AN ABSTRACT OF THE THESIS OF

Carlos Francisco Cruz-Fierro for the degree of Master of Science in Chemical Engineering presented on April 2, 2003.

Title: Coupled Momentum and Heat Transport in Laminar Axisymmetric Pipe Flow of Ferrofluids in Non-Uniform Magnetic Fields: Theory and Simulation.

Abstract approved: ____

Goran N. Jovanovic

The effect of a non-uniform magnetic field on the coupled transport of momentum and heat is studied for the case of laminar pipe flow of a magnetically susceptible ferrofluid. The momentum and heat transport equations are complemented with the necessary electromagnetic terms and used to develop a computer simulation of the velocity profile and temperature distribution in the fluid.

Two magnetic field configurations are studied. The first configuration is produced by a single short solenoid, located around the pipe. The magnetic field produced has both radial and axial components. For the second configuration, the electric current is inverted in one half of the solenoid, creating much stronger field gradients in both directions.

The flow is laminar, driven by a constant pressure difference between the ends of the pipe. The apparent viscosity of the ferrofluid is modeled as

dependent on temperature and magnetic field. In simulations involving heat transfer, a section of the pipe is maintained at higher constant temperature. The rest of the wall is adiabatic.

A Visual-Basic code, FiRMa (**F**low **i**n **R**esponse to **Ma**gnetic field), was developed to perform the numerical simulations.

For the water-based ferrofluid, results show reduction of average velocity and small deviations from the parabolic velocity profile as the result of vortex viscosity. Heat transfer calculations show a decrease in the heat transfer coefficient and an increase in the fluid exit temperature. These effects are due to the change in flow pattern and average velocity.

Current research aims for the development of a stable liquid-metal based ferrofluid, because of the high electric and thermal conductivities. The FiRMa code is used to examine the expected response of a mercury-based ferrofluid to the magnetic fields under study. Results show that the electromagnetic effects on the liquid metal-based ferrofluid are much stronger, due to induced electric currents and the Lorentz force acting on them.