The Apparent Thermal Conductivity of Liquids Containing Multi-Wall and Double-Wall Carbon Nanotubes: A Critique

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There have been conflicting statements in the literature of the last twenty years about the behavior of the apparent thermal conductivity of two- or three-phase systems comprising solid particles with nanometer dimensions suspended in fluids. It has been a feature of much of the work that these multi-phase systems have been treated as if a single-phase fluid and that the thermodynamic characteristics of the system have varied even though the systems have been given the same name. These so-called nanofluids have been the subject of a large number of investigations by a variety of different experimental techniques. In a recent paper, we critically evaluated the studies of seven of the simplest particulate/fluid systems; Cu, CuO, Al2O3, and TiO2 suspended in water and ethylene glycol. Our conclusion was that when results for exactly the same thermodynamic system, are obtained with proven experimental techniques, the apparent thermal conductivity of the nanofluid exhibits no behavior that is unexpected and inconsistent with a simple model of conduction in stationary, multiphase systems [1]. The wider variety of behavior that has been reported in the literature for these systems is therefore attributed to ill-characterization of the thermodynamic system and/or the application of experimental techniques of unproven validity.

In this work the enhancement of the apparent thermal conductivity of water or ethylene glycol when multi-wall (MWCNT) or double-wall carbon nanotubes (DWCNT) are added to the liquid phase, is investigated. These systems differ from those containing near spherical particles because solid/solid contact and extended conductive pathways in the solid are much more important. The aim is to examine whether the wide variety of behavior that has been reported in the literature for these systems has also to be attributed to ill-characterization of the thermodynamic system and/or the application of experimental techniques of unproven validity, or whether the heat transport processes are genuinely different in different geometries and on different timescales as might be expected from this particular kind of multiphase system.

References

[1] Hamilton, R. L.; Crosser, O. K, *I & EC Fundamentals*, **1962**, 1, 187-191.