Thermal Conductivity Meter

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INTRODUCTION

In heat transfer applications thermal properties of different materials are necessary when solving problems. Knowing the thermal conductivity of an object is an important preface to many physical and mechanical processes where thermal stresses may be a concern. To this end, we have been tasked by Dr. Sumner to design and build a thermal conductivity measurement device using the cut-bar method. This device must be able to accurately measure the thermal conductivity of solid materials and stream the collected data to connected computers, making it a simple device to incorporate into labs and research.

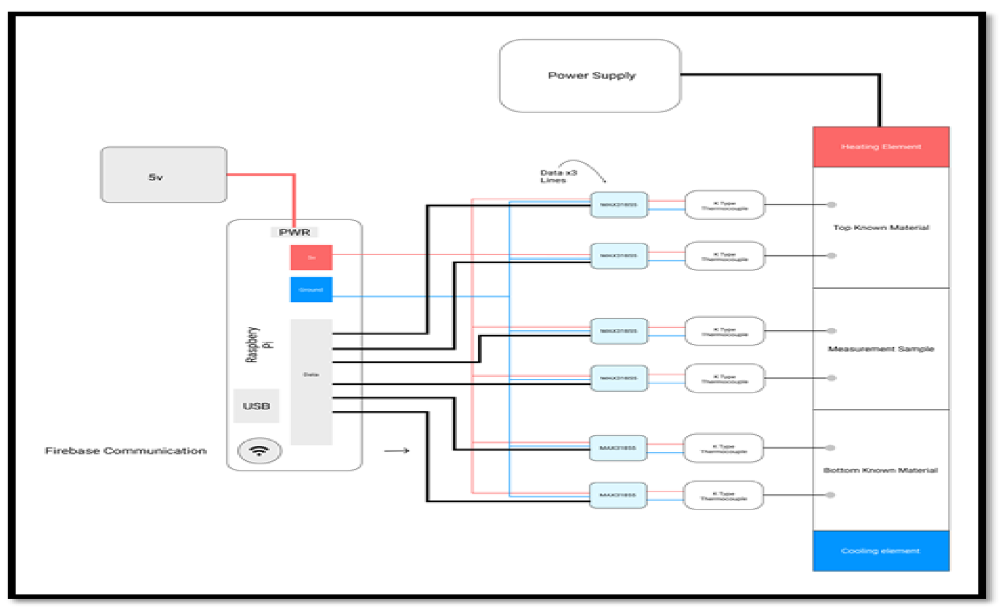

Figure 1: System Diagram

METHODS

Controls Portal

The controls portal consists of a display that mirrors the measurement device with 3 sections and 2 display per section. Each display updates in real time and corresponds with a physical thermocouple on the device. Additionally, the website has text boxes and buttons that act as the heater wattage and power controls.

Raspberry Pi

The data acquisition code is written in Python 3. Python was chosen because of its unique property of being compatible with Firebase (through the pyrebase module), its easy access to the Raspberry Pi's GPIO, and its low coding time due to it not being a compiled language.

Assemblage

Figure 3 depicts how the apparatus was assembled for the intent of testing. Bases, plates, and heating elements were assembled in a way as to allow the meter bars and samples to be inserted and pressed tightly between the two. Thermocouples that were permanently joined to the heating element would then be connected to the data acquisition system and the appropriate wires would be connected to the power supply to provide a one directional heat flow. Once the data is collected from the thermocouples, the programming portion runs the code to calculate K. This calculation is based on the temperatures being recorded from the power input, locations of thermocouples, and the cross-sectional area of the sample.

RESULTS

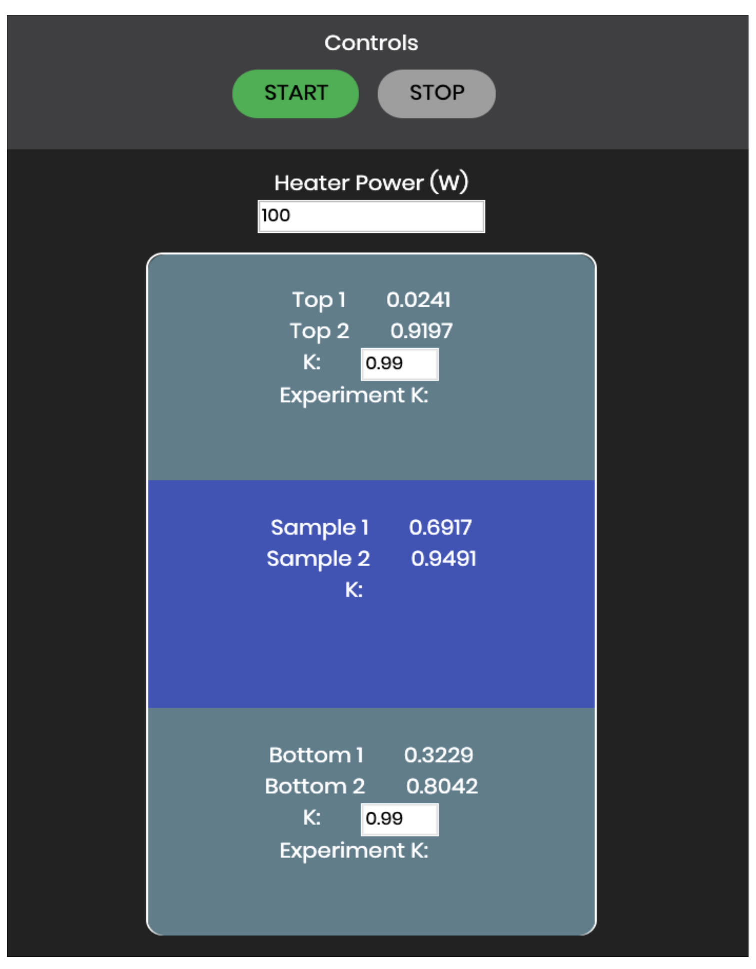

Figure 2: Website

All equipment used in the prototype passed the check and worked as expected, so we were able to rule out hardware functionality as a problem early in the construction process. The heating elements were tested to see if they could reach the temperatures necessary to calculate the thermal conductivity of our known samples, and after some minor adjustments, they were able to with no problems. The cooling system, however, was pre-existing lab technology, and its cooling abilities were assumed, but never tested with the heating elements due to the fact we could no longer enter the lab. The full heat transfer system worked separately but because it was never tested together, we can't say it completely passed. The program runs a simulated version of the apparatus and displays the temperatures, and power output of the heating element in easy to read way. The program does not display k values yet because the temperatures and power output aren't yet coming from the apparatus. Due to current issues, the full apparatus could not be constructed, so it couldn't be tested.

Figure 3: Apparatus

CONCLUSIONS

The goal of this project was to gain a better understanding of thermal transport properties, more specifically thermal conductivity, for different materials. Due to corona virus, the project couldn't be fully constructed, but the DAC and Web server are as complete as possible. We failed to deliver an actual measurement apparatus, but what we did complete can easily be attached to one to finish the device for lab use. The device could be furthered in the following ways: Adding multiple devices to the DAQ and web server using firebase's unique id system., using firebase's authentication services to make user accounts for lab use (this should be required as a security step for any future project), and by using firebase functions to encrypt any sensitive data.

FUTURE WORK

The system is almost feature complete, with the one thing that was not implemented being the gathering of data from the thermocouples. This feature was not implemented because COVID19 completely cut off the Raspberry Pi from interfacing with the measurement device. If a separate group would want to pick up this project in the future, all they would have to do is connect the thermocouples via the Raspberry Pi GPIO and update the associated method in the script.

ACKNOWLEDGMENTS

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