ABSTRACT

Natural convection heat transfer from a horizontal and vertical cylinder with annular fins has been studied numerically. The present numerical investigation is able to capture a complete picture of natural convection over an annular finned cylinder from where easy visualization of the plume structure and flow field over the tube-fin surface can be obtained pictorially. In the present study, numerical simulations of full Navier-Stokes equation along with the energy equation have been conducted for a horizontal tube with annular fins of constant thickness by varying the Rayleigh number based on fins pacing (Ra_S) in the range of $5 \leq \mathrm{Ra}_S \leq 10^8$, and for a vertical cylinder with annular fins by varying the Rayleigh number (Ra) in both laminar ($10^4 \leq \mathrm{Ra} \leq 10^8$) and turbulent ($10^{10} \leq \mathrm{Ra} \leq 10^{12}$) regimes using the algebraic multi-grid solver of FLUENT 15. The computations were carried out by varying the fin to tube diameter ratio (*D/d*), fin spacing to tube diameter ratio (*S/d*) in the range of 2-5 and 0.126-5.840 respectively. Optimization studies on the conjugate heat transfer characteristics have been conducted to find the best fin spacing (*S*) and fin-to-tube diameter ratio (*D/d*) for maximum heat transfer. With addition of fins to the heated horizontal cylindrical surface, heat transfer increases, gets a maximum value, and then it starts to decrease. Whereas, with the addition of fins to the heated isothermal vertical cylinder, heat transfer goes on increasing for laminar flow and for turbulent flow heat transfer first increases, gets a maximum value then starts to decrease. The optimum *S/d* for maximum heat transfer varies between 0.2 to 0.25 for horizontal finned tube, and for the cases of vertical finned tube in turbulent flow it varies between 0.28 to 0.31. Correlations for Nu has been developed for horizontal and vertical finned cylinders against pertinent input parameters. An annular finned horizontal cylinder with different eccentricity has also been studied numerically in the present work. With the increase in eccentricity of the fins, the heat transfer decreases for a fixed fin diameter. But that decrease in heat transfer is marginal. In addition to the heat transfer study, a detailed study on entropy generation around the fin tube configuration has also been studied.

Keywords: Natural convection; heat transfer; horizontal cylinder; vertical cylinder; annular fins; eccentricity; inter-fin spacing