Analysis on the Thermal Performance of Nanofluids As Working Fluid With Porous Heat Sinks: Applications in Electronics Cooling

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Abstract: The enhancement of consumer and industrial electronics has led to an increase in both the power and compactness of the products available. However, with these increases follows a subsequent increase in the thermal losses experienced across, for example, a central processing unit (CPU). As well, the need to dissipate waste thermal energy is compounded by the increased compactness. As the chipsets become smaller, the threads contained therein also reduce in size and as such become more sensitive to temperature gradients which can cause deformation. Although this deformation is miniscule, its continuous repetition can ultimately result in a thermally induced fatigue failure of the components. The objective of the following is to determine the effectiveness of Nanofluids to enhance heat transfer in electronics applications with porous foam metal heat sinks. The Nanofluid used in subsequent experiments was prepared by MKNano and is composed of γAl_2O_3 Nanoparticles, with water as a base fluid. The porous media sample employed for the experiment was synthesized by ERG aerospace and is composed of 6061-T6 aluminum, with a linear pore density of 10 pores per inch (PPI), and a relative porosity of 0.9. The experiment utilized a heater with controlled constant heat-flux to simulate an intel i7® CPU. The simulated chipset had a surface area of 0.00129 metres squared, this value being consistent with that of the manufacturer. The heat flux into the heater was calculated using the power into the heater and the aforementioned area. The second control parameter within the experiment was the flow rate of the working fluid across the heater. The flow rate was measured using a rotameter with readings sent through a data acquisition unit for recording. In order to establish a baseline for comparison the experiment was first performed using water as the working fluid with the porous sample, the subsequent test was performed using the aforementioned Nanofluid with a Nanoparticle concentration of 0.4% by volume. When the two tests were performed and compared it was observed that under similar test conditions, i.e., same flow rate and inward heat flux, that the Nanofluid absorbed more thermal energy than the corresponding experiment with water. The amount of thermal energy which was absorbed by each working fluid was determined as a function of the mass flow rate, the average thermal capacity of the fluid, and the change in temperature between the inlet and outlet of the test section. The mass flow rate was determined based on the fluids average density and the previously mentioned volumetric flow rate recordings. On average the Nanofluid was noted to remove an additional 7.3 percent of thermal energy when compared to water. However, it is worth noting that this increase in dissipated energy came with an average viscosity increase of 4.8 percent across the same trials. This increase in viscosity can of course be tied to an increase in the required pumping power of the system. Ultimately, it can be seen based on the above analysis that the use of Nanofluids does prove to be a valid option for further pursuit in the study of electronics cooling where the pumping power be allowed to fluctuate.

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