CALIFORNIA STATE SCIENCE FAIR
2003 PROJECT SUMMARY

Name(s)
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Project Number
S1223

Project Title
One and Two-Dimensional Finite Element Analysis of Heat Transfer and Applications to Ferrofluid

Abstract

Objectives/Goals
The purpose of the research project was to develop a one and two-dimensional finite element analysis of heat transfer and applications for ferrofluid. In detail, the problem was to develop a fast and accurate numerical analysis which can calculate temperature distribution in a container of ferrofluid over time. The need for a ferrofluid heat transfer and convection simulation program arose during my team NASA Student Involvement Program (NSIP) project to develop a microgravity ferrofluid heat transfer experiment and a passive ferrofluid heat pump.

Methods/Materials
I used the implicit time marching finite element method to simulate heat transfer in any material, including ferrofluid. I started with a one-dimensional finite element solution, and after gaining experience with programming the finite element algorithm, I moved on to develop and program in C++ the two-dimensional finite element solution. I compared the simulation results with actual experimental data experiment for heat distribution in ferrofluid over time from my team NSIP experiment.

Results
I simulated the temperature distribution as a function of time in ferrofluid for both the one and two-dimensional models. I verified my simulation results with experimental data collected from my team project. I ran simulations and compared measured experimental data with simulated data from both a simulation of heat transfer by conduction only, and a simulation of heat transfer by convection and conduction. The simulation results were in good agreement with the measured data, indicating the power of this simulation method.

Conclusions/Discussion
In conclusion, I successfully developed the one and two-dimensional computer simulation program of heat transfer in ferrofluid, and my simulated results match measured results from an actual experiment.

Summary Statement
I successfully developed a one and two-dimensional finite element analysis of heat transfer and applied it to the problem of heat transfer in ferrofluid.

Help Received
Proffessor Finlayson at University of Washington supplied ferrofluid for experiments, and provided me with the ferrofluid convection equations.