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Thermal performance of nanofluids in parallel microchannel systems-U, I, Z

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Parallel microchannel heat exchangers [1] employing nanofluids [2] have received attention as potential cooling systems for microelectronic devices. Designing effective nanofluid based microchannel heat exchangers requires critical understanding of the particle and thermo-hydraulic distribution in parallel microchannels. Extensive computational studies have been performed to understand the behavior of nanofluids in parallel microchannel configurations (U, I and Z) using Eulerian–Lagrangian discrete phase model (DPM) and effective property model (EPM). Figure 1 illustrates details of flow configurations used for the study.

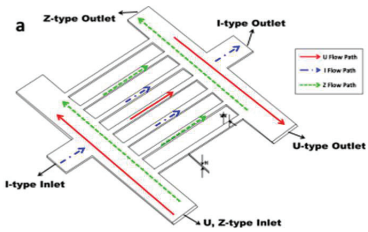

Figure 1: Geometry of U, I, Z configurations

The pressure drops for nanofluids predicted by both EPM and DPM models as compared (alumina-water) with respect to water have been shown in Figure 2.

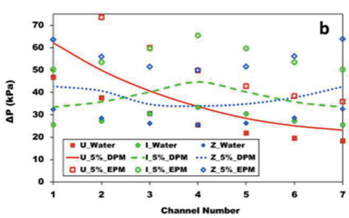

Figure 2: Channel-wise pressure drop of water and nanofluid for different domain configurations using DPM and EPM

The present study discloses that nanofluids cannot be treated as homogeneous, single component, single phase fluids in such complex flow domains and EPMs fail drastically to predict the performance parameters and the same can be inferred from Figure 3. To understand the extent of flow and particle maldistribution, the Flow Maldistribution Factor (FMF= $[(\Delta P_{max}-\Delta P_{min})/\Delta P_{max}]$) and the Concentration Maldistribution Factor (CMF= $[(\phi_{max}-\phi_{min}/\phi_{max})]$) have been proposed.

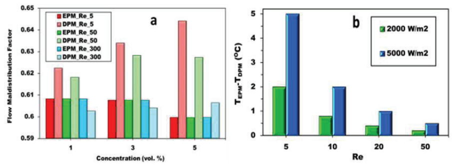

Figure 3: The difference between EPM and DPM results a) In terms of FMF b) In terms of temperature difference. EPM predicts poor cooling and hence should not be used for design of such systems

The maldistribution of nanoparticles for different configurations is shown in Figure 4 using CMF.

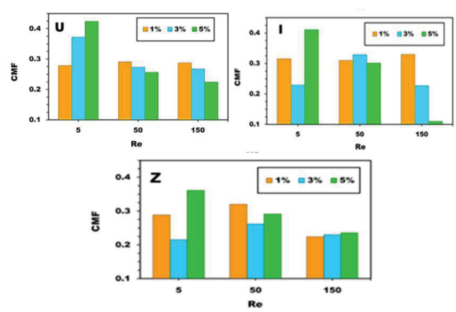

Figure 4: CMF data vis-à-vis flow configurations

It has been observed that distribution of particles need not necessarily follow the fluid. The implications of particle distribution on the cooling performance have been illustrated and *smart fluid* effects of nanofluid have been observed.

References

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2. S. U. S. Choi, and J. A. Eastman, proceedings of the 1995 ASME International Mechanical Engineering Congress and Exposition, San Francisco, CA, USA, 1995.