THE EFFECT OF NANOPARTICLE COATING AND CLUSTERING ON THE THERMAL CONDUCTIVITY ENHANCEMENT OF NANOFLUIDS

By

Michael J. Fornasiero

An Abstract of a Thesis Submitted to the Graduate
Faculty of Rensselaer Polytechnic Institute
In Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
Major Subject: MECHANICAL ENGINEERING

The original of the complete thesis is on file
In the Rensselaer Polytechnic Institute Library

Approved:

Diana-Andra Borca Tasciuc
Thesis Advisor

Rensselaer Polytechnic Institute
Troy, NY

January 2010
(For Graduation May 2010)

ABSTRACT

Nanofluids are engineered colloidal suspensions of nanometer-sized particles in a carrier fluid and are receiving significant attention because of their potential applications in heat transfer and thermal management. Theoretical and experimental investigations have shown that the enhanced thermal conductivity observed in nanofluids can be due to nanoparticle clustering and networking or chaining. This provides a low resistance path to the heat flowing through the fluid. However, the surface coating of the nanoparticles, which is often used to provide stable dispersion over a long period of time, may act as a thermal barrier, reducing the effective thermal conductivity of the nanofluid. Moreover, nanofluids with the same type/concentration of nanoparticles may exhibit different effective thermal conductivities, depending upon the thermal properties and thickness of their surface coating and the quality of their dispersion. In this context, thermal conductivity characterization of well dispersed iron oxide nanoparticles of 5-10 nm in diameter and two different surface coatings was carried out employing the transient hot wire technique. The functionalized surface coatings used were carboxymethyl dextran (CMX) and aminosilane. In both cases, the measured effective thermal conductivity was higher than predictions based on Maxwell theory, but much lower than that reported in literature for similar iron oxide nanofluids. This suggests that nanoparticle coating may have a significant effect on the effective thermal conductivity of nanodluids. Tests were also performed to gain insight in the effects of nanoparticle chaining on the overall thermal conductivity of nanofluids employing a magnetic field of varying strength to align the particles. Two types of commercial magnetic nanofluids (FluidMAG CMX and EHF-1) and a magnetorheological fluid prepared in house were tested. For these tests the transient hot wire cell was placed within a homemade coil arranging the hot wire to be perpendicular to the magnetic field lines. Results of thermal conductivity testing in a varying magnetic field showed a negligible change in thermal conductivity for both nanofluids, while tests performed on the MR fluid sample showed a minor increase (~3%) with increasing magnetic field strength. The thermal conductivity enhancement in the MR fluid is likely caused by the formation of particle chains due to the applied magnetic field, while the lack of enhancement in the nanofluid samples is a possible

indication of nanoparticles remaining stable in suspension and not aligning in chain like structures.