Abstract

Suspension of nano-size particles (<100 nm) in fluids, usually termed as nanofluid, are known to show higher thermal conductivity as compared to the base fluid. The thermal conductivity enhancement in the nanofluids reported by different investigators, often vary over a wide range. The present work aims to identify the cause of this wide variation. In course of the present work it was discovered that the thermal conductivity enhancement of nanofluids depends not only on the volume fraction, size distribution and shape of the nanoparticles, base fluid, surfactant addition, temperature, and sonication time, but also on the container material and the type of the measuring technique used.

Four different type of nanoparticles (Ag, NiAl, α-Al_2O_3, and γ-Al_2O_3) have been dispersed in base fluids to prepare nanofluids. The average and local thermal conductivity of water-based Ag and NiAl nanofluids held in polypropylene and metallic containers using transient hot-wire method revealed a new phenomenon. The local thermal conductivity of water-based Ag nanofluids significantly varied with position in the metallic container, but not in the polypropylene container. This observation has been attributed to the electric charge development (inferred from cyclic voltammetry) on the surface of the metallic container, which resulted in high concentration of metallic nanoparticles near the container wall as compared to the centre of container. Similar observation has been found in the case of water-based NiAl nanofluid, but not in water-based Al_2O_3 nanofluid (Al_2O_3 does not have free electrons). Similarly, this phenomenon was not observed for ethylene glycol based Ag-nanofluid, due to charge neutralization by ethylene glycol on the container wall.

A wide difference has also been observed in the thermal conductivity of Ag, α-Al_2O_3, and γ-Al_2O_3 nanofluids when measured by transient hot-wire and laser flash methods. This anomaly has been quantitatively resolved on the basis of the collision mediated heat transfer model of nanofluid. Collision mediated heat transfer model revealed that significantly smaller size of liquid pool (~ 50 µl) used in laser flash method, as compared to that liquid pool available in the transient hot-wire method (~ 50 ml), results in significantly lower frequency of collision of nanoparticles with the wall of heat source. This, in turn, results in significantly lower enhancement of thermal conductivity in the laser flash method. This analysis also gives an indication that the nanofluids are unlikely to be effective for heat transfer in micro-channels.

Keywords: Nanofluids; Thermal conductivity; Container material; Transient hot-wire method; Laser flash method; Collision mediated heat transfer model.