CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
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Project Number
J1308

Project Title
Heat Be Gone: A Study of Heat Transfer in Metal Foams

Abstract

Objectives/Goals
To discover how heat moves through porous metal foams, why some work better as heat sinks or insulators than others, and how changing porosity, density, pores per inch (PPI) and shape affect effectiveness in dissipating heat.

Methods/Materials
I tested the steady state heat flow of foams of different materials, pores per inch (PPI), pore densities and shapes. Three tests where conducted: free convection, forced convection test (fan), and wet convection. Other tests were conducted: free convection tests of various shaped, finned and plated structures. Materials: Corning PC-35 hot plate, Ryobi infrared digital thermometer, ruler, timer, bladeless fan (air speed 1.2 meters per second calculated),various copper, aluminum, and carbon foams from ERG Corp. sample kit with technical data. Measured temperature every half-inch up the foam.

Results
Overall, the smaller the PPI, the less air got through the foam and the more surface there was for convection. In wet test, evaporative cooling was more effective than free convection and forced convection, while forced convection was more effective than the free convection test. In fin test an inch from the left and right of the center of the fin (beyond the base) the temperature dropped. In solid plate test, having plate touch heat source was more effective than foam touching hot plate. On the vertical copper 20PPI foam cylindrical doughnut test, it was overall cooler than the 20PPI copper foam square. In horizontal foam test doughnut test doughnut was the same temperature as the 20PPI copper foam square. In the carbon insulator test the higher the PPI, the better the foam acted as an insulator.

Conclusions/Discussion
Desirable in foam heat sink is a balance between a large PPI for large outside surface area convection and a small PPI for large longitudinal conduction through the foam. I could note in concept the effects upon Nusselt, Rayleigh, and Prandtl numbers with changes in foam type and experiment type. A finned foam would be a good consideration because of more surface area to dissipate heat. Evaporative cooling, or wetting the foam is a successful way to dissipate heat. If plated on one side it is better to have plate at the heat source. If a cylindrical doughnut foam were to be used as a heat sink it would be more effective to place the foam vertically than horizontally. If a foam were to be used as an insulator use a larger PPI.

Summary Statement
The purpose of my experiment is to explore heat transfer in various types of porous metal foams.

Help Received
Borrowed hot plate from a lab and took it home. Metal and carbon foam sample kit was provided by ERG Corp. Mother proofread report. Science teacher helped me put procedures together.