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THE IMPORTANCE OF NOZZLE LENGTH AND ISSUING PROFILE IN SUBMERGED IMPINGING JET HEAT TRANSFER

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ABSTRACT Stagnation point heat transfer under an impinging jet (IJ), and consequently average heat transfer, has been previously shown to depend strongly on the issuing velocity profile and centerline velocity, which in turn depend on the nozzle shape and length. While traditionally orifices (L/d<1) and long pipes (L/d>>1) have been studies, nozzles of lengths up to 10 diameters are common in arrays of micro-IJ. In the current work, direct numerical simulations were used to study the effects of issuing velocity profile as a function of nozzle length on heat transfer of a single submerged IJ. Numerical simulations were conducted for nozzle lengths of 0.25 to 6 diameters, jet Reynolds numbers (Re) of 500 to 2000, at a fixed nozzle-to-heater spacing of 3 diameters, values that are typical in arrays of micro IJ. It was found that the issuing centerline velocity as a function of nozzle length obtains a maximum which is quite independent of Re, at around (L/d)=0.5, for Re=500 to 2000, and which can be associated with the inlet vortex (separation bubble). Conversely, farther downstream the centerline scaling converges to that of ideal pipe-flow, beginning at around (L/d)/Re=0.002. Consequently, IJ heat transfer under these conditions has a non-monotonous dependence on nozzle length, with a minimum emerging at around 1.5 diameters length for Re=1000. It is seen that sharp-inlet nozzles of lengths L/d<5 must consider the inlet vortex in characterizing the laminar flow and impingement heat transfer.