ABSTRACT

This thesis is a theoretical analysis of four hydrodynamic stability problems. First two problems belong to class of dynamic stability where stability of the system is obtained by modulating one of the operating parameter. In other two problems the flow domain is divided into two different regions either by geometry or by different fluids. Here the stability of the system is function of local Taylor number.

The linear stability of cylindrical Couette flow of an electrically conducting fluid in the presence of an axial magnetic field is examined, where the magnetic field has a small oscillatory component imposed on a steady value. Modulation is found to have a stabilizing effect for low values of the Chandrasekhar number, a destabilizing effect for intermediate values, and again a stabilizing effect for still higher values of Chandrasekhar number. The effect of modulation is found to be almost independent of the magnetic Prandtl number and the modulation frequency.

Thermal instability in a horizontal layer of fluid with the boundary temperatures modulated sinusoidally in time is studied. The amplitude of modulation is assumed small and is used as an expansion parameter. It is shown that an exact solution can be obtained, even when the boundaries are considered to be rigid. The equations at higher orders too can be solved in closed form. The study produces results, which are qualitatively similar to those previously published for the same configuration but quantitatively more refined since we have exact solution of higher order equations.

An axisymmetric numerical study of the flow between two coaxial cylinders, where one of the cylinders has a step change in radius, is carried out for different end plate conditions and step sizes. The inner cylinder undergoes rigid rotation, while the outer cylinder is stationary. Taylor vortices are found to appear in each region when the local Taylor number in that region reaches the critical Taylor number for onset of instability. Depending upon radial extent of the step and end plate conditions, individual region may have even or odd number of vortices. Total number of vortices along the whole length of cylinder is always even for symmetric end plate conditions, and odd for asymmetric end plate conditions. For independently rotating end plate conditions, the flow pattern near the end plates changes at lower values of rotation rate in wide gap region as compared to the narrow gap region. More numbers of vortices are formed with sudden start of inner cylinder at supercritical state.

The linear stability of two axially superposed immiscible fluids between two rotating coaxial cylinders is considered. The effect of viscosity ratio of the two fluids on the condition for onset of instability is studied. The critical Taylor number in the less viscous fluid for onset of instability is obtained as a function of the viscosity ratio. The marginal state is found to be stationary.

Keywords: Taylor-Couette flow, Bénard convection, Modulation, Thermal instability, Step cylinder, Rotating flows.