INSTABILITY OF THE MIXED CONVECTION FLOW IN A HEATED POROUS CHANNEL WITH AN ADIABATIC UPPER WALL

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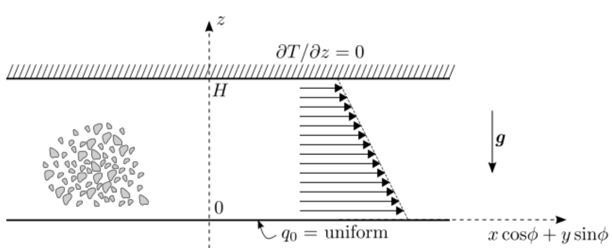
ABSTRACT

A numerical and analytical study of linear stability is carried out for the horizontal throughflow in a plane porous channel bounded by impermeable plane horizontal walls and having vertical thickness H. A uniform upward wall heat flux, $q_0 > 0$, is prescribed on the lower boundary wall, while the upper boundary wall is considered as thermally insulated.



The studied problem is considers mixed-convection flow with prescribed values for the Péclet number in the porous layer, by using the Oberbeck-Boussinesq approximation, Darcy's law, and by assuming local thermal equilibrium between the phases. This problem extends a previous analysis carried out by Barletta [1] with reference to a symmetric case where both the boundary walls of the channel are subject to a uniform heat flux, q_0.

A stationary basic solution of the local balance equations (mass, momentum and energy) exists such that the seepage velocity field is parallel, and the temperature gradient has both a vertical component and a horizontal component in the direction of the flow.

A linear stability analysis is carried out by perturbing the basic solution with small amplitude disturbances. A specific study of the neutral stability bound, to find the conditions for the onset of a secondary free convection flow, is devoted to the case of longitudinal rolls, *viz.* the normal modes with wave vector perpendicular to the basic flow direction.

The governing equations for the longitudinal rolls lead to an ODE eigenvalue problem. This problem is solved by employing the Generalized Integral Transform Technique [2-4], in which simpler eigenvalue problems (based on Helmholtz's equation) are used as bases for the eigenfunction expansions of the original eigenproblem solutions. With the proposed methodology, the neutral stability curves and the critical values of the wave number and of the Rayleigh number are obtained. An analytical solution is then presented for the longitudinal modes with zero wave number. Finally, one shows that the basic flow is linearly stable when the Péclet number is smaller than a minimum value.

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