Analytical and numerical stability analysis of Soret-driven convection in a horizontal porous layer: effect of conducting bounding plates.

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ABSTRACT

The aim of this study is to investigate the effect of conducting boundaries on the onset of convection in a binary fluid-saturated porous layer. The isotropic saturated porous layer, of thickness H, is bounded by two impermeable but thermally conducting plates, of thickness h, subjected to a constant heat flux. These plates have identical conductivity. Moreover the conductivity of the plates is generally different from the porous layer conductivity. The overall layer is of large extent in both horizontal directions.

The problem is governed by seven dimensionless parameters, namely, the normalized porosity of the medium, ε, the ratio of plates over porous layer thickness, δ, and their relative thermal conductivities ratio, d, the aspect ratio of the cell, A, the separation ratio, ψ, the Lewis number, Le, and thermal Rayleigh number, Ra. In this study, an analytical and numerical stability analysis are performed. The equilibrium solution is found to lose its stability via a stationary bifurcation or a Hopf bifurcation depending on the values of the dimensionless parameters. For the long wavelength mode, the critical Rayleigh number is obtained as $Ra_{cs} = 12(1+2d\delta)/(1+\psi(2Led\delta + Le + 1))$ and $k_{cs} = 0$ for $\psi > \psi_{mono}$ >0. For the latter condition, the unicellular flow leads to species separation between the two ends of the cell [1]. The species separation depends significantly on the characteristics of the plates (δ and d). The separation is determined analytically and the results are corroborated by direct 2D numerical simulations. This work extends an earlier paper by Mojtabi and Rees [2] who considered a configuration where the porous layer is saturated by a pure fluid.

REFERENCES

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