Spatially-Resolved Temperature Measurement in External and Internal Microscale Flows

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Measurement of local surface temperatures in microscale geometries has been a considerable challenge to researchers. Such measurements are important in evaluating and improving the designs of components in miniature thermal systems. Fundamentally, they aid in understanding heat transport phenomena by providing boundary conditions for, or by validating, heat transfer models. The use of Infrared (IR) thermography to determine local temperature in external and internal convective microscale flows with heat transfer is presented. The technique is demonstrated on microscale jet impingement heat transfer for external flows, and diabatic single and two phase flows through Silicon (Si) microchannels for internal flows.

Microscale jets flows are associated with low exit Reynolds number (Re) due to the small characteristic length of the nozzle, but correspondingly high exit velocities, and hence, a high subsonic Mach number. For external flows, a heated thin foil technique was implemented to a 125-μm-diameter jet impingement and surface temperatures extracted to determine local heat transfer coefficients. Jet exit Re between 690 and 1770 are studied at nozzle to surface spacings of 2, 4, and 6 jet diameters. Lateral conduction along the foil is significant and therefore included in calculating the heat transfer rates.

For single-phase internal liquid flows, experiments through a single 13-mm long and 50 μm wide by 135 μm deep Si microchannel at a constant electrical input of 2.31 W to the heater for four fluid flow rates between 0.6 g/min and 1.2 g/min are presented. Measurements of the heat sink surface temperature indicate that axial non-uniformity can be significant for the larger Peclet number flows. Uncertainty in local Nu varied between 7.5 to 13.5 percent for different Re. Preliminary experiments on diabatic two-phase internal flows through 150 μm by 135 μm channels are also reported.