Analysis of the walls thermal conductivity influence on conjugate natural convection in a square enclosure filled with a porous medium under local thermal non-equilibrium condition

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Abstract

In this article, conjugate natural convection heat transfer in a square porous enclosure saturated by a fluid surrounded by two equal thickness vertical solid walls is studied numerically. The vertical walls of enclosure are partially heated at two different temperature and the horizontal ones are insulated. The Brinkman-Darcy-extended Darcy model and the local thermal non-equilibrium model are utilized to simulate the flow and heat transfer in the porous medium. The governing equations are transformed into the non-dimensional form, and the Galerkin's finite element method is utilized to solve the governing equations. The influence of critical parameters comprising of the Rayleigh number, Darcy number, Prandtl number, fluid to solid thermal conductivity ratio, and the heat transfer coefficient between the fluid and solid phases of the porous medium as well as the conjugate properties such as the wall thickness and the wall to fluid thermal conductivity ratio on the heat transfer rate inside the enclosure are investigated. The results show that, except for the Prandtl number, alteration of all the aforementioned parameters has significant effects on the average Nusselt number. It is also observed that, in high values of fluid to solid thermal conductivity ratio and heat transfer coefficient between them, the values of the average Nusselt number for the thermal equilibrium model and the thermal non-equilibrium model become equal and the local thermal equilibrium assumption between the phases of the porous medium would be valid.

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