ABSTRACT

Studies in Thermal Instabilities

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Thermal instability is investigated in a horizontal layer of non--Newtonian fluid with the non-Newtonian effects from two sources, microstructure and elasticity, using respectively the micropolar model and the Jeffreys' viscoelastic model. The method used is that of linear analysis based on normal modes.

For the micropolar fluid the possibility of surface tension driven convection is introduced and it is shown that in this case overstability is impossible. Convection due to the agencies of buoyancy, temperature-dependent surface tension and concentration-dependent surface tension is considered. A Fourier series method is used to find the characteristic values of the systems of differential equations governing disturbances. It is found that microstructure leads to greater stability in respect of all three agencies. It is shown, in the case of two rigid boundaries, that microstructure can result in Bénard-type convection for negative Rayleigh numbers. Stability in a rectangular enclosure is considered and it is found that for deep enclosures, the walls invariably have a stabilizing influence.

For the viscoelastic fluid, the stability of a layer subject to a horizontal temperature gradient is investigated. Stationary and oscillatory disturbances, longitudinal and transverse, are investigated in buoyancy driven convection. Oscillatory disturbances, longitudinal, transverse and oblique, are investigated in convection driven by surface tension with buoyancy effects and oscillatory disturbances are examined in a thermocapillary layer with the possibility of free surface deformation. The resulting systems of differential equations have to be solved numerically for eigen values and computer codes are developed. Instability characteristics are presented as a function of the Prandtl number and the viscoelastic parameters. It is found that elasticity can have both stabilizing and destabilizing effects.

On letting the values of the micropolar and viscoelastic parameters tend to zero, the numerical results obtained find excellent, sometimes exact, agreement with results in the literature for Newtonian fluids.

Keywords: Thermal instability; micropolar model; Jeffreys' viscoelastic model.