Thermal and hydrodynamics performance of microchannel heat sink with diverging cross section

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ABSTRACT

In this thesis a hydrodynamics and thermal characteristics of laminar flow, 3D conjugate heat transfer in diverging microchannels cross section were investigated numerically. The governing equations were solved using CFD software FLUENT 15.

The main parameters studied are: micro channel geometry (as square, rectangular, circular, trapezoidal and triangular), diverging angle (θ), thermal conductivity ratio (K_r), different flow arrangements (parallel and counter flow), number of channels and the different working fluids (nanofluids and Microencapsulated phase change material).

Different microchannel geometries were studied with variable cross section. The cross sections were diverging with an angle with range of (0° to 3°) was used. It can be noticed the shape of the channel can have a great effect on the heat transfer enhancement and there was an optimum divergence angle which gives maximum thermal performance for every geometry; it was 1.5°, 2°, 1.5°, 2° and 2° for square, rectangular, circular, trapezoidal, and triangle cross section respectively. Also it was found that the channels with square cross section produce a better cooling performance than other microchannel geometries.

The effect of the height and width of the square cross section channels on the performance were investigated. The results show that, the increase in depth from 100μm to 1915 μm resulted in 145.13% increase in thermal heat sink performance, while increase in width from 100μm to 1915 μm resulted in 118.39% as compared with uniform channel. It can detect that thinner

microchannels provide higher thermal heat sink performance than wider channels.

The effect of using heat sink with one, two, three and five channels was investigated. The results indicated increasing the number of channels was useful to make the temperature more-uniformity and reduced pressure drop. Also, it is observed that multi channels heat sinks produced lower thermal resistance and pressure drop than single channel.

Nanofluids are used as coolants fluid with volume fraction of 1 %, 3 %, 5 %, and 7%. The results show significant enhancement of cooling performance of microchannel heat sink with nanofluids as compared with the base fluid. It is appeared that 26% increased of Nu more than water obtains when using 7% volume concentration.

Microencapsulated phase change material (MPCM) slurries have been studied, the suspension used with volume fraction of 5%, 10%, 15 and 20 %. The effects of volume concentration on local Nusselt number, average Nusselt number, bulk and wall temperature rise and pressure drop were investigated. It was found that the maximum reduction in fluid bulk temperature at Re = 50 was 2.07, 4.27, 7.17 and 8.01K at volume concentrations of 5%, 10%, 15% and 20% respectively as compared to water. The average Nusselt numbers for 5% concentrations is 79.7% and 75.45% higher than pure water for n-octedecan and n-icosan respectively. This means that using MPCM which has lower melting temperature range more preferred than that one which has high melting temperature range in producing large value of average Nu.