Public Abstract
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Title:Heat Transfer Enhancement of Vapor Condensation Heat Exchanger

A typical vapor condensation condenser consists of two major heat transfer processes, i.e., vapor condensation and forced convection. In order to enhance heat transfer, the condensation heat transfer utilizing the porous medium is investigated, and at the same time, the elliptical pin fin effect on the forced convection of nanofluid studied. The forced convective heat transfer on nanofluids in an elliptical pin-fin heat sink of two different pin orientations is numerically studied by using a finite volume method. Additive manufacturing of making three dimensional pin fin heat sinks prototype is utilized. Three materials of pin fin heat sinks were created and tested; namely, PLA (Polylactic Acid) and ABS (Acrylonitrile Butadiene Styrene) and MIM (Metal Injection Molding). All materials showed good performance. Results show that with increasing Reynolds number, the recirculation zones behind the pins increased. There were more recirculation zones for the pins with varying angular orientations than for pins with the same angular orientation. It is observed that the Nusselt number for the pins with varying angular orientations was higher than that for pins with the same angular orientation. The results show that with increasing volume fraction of nanoparticles and angular orientation of pins for a given Reynolds number, Euler and Nusselt numbers as well as overall heat transfer efficiency increase.

Pin fin heat sinks and heat exchangers are classified as either single-phase or two-phase according to whether fluid superheats inside the microchannels. The primary parameters that determine the single-phase and two-phase operating regimes are the heat flux and the mass flow rate. For uniform heat flux, the fluid may maintain its liquid state throughout the microchannels. For higher heat flux and mass flow rate, the fluid flowing inside the microchannel superheats, resulting in a two-phase heat exchanger. The temperature is higher near the wall of the two-phase heat exchanger where the heat transfers to the coolant and the heat generated must be dissipated in order to keep temperature distribution uniformity. Thin-film evaporation is addressed as it plays an important role in this two-phase system.

The non dimensional mass, momentum and energy equations based on non dimensional pressure, temperature, heat capacity, capillary, and bond numbers are developed for the vapor condensation occurring in the porous medium. The volumetric viscous force for the flow is described by Darcy’s law. For the microscopic interfacial shear stress, a permeability term that relates flow rate and fluid physical properties (i.e. viscosity) to pressure gradient is implemented. The effects of permeability, porosity, and effective pore radius parameters on porous medium performance are introduced. The occurrence of thin liquid film inside pores is addressed and the Laplace-Young equation is depicted. In calculations the Darcy-Ergun momentum relation is implemented which provide accurate means to determine the capillary performance parameters of porous medium. The dimensionless thicknesses of the two-phase and liquid regions and embodiment of unique characteristics based on the total thermal diffusivity and absolute permeability are depicted. Therefore, analyses of the phase change and two-phase flow are made by defining regions, over which appropriate approximations are made.