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Numerical Simulation of Natural Convection Heat Transfer in a Porous Cavity Heated From Below Using a Non-Darcian, Thermal Non-Equilibrium Model

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Abstract: The present paper investigates the numerical simulation of steady laminar incompressible natural convection heat transfer in an enclosed cavity that is filled with a fluid-saturated porous medium. The bottom wall is subjected to a relatively higher temperature than the top wall while the vertical walls are considered to be insulated. The flow field is modeled upon incorporating different non-Darcian effects, such as the convective term, Brinkman effect and Forchhiemer quadratic inertial effect. Moreover the two-equation model is used to separately account for the local fluid and solid temperatures. The numerical solution is obtained through the application of the finite volume method. The appraisals of the sought objectives are performed upon identifying key dimensionless groups of parameters. These dimensionless groups along with their operating domains are: Rayleigh number 1 ? Ra ? 400, Darcy number 10?4 ? Da ? 10?3, effective fluid-to-solid thermal conductivity ratio 0.1 ? ? ? 1.0, and the modified Biot number 1 ? ? ? 100. The non-Darcian effects are first examined over a broad range of Rayleigh number. Next, the implications of the group of parameters on the flow circulation intensity, local thermal non-equilibrium (LTNE) and average Nusselt number are highlighted and pertinent observations are documented.