Proceedings of CHT-17
ICHMT International Symposium on Advances in Computational Heat Transfer

May 28-June 1, 2017, Napoli, Italy

CHT-17-275

EFFECTS OF SURFACE CURVATURE ON THE THERMAL BOUNDARY LAYER DEVELOPING ALONG THE SURFACE OF AN ISOTHERMALLY HEATED VERTICAL CYLINDER

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ABSTRACT In the present study, the effects of transversal curvature of vertical cylinders, which is quantified by the aspect ratio AR (i.e. height to diameter ratio, AR=H/D), on natural convection boundary layers adjacent to cylindrical surfaces are studied using direct numerical simulations for a fixed Rayleigh number of $Ra=3.5\times10^9$. A flat plate case (AR=0) of the same characteristic parameters is also calculated as a reference. It is found that the temperature profile in the thermal boundary layer deforms towards the surface as the aspect ratio increases. For relatively small aspect ratios (AR<55), the secondary thickness of the thermal boundary layer, which refers to the distance from the cylinder surface to the location where the 50% temperature difference threshold is reached, changes approximately linearly with the aspect ratio. An approximately linear dependence between the aspect ratio and the peak streamwise velocity is also found for relatively small aspect ratios (AR<55). Enhanced heat transfer, as indicated by an increase of the Nusselt number, is observed when the aspect ratio increases. Over the range of the aspect ratios considered in this study, the dependence of the averaged Nusselt number over the cylindrical surface on the secondary thickness of the thermal boundary layer is approximately linear.