CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)

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Project Number

S0202

Project Title

Convection and Heat Transfer in Ferrofluid

Abstract

Objectives/Goals

The purpose of our experiment is to demonstrate the benefits of convection and heat transfer in ferrofluid, a magnetic liquid. We will show 1) a plan for a ferrofluid heat transfer experiment that we designed to fly on the space shuttle next year as an extension of our experiment. Our team won the 2002 NASA Student Involvement program competition in the Space Flight Opportunities category that allows us to fly our experiment on the space shuttle. We will also demonstrate 2) a set of ground experiments to show convection in ferrofluids without the help of gravity, 3) a computer simulation of ferrofluid heat transfer that we wrote, and 4) a completely passive, non-mechanical ferrofluid heat pump.

Methods/Materials

We tested convection and heat transfer in ferrofluid by measuring the temperature difference between two sides of a container of ferrofluid with an elecrical bridge circuit. We used plastic containers, electric heaters, and permamnent magnets in our experiment. We also wrote a computer simulation program to simulate heat transfer in ferrofluid. We used the finite element method to solve the one- and two-dimensional heat transfer differential equations. We wrote our code in C++.

Results

We developed an experiment to test ferrofluid convection in space; this experiment will be launched on the space shuttle next year. We sent our flight ready experiment to NASA this month. We also have developed and tested a ground experiment that shows that convection and convection-based heat transfer can occur in ferrofluid without the help of gravity. Classical convection does not occur without gravity, but through our experiments we proved that convection can be created using ferrofluid and used to induce heat transfer in microgravity. In addition, we have built a heat pump device that uses ferrofluid for non-mechanical, passive heat transfer. We wrote a C++ computer program to simulate heat transfer in ferrofluid. We have compared our simulation results to our measured data. They are in good agreement.

Conclusions/Discussion

From our research, we have found that it is possible to induce convection and improve heat transfer in ferrofluid without gravity. The system requires only a heat source and a permanent magnet. Ferrofluid based convection and heat transfer can also be used to build a completely passive and non-mechanical heat pump. Heat transfer in ferrofluid can be accurately simulated by computer models.

Summary Statement

We demonstrated that in ferrofluid, convection can be created without the help of gravity, and heat transfer can be improved.

Help Received

Dr. Finlayson of University of Washington supplied ferrofluid; Mr. Gussin of Raytheon Co. helped assemble circuit board; Dr. George Valley of Aerospace Co. and Dr. Peter Petre of HRL helped with consulation