THE COMPARISON OF THE EFFECTS OF TOP AND BOTTOM WALL HEATING ON MIXED CONVECTION OF YIELD STRESS FLUIDS IN A CYLINDRICAL CONTAINER WITH ROTATING END WALL

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ABSTRACT

Steady-state laminar mixed convection of Bingham fluids in a cylindrical enclosure has been numerically analysed based on axisymmetric incompressible flow simulations for different values Reynolds number and Richardson number ranges given by $500 \leq Re \leq 3000$ and $0 \leq Ri \leq 1$ respectively at $Pr = 100$. The aspect ratio (i.e. height: radius $= AR = H/R$) of the cylindrical container is considered to be unity (i.e. $AR = H/R = 1$). The bottom and top covers of the cylindrical enclosure are kept at different temperatures ($T_C < T_H$), while the cylindrical surface is considered to be adiabatic. The simulations for Newtonian fluids (i.e. $Bn = 0$) for rotating top and bottom cover configurations yield the same numerical value of the mean Nusselt number $\overline{Nu}$ when the thermal boundary conditions are kept unaltered. For this reason, only rotating top hot wall (i.e. CASE 1) and rotating top cold wall (i.e. CASE 2) configurations have been considered for this analysis. In Newtonian (i.e. $Bn = 0$) fluids and for small values of Bingham number, the mean Nusselt number $\overline{Nu}$ has been found to assume higher values for CASE 2 than in CASE 1. However, this difference in the mean Nusselt number $\overline{Nu}$ between CASE 1 and CASE 2 decreases with increasing $Bn$ and thermal transport takes place purely due to thermal conduction for large values of Bingham number $Bn$ for both CASE 1 and CASE 2. Moreover, it has been found that the variation of the mean Nusselt number with Richardson number in CASE 2 is qualitatively different from that in CASE 1. A detailed scaling analysis has been carried out to elucidate and explain the influences of Reynolds, Richardson, and Bingham numbers on the mean Nusselt number.