Computational modelling of natural convection of non-Newtonian fluids

General scope

Natural convection of Newtonian fluids in rectangular enclosures has been studied extensively using experimental and numerical means. In comparison little effort has been directed to the study of natural convection of non-Newtonian fluids in rectangular enclosures in spite of several applications in solar collectors, electronic cooling, cryogenic applications and preservation and storage of canned foods. In this research programme laminar natural convection of yield stress fluids obeying Bingham law and power law fluids are numerically simulated in rectangular enclosure for different Prandtl numbers and aspect ratios for differentially heat vertical sidewalls. A detailed scaling analysis has been carried out for the natural convection of Bingham and power-law fluids in rectangular enclosures with differentially heated vertical side-walls. The scaling analysis and numerical simulation results are used to propose new correlation for Nusselt number for natural convection of Bingham and power-law fluids in rectangular enclosure.

Relevance of this work:

This research programme has given rise to important insight into the heat transfer behaviour of Bingham and power-law fluids. This knowledge can be used in developing novel devices involving electro-rheological fluids so that the heat transfer from a container can be regulated continuously depending on requirement and when the heat transfer needs to be significantly reduced only the conduction mode of heat transfer in fluid will remain active. These characteristics can be used effectively in designing new generation cryogenic storage tanks.

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Schematic diagram of a rectangular enclosure with differentially heated vertical sidewalls subjected to constant wall heat fluxes.
Contours of non-dimensional temperature for different values of aspect ratio (height: width) and Bingham number for laminar natural convection of Bingham fluids at nominal Rayleigh number of $10^6$ and Prandtl number of 7. The vertical sidewalls are subjected to constant wall heat fluxes.