Abstract:

The properties of an acetone-based heat pipe constructed from a glass tube and insulation are detailed in this report. The heat pipe was tested in a variety of configurations and conditions—with and without a condenser, at different temperatures and with different volumes of acetone—and ultimately optimized for maximum power throughput with the hot end at 65 deg C. The performance of the heat pipe was tested with a power resistor and thermocouples.

Introduction:

Our laboratory group was tasked with creating the most efficient heat pipe possible using a glass tube, rubber stopper, insulation, and water. Finding water’s boiling point to be too high for our purposes, we opted instead to use acetone, and to machine an apparatus to improve the contact of the power resistor (a stand-in for the heat supplied by a CPU) with the glass tube. Using these methods, we were able to achieve the second-highest efficiency of fifteen teams with the same resources at 65 deg C.

Body:

To establish a baseline, we attempted to measure the thermal conductivity of the empty glass tube by insulating the rod, heating it at one end with the power resistor, and calculating conductivity based on the temperature gradient established. However, we were unable to raise the temperature of the power resistor to a point where the end temperature of the rod rose above room temperature, making it too difficult to measure the conductivity of the tube in this configuration. A better insulated system, improved contact between the glass tube and power resistor, more sensitive thermocouples, and shorter rod would have made this task easier.

Measurements were also taken with a few centimeters of liquid acetone inside of the tube, and a small amount of boiling acetone. RESULTS RESULTS RESULTS.

The heat pipe operated at maximum efficiency when a condenser was introduced into the system, the pipe was as thoroughly insulated as possible, AMOUNT AMOUNT AMOUNT of acetone was used (placed in the heat pipe, raised to the boiling point, and allowed to depressurize slightly be briefly removing the stopper) and a copper piece was machined to improve contact between the glass tube and power resistor. In this configuration, we found that the heat pipe dissipated AMOUNT AMOUNT AMOUNT when raised to a temperature of 65 deg C, the target temperature. The cold end of the heat pipe was also attached to a copper heat sink modified to fit the pipe as closely as possible. The power dissipated was calculated based on the resistance of and voltage across the power resistor. In all likelihood, the actual power through the heat pipe was less than this, due to thermal contact resistance between the resistor and the glass pipe.

The bottleneck of the heat pipe was the heat pipe itself, as opposed to the cooling element or the link between power resistor and glass tube. The heat pipe was capable of dissipating in excess of 15 W when the temperature was allowed to rise above 65 deg C. While decreasing the resistance between glass and power resistor or improving the cooling element of the heat pipe would have increased efficiency, it was not immediately obvious to us how to do so: custom pieces were machined in each case. Water-cooling the heat sink was one option we did not have time to thoroughly explore.