Laminar Flow Forced Convection Heat Transfer Behavior of a Phase Change Material Fluid in Microchannels

In this paper, a phase change material (PCM) fluid (N-eicosane) is compared with pure water as heat transfer fluid. The heat transfer behavior of PCM fluid under laminar flow conditions (Reynolds number of 700) in circular and rectangular microchannels was studied numerically. In the numerical study, an effective specific heat model was used to take into account the phase change process. Heat transfer results for circular and rectangular microchannels with PCM fluid were obtained under hydrodynamically and thermally fully developed conditions. A PCM fluid in microchannels with aspect ratios of 1 to 2, 1 to 4, and 1 to 8 was found to enhance the thermal behavior of microchannels which can be beneficial in a host of cooling applications. The flow was assumed to be hydrodynamically fully developed at the inlet and thermally developing inside the microchannel. Heat transfer characteristics of PCM slurry flow in microchannels have been studied under three types of wall boundary conditions including constant axial heat flux with constant peripheral temperature (H1), constant heat flux with variable peripheral temperature (H2), and constant wall temperature (T) boundary condition. The fully developed Nusselt number was found to be higher for H1 than for H2 and T boundary conditions for all the geometries. Moreover, Nusselt number also increased with aspect ratio and was sensitive to the variations in effective specific heat. [DOI: 10.1115/1.4023221]

Keywords: phase change material fluid, microchannel, convective heat transfer, constant heat flux, constant wall temperature, effective specific heat