ABSTRACT

Convective heat transfer from spherical and vertical rotating cylindrical devices has wide range of practical applications. It is often required to increase the rate of heat transfer by natural convection amongst these devices (due to flow of surrounding air) by means of extended surfaces or through axial aiding flow. The present study tries to numerically analyse the rate of heat transfer in such cases for different input parameters relevant to some useful industrial applications.

Firstly, natural convection heat transfer from a finned sphere has been studied numerically in both laminar ($10^5 \leq Ra \leq 10^8$) and turbulent ($10^{10} \leq Ra \leq 10^{12}$) regimes. Computations are done for the Nusselt number (*Nu*) by varying the fin-height-to-sphere-diameter ratio (*H/D*) and the fin-pitch-to-sphere-diameter ratio (*P/D*) in the range of 0.017 - 0.200 and 0.131 - 0.393 respectively. Five different turbulence models have been used to compute the mean Nusselt number for some cases and for the purpose of developing a general correlation for the *Nu* from our computed results we have used the k-ε model. The numerical procedure has been verified first by comparing the numerically obtained Nusselt number for a simple sphere (without fins) with that of the given correlations from the literature. For the sphere having conductive (Al) fins, with increasing number of fins, *Nu* decreases for laminar heat transfer and increases for turbulent heat transfer. For the sphere having non-conductive fins, *Nu* decreases with increasing number of fins in both laminar and turbulent heat transfer. Also, *Nu* increases with increasing fin height for conductive fins over the sphere and decreases for non-conductive fins. Finally, correlations of Nusselt number for natural convective heat transfer from a finned sphere are developed with the pertinent input parameters like *Ra*, *P/D* and *H/D* in the range stated above.

Subsequently, mixed convection heat transfer from a rotating vertical cylinder has been studied numerically using an axisymmetric swirl flow model. Five different turbulence models have been used to compute the mean Nusselt number for some cases and for the purpose of developing a general correlation for Nu_l from our computed results we have used the standard k-ε model. The average Nusselt number (Nu_l) has been computed for aspect ratio of 1 - 10 when Ra_l and Re_d are in the range of

1.31×10^{10} - 1.31×10^{13} and 6.26×10^4 - 1.56×10^6 respectively. The effect of the pertinent input parameters like *l/d*, Ra_l and Re_d on Nu_l has been analysed and a correlation of average Nusselt number has been developed for mixed convection from a rotating vertical cylinder along with the visualization of flow pattern around it for some of the important parameters.

Finally, combined natural and forced convection (with aiding flow) heat transfer from a vertical rotating cylinder has been numerically investigated in turbulent flow regime using an axisymmetric swirl flow model. Several computations were performed using five different turbulence models to compute the mean Nusselt number and for the purpose of developing a general correlation of Nu_l from our computed results we have used the standard $k-\varepsilon$ model. The average Nusselt number (Nu_l) has been computed for aspect ratio (l/d) between 2 - 10 when Gr_l, Ri_l, and Re_d are in the range of 1.81×10^{10} - 1.81×10^{13}, 0.1 - 5.0, and 6.26×10^4 - 1.56×10^6 respectively. The effect of the pertinent input parameters like l/d, Gr_l, Ri_l and Re_d on Nu_l has been analysed and a correlation of average Nusselt number has been developed for mixed convection (with aiding flow) from a rotating vertical cylinder along with visualization of flow pattern around it for some of the important parameters. It has been found that Nu_l increases with an increase in Gr_l, Re_d and with a decrease in Ri_l in general, barring some exceptions.

Keywords: Nusselt number, natural convection, sphere, fin, heat transfer, mixed convection, cylinder, rotating, aiding flow, laminar, turbulent.