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Thermal analysis of micro-channel heat exchangers with two-phase flow using FEM

Abstract

Purpose - To analyze two-phase flow in micro-channel heat exchangers used for high flux micro-electronics cooling and to obtain performance parameters such as thermal resistance, pressure drop, etc. Both uniform and non-uniform micro-channel base heat fluxes are considered. Design/methodology/approach - Energy balance equations are developed for two-phase flow in micro-channels and are solved using the finite element method (FEM). A unique ten noded element is used for the channel descritization. The formulation also automatically takes care of single-phase flow in the micro-channel. Findings - Micro-channel wall temperature distribution, thermal resistance and the pressure drop for various uniform micro-channel base heat fluxes are obtained, both for single- and two-phase flows in the micro-channel. Results are compared against data available in the literature. The wall temperature distribution for a particular case of non-uniform base heat flux is also obtained. Research limitations/implications - The analysis is done for a single micro-channel and the effects of multiple or stacked channels are not considered. The analysis needs to be carried out for higher heat fluxes and the validity of the correlation needs to be ascertained through experimentation. Effects of flow mal-distribution in multiple channels, etc. need to be considered. Practical implications - The role of two-phase flow in micro-channels for high flux micro-electronics cooling in reducing the thermal resistance is demonstrated. The formulation is very useful for the thermal design and management of microchannels with both single- and two-phase flows for either uniform or non-uniform base heat flux. Originality/value - A simple approach to accurately determine the thermal resistance in micro-channels with two-phase flow, for both uniform and non-uniform base heat fluxes is the originality of the paper.

Keywords — Finite element analysis, flow, pressure, thermal resistance