Effect of aspect ratio of enclosure on free convection from horizontal cylinders in Bingham plastic fluids

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Abstract

Heat transfer problems for steady free convection from differentially heated cylinders enclosed in a rectangular duct filled with Bingham plastic fluids have been solved numerically for the ranges of the dimensionless groups, in particular when Rayleigh number $10^2 \leq Ra \leq 10^6$, Prandtl number $10 \leq Pr \leq 100$, and Bingham number $0 \leq Bn \leq 50$ for aspect ratios AR = 0.5, 0.6, 0.7, 0.8, 0.9 and 2. The streamlines, isotherm contours, yield surfaces, local and average Nusselt numbers were analyzed and discussed. It is found that as the aspect ratio of the enclosure increases from 0.5 to 0.9, the average Nusselt number on the surface of the hot cylinder increases as larger amount of fluid takes part in convection. Moreover, at sufficiently large Bingham numbers, yield stress forces dominates over buoyancy causing the flow to cease and thus the Nusselt number approaches its conduction limit. Finally, the Nusselt number approaches its conduction limit once the maximum Bingham number is reached.

Keywords: Bingham plastic fluids, aspect ratio, Rayleigh number, Nusselt number, natural convection.