample was weighed to determine it had a mass of 17.615 grams. Multiple thermal couples were placed to gather temperature data. One measured the temperature of the boiling water, one measured the ambient temperature of the room, and two measured the temperature of the calorimeter. The experiment was completed by placing the unknown sample in boiling water for approximately 10 minutes, which is then immediately placed in the calorimeter. The insulation is quickly replaced on the calorimeter, and the sample is left to sit for a few minutes while the thermal couples measure the heat transfer. These readings are then put into a csv file and read by my Matlab code in order to create plots which will show accurately the necessary data required for this project. The completed plot is attached below:



III. Results

Based on the completed graph above and my Matlab code, it can be determined that the initial temperature of the calorimeter is 31.73 degrees Celsius. Additionally, the initial temperature of the sample was found to be 93.96 degrees Celsius while the final temperature of the calorimeter and sample at equilibrium was found to be 34.39 degrees Celsius.

IV. Conclusion

These temperatures, along with the mass of the calorimeter, the mass of the sample, and the specific heat capacity of the calorimeter were then applied in the equation cited above. This resulted in me determining that the specific heat capacity of the unknown material was approximately 1.15 J/(gC). This led me to conclude that the material was most likely made of Aluminum 6061, the same material as the calorimeter. The table used to make this assumption is cited below:

ASEN 2012: Calorimetry candidate materials

Material	*Specific Head Capacity*	*Units*
Acrylic	1.47-1.5	J/(gC)
Zinc	0.402	J/(gC)
Aluminim 6061	0.895	J/(gC)
Copper	0.261	J/(gC)

The calorimeter is made of Aluminum 6061

V. Discussion

One major potential source of error in calorimetric data collection is the reliability of the insulation being used in the experiments. If the insulation absorbs too much heat, then the results and following analysis of the reaction being observed will be skewed. Therefore it is important to account for this by using an insulating material that has been proven to absorb a negligible amount of heat. Another potential source of uncertainty in calorimetric data collection is the transfer of the heated body into the insulation device, as depending on the material of the heated substance, it could lose thermal energy quickly during the transfer period, thus skewing the results. While there are some complex solutions that may be required depending on the material, such as heating the body directly in the insulation device, the experimenter can also account for this potential error by having fast hands.

VI. References

Jackson, J., "Project 1 Calorimetry ASEN 2012 Fall 2020", Oct. 2020.

Jackson, J., "CalorimeterData1", Oct. 2020.

Jackson, J., "ASEN201202._SampleAssignmentcsv", Oct. 2020.

Jackson, J., "Calorimetry values v2", Oct. 2020.

VII. Appendix