Abstract

The thesis is based on few investigations carried out on the extended HortonRogers-Lapwood problem. The studies are associated to the onset of convective instability driven by the combined effect of thermal and solutal buoyancy forces. These investigations will be significant in taking forward the research in this area as they possess real life applications. One of the most important applications is found in the geothermal plants. The consideration of various physical effects such as viscous dissipation, cross-diffusion, etc., as well as the different kinds of hydrodynamic, thermal and solutal boundaries takes the investigation more closer to the practical scenario.

The studies (except in Chapter 6) in this thesis are based on the Brinkman extended Darcy model which is applicable to sparsely packed porous beds or high permeability porous media. It also acts as a generalized model which takes the form of a Darcy model as one of the limiting cases. All these studies also consider the persistence of throughflow along with the effect of viscous dissipation inside the medium, in some of them. Some of them consider the effect of inclined thermosolutal gradients across the medium or the effect of cross-diffusion in the thermal and solutal fields inside the medium. All these physical factors are responsible of altering the internal energy of the flow system, thus affecting its stability. The boundary conditions used for the flow, thermal and solutal fields, specially the thermal boundaries of Dirichlet, Neumann and Robin kinds are the main substance of the investigations. The Robin condition used for the thermal field in one of the studies describe the mixed convection occurring in the system, due to the forced convection driven by the external heating at the boundaries, superimposed on the buoyancy driven convection. All the studies intend to find the onset criteria of the convective instability in terms of the critical parameter values, using the linear stability analysis. However, one of them also establishes the nonlinear stability theory for the convective stability problem using the energy method, which complements the analysis of linear stability. The stability analysis witnesses the convective instability inside the system occurring in the form of stationary or oscillatory modes. Some of the studies presented in this thesis focus on explaining these aspects of the problems. One of the later studies in this thesis is based on the double-diffusive convective instability occurring in an inclined porous layer which is bounded by the permeable boundaries. Thus, it explains the effect of no-stress boundaries as well as the inclination in driving the convection inside the medium. The instability prevailing in the oscillatory and the stationary modes are illustrated well with the help of neutral stability curves.

Keywords : Horton-Rogers-Lapwood problem; Double-diffusive convection; Linear stability analysis; Energy method; Brinkman model; Throughflow; Viscous Dissipation; Inclined gradients; Soret effect; External heating; Permeable boundaries; Inclined porous layer; Oscillatory instability