ABSTRACT

The present study is focused on Lapwood convection in isotropic porous media saturated with non-Newtonian shear thinning fluid. The non-Newtonian rheological behavior of the fluid is modeled using the general viscosity model of Carreau–Yasuda. The convection configuration consists of a shallow porous cavity with a finite aspect ratio and subject to a vertical constant heat flux, whereas the vertical walls are maintained impermeable and adiabatic. An approximate analytical solution is developed on the basis of the parallel flow assumption, and numerical solutions are obtained by solving the full governing equations. The Darcy model with the Boussinesq approximation and energy transport equations are solved numerically using a finite difference method. The results are obtained in terms of the Nusselt number and the flow fields as functions of the governing parameters. A good agreement is obtained between the analytical approximation and the numerical solution of the full governing equations. The effects of the rheological parameters of the Carreau-Yasuda fluid and Rayleigh number on the onset of subcritical convection thresholds are demonstrated. Regardless of the aspect ratio of the enclosure and thermal boundary condition type, the subcritical convective flows are seen to occur below the onset of stationary convection. Correlations are proposed to estimate the subcritical Rayleigh number for the onset of finite amplitude convection as a function of the fluid rheological parameters. Linear stability of the convective motion, predicted by the parallel flow approximation, is studied, and the onset of Hopf bifurcation, from steady convective flow to oscillatory behavior, is found to depend strongly on the rheological parameters. In general, Hopf bifurcation is triggered earlier as the fluid becomes more and more shear-thinning.