Thermocouple
Short Experiment
2015

Data collection

Introduction
In this experiment you will measure the temperature of a thermocouple as it is heat and cools. You will know (at least approximately) the starting and ending temperatures, so the emphasis is on understanding the heating and cooling of the thermocouples themselves. In addition, you will gain experience with using an analog to digital converter in a real experiment, collecting data with a VI, and analyzing the results.

Materials
You will have ice water (0°C), and recently boiled water (slightly below 100°C), baths to provide environments of known temperature. You will have two type E thermocouples connected to an A/D converter consisting of a NI-cDAQ-9174 chassis with a 9211 voltage recorder module. However, you should only need one of the thermocouples for the experiment (one spare). The converter is wired into a computer, where you will set up a VI and use it for data acquisition. In addition to making the analog to digital conversion, this unit can process thermocouple voltage and convert it into the corresponding temperature. We will take advantage of this capability here. [The alternative is to input the data to the computer without conversion and subsequently process the data in LabVIEW to convert from the thermocouple voltage to temperature.]

VI
You will be building a simple VI to acquire the measured temperature data. We will lead you through the process of building this VI during the lab.

Heating
Place your thermocouple into the ice water bath and give it a minute or two to equilibrate. Begin recording data (i.e. start your VI) and then remove the thermocouple from the ice water bath and plunge it into the hot water. (Handle and “plunge” your thermocouple carefully, if you move it too violently/quickly it may break and/or short and put large spikes into your data)

Cooling
Remove the thermocouple from the boiling water and use the heat gun (set on high) to dry the end of the thermocouple while also heating it. Begin recording data (i.e. start your VI) and then turn off the heat gun and let the thermocouple cool to room temperature.

Re-do
It is easy to repeat these experiments, so feel free to re-do them as needed to find good values for the sampling rate, number of data points, etc.

End of data collection portion of laboratory
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Analysis and reporting

Time constant determination
We expect the heating and cooling of the thermocouples in this experiment to follow approximately first-order behavior. (If you do not remember how this works, see Chapter 3 of the textbook). Moreover, in the experiment, you imposed something close to a step function change in the temperature. Therefore, the following equation is expected to fit the data:

\[ T = T_{final} + (T_{initial} - T_{final})e^{-t/\tau} \]  

where \( T \) is the temperature, \( t \) the time, and \( \tau \) the time constant of the system. (Note: this equation is just equation 3.5 from your textbook as applied to the current system). The time constant depends on the physical properties of the thermocouple and the heat transfer coefficient. (But, to the extent this model is correct, should not depend on the initial and final temperatures.)

Report
Report your results by responding to the following points (a formal lab report is not necessary).

1) Based on your results, find the two time constants (one for heating and one for cooling). [Note: See the textbook, pages 85-88, for help with how to best do this.]

2) Provide a temperature vs. time graph of your heating data. Also show a model prediction based on fitting a first order model to your data using the value of the time constant for heating.

3) Provide a temperature vs. time graph of your cooling data. Also show a model prediction based on fitting a first order model to your data using the value of the time constant for cooling.

4) Why do you think the time constants for heating and cooling are so different (assuming they are)?