NUMERICAL SIMULATION OF A SINGLE CONFINED MICROSCALE IMPINGING JET WITH CONJUGATE HEAT TRANSFER EFFECTS

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ABSTRACT

A single, 100 μm diameter, initially laminar impinging jet was modeled numerically in FLUENT with a two-dimensional axisymmetric mesh for compressible air and incompressible water. The jet impinged upon a disk with a thickness of zero or one nozzle diameters and heated by a constant wall heat flux. The effects of varying the nozzle exit Reynolds number (500 to 2000), heater size (zero to four nozzle diameters), and disk material (aluminum, silicon, and Pyrex) on the temperature, local wall heat flux, and Nusselt number at the impinging surface were investigated. The extent to which conjugate heat transfer effects significantly impact the heat transfer performance of the impinging jet was analyzed.

Viscous heating in the core of the compressible air jet caused the temperature of the impinging jet to increase and diminish the local heat transfer rates at the stagnation point. This manifested in the appearance of a local minimum in the Nusselt number at the stagnation point and an offset maximum at an increased radial distance from the stagnation point. The Nusselt number at the stagnation point decreased with increasing nozzle exit Reynolds number as the effects of viscous heating increased. In cases with large nozzle exit Reynolds numbers or small heater sizes, the temperature of the jet surpassed the temperature of the disk. This resulted in a negative Nusselt number at the stagnation point. Larger Nusselt numbers at increased radial distances compensated for the decreased values at the stagnation point and the average Nusselt number at the impinging surface increased with increasing nozzle exit Reynolds number. Temperature distributions within the aluminum and silicon disks were uniform due to the large thermal

conductivities. Larger temperature gradients existed within the Pyrex disk because heat flow was confined to near the heater.

The Nusselt number distributions on the impinging surface for incompressible water were bell shaped with maxima at the stagnation point. No offset or secondary peaks formed in the distributions at increased radial distances. Varying the heater radius and material of the disk had a negligible effect on the local Nusselt number distributions. Increasing the nozzle exit Reynolds number caused the local Nusselt number distribution to increase at all points on the impinging surface. Significant temperature gradients existed within all disks because of the larger applied heat flux from the heater.