ABSTRACT

The thermal loads are increasing in a wide variety of applications like microelectronics, transportation, lighting, utilization of solar energy for power generation, etc. Micro-electro-mechanical systems (MEMS) technology and nanotechnology are also rapidly emerging as a new revolution in miniaturization. Heat exchangers play a very important role in energy conversion, transmission, and utilization. Hence, the management of high thermal loads in these systems offers challenges and the thermal conductivity of heat transfer fluid has become vital. Microchannel is a device used to remove high fluxes from smaller area. Different phenomena have been observed in various works indicating the friction factor characteristics and heat transfer characteristics of micro channels are still not understood clearly. The fluid flow and heat transfer phenomena deviate significantly from the prediction of conventional theories of fluid mechanics. The transition and laminar heat transfer behavior in micro channels are very unusual and complex and they are strongly affected by liquid Parameter like temperature, velocity and micro channel size. This implies that a detailed study is required in microchannels.

Traditional heat transfer fluids such as water, engine oil, and ethylene glycol (EG) are inherently poor heat transfer fluids and thus major improvements in cooling capabilities have been constrained. To overcome this limited heat transfer capabilities of these traditional heat transfer fluids, micro/millimeter-sized particles with high thermal conductivity suspended in the fluids were considered in this research. Energy efficient heat exchangers can save a significant amount of energy by improving power conversion efficiency.

In the present study, the pressure drop and laminar convective heat transfer characteristics of three different nanofluids of $\text{Al}_2\text{O}_3$ and CuO in microchannel heat sink with rectangular duct of serpentine shape are experimentally investigated and compared with numerical values. The optimization of the microchannel for enhanced heat transfer is done with varying the hydraulic diameter of the serpentine shaped microchannel to get the maximum pressure drop across the channel for improved thermal conductivity.
The Nanofluid I is prepared with Al$_2$O$_3$ nanosized particle of 15nm with water as the base fluid, its heat transfer performance is experimented in the serpentine shaped microchannel. The experimental results show that nanofluids in all concentration from 0.01 to 0.3 has enhanced thermal conductivity than pure water. Based on the pressure drop for Al$_2$O$_3$ water nanofluid the friction factor is measured and it has good coordination with theoretical results of the Darcy friction factor correlation for the fully developed laminar flow. The convective heat transfer coefficient for the low volume percentage and there is considerable enhanced thermal conductivity for the Al$_2$O$_3$/water nanofluid. Thermal Resistance of the MC heat sink was decreased when using Al$_2$O$_3$. When the volume fraction is increased from 0.01 - 0.3, then the nanofluid thermal conductivity increases considerably and also heat transfer performance has been enhanced.

The Nanofluid II is prepared with CuO nanosized particle of 15nm with water as the base fluid, its heat transfer performance is experimented in the serpentine shaped microchannel. The experimental results show that nanofluids in all concentration from 0.01 to 0.3 have enhanced thermal conductivity than pure water. The CuO nanofluid has improved thermal performance than the Al$_2$O$_3$ nanofluid due to increased thermal conductivity of copper. The theoretical results of the Darcy friction factor correlation for the fully developed laminar flow have good coordination due to pressure drop for the CuO water nanofluid.

The Nanofluid III is prepared with CuO nanosized particle of 15nm with ethylene glycol as the base fluid, its heat transfer performance is experimented in the serpentine shaped microchannel. The experimental results show that a nanofluid in all concentration from 0.01 to 0.3 has enhanced thermal conductivity than base fluid ethylene glycol. The results also show that there is increased thermal performance compared to water based Al$_2$O$_3$ and CuO due to the higher density of ethylene glycol which favors for the increased pressure drop in the microchannel.

When comparing the three different nanofluids with same concentration the CuO/ethylene glycol has enhanced heat transfer coefficient due to the higher viscosity and density of the basefluid ethylene glycol. The serpentine shape also
favors for the enhanced heat transfer rate. This is due to the increased Brownian motion of the nanoparticle while passing through the serpentine shaped with fins channel.

From this experimental work the use of nanofluids for heat transfer and geometry of the microchannel becomes an important factor for the enhanced heat transfer performance, these two combined factors provides way for the future researchers in heat transfer enhancement.