ABSTRACT

In this investigation, the numerical solutions of Navier-Stokes equations and energy equation are presented for (i) laminar free slot jet, (ii) laminar free axisymmetric jet, (iii) laminar jet impingement on a circular cylinder, (iv) vertically downward laminar slot jet impinging on a flat surface with and without buoyancy, and (v) offset slot jet in the range of low Reynolds numbers for both, the uniform and the parabolic slot-exit velocity and temperature profiles. SIMPLE and SIMPLEC algorithm have been used for the numerical solutions.

The velocity and temperature profiles are presented near the nozzle-exit and far away from the nozzle-exit plane for free slot jet and free axisymmetric jet. The centreline velocity and temperature become coincident for all Reynolds numbers when plotted against $\bar{X}$= X/Re. The velocity profiles become coincident for all Reynolds numbers far away from nozzle-exit in Schlichting's variable η and with half jet width as characteristic length. The results are in good agreement with the available experimental results. The jet diffuses at a fast rate at lower Reynolds numbers and the jet spread decreases at higher Reynolds numbers.

Jet impingement over a cylinder has been investigated for low Reynolds numbers. The results for skin friction, pressure distribution and velocity profiles on cylinder surface, are presented. The results do not depend strongly on slot width. The effect of decrease in slot-to-cylinder spacing is equivalent to increase in Reynolds number. The flow separation occurs earlier at

higher Reynolds numbers.

In case of vertically downward slot jet impinging on a flat surface, the buoyancy force significantly affects the flow field, the local Nusselt number, local friction factor and the pressure distribution along the impingement surface. The jet behaves almost like a non-buoyant jet for values of Richardson numbers less than 0.014 with uniform slot-exit profiles and Richardson number less than 0.007 with parabolic slot-exit profiles. The jet detaches from the surface and rises up like a plume for $Ri \geq 0.014$ with uniform slot-exit profiles and for $Ri \geq 0.007$ with parabolic slot-exit profiles. The jet does not come into contact with the surface at all for $Ri \geq 1.25$ for both, the uniform and parabolic slot-exit profiles. Empirical correlations have been developed for determining the average Nusselt number, maximum Nusselt number and the stagnation point Nusselt number for both the types of velocity and temperature profiles in absence of buoyancy for laminar flow. The maximum Nusselt number occurs at the stagnation point for parabolic slot-exit profiles, whereas for uniform slot-exit profiles, it occurs slightly away from the stagnation point.

The offset ratio significantly influences the local Nusselt number, local friction factor and the pressure along the impingement surface for offset slot jet in the range of low Reynolds numbers. Secondary recirculation is observed at an offset ratio of 7 and Reynolds number of 80. The reattachment length is observed to be approximately constant at higher values of Reynolds numbers. Empirical correlations have been developed for the reattachment length, maximum Nusselt number and the average Nusselt number in the separated region.

Key word: slot jet, axisymmetric jet, reattachment length, separated region, wall jet, laminar, buoyant jet, offset jet, stagnation point, reattachment point, free jet, circular cylinder, recirculation.