ABSTRACT

Hydrodynamic stability is an extremely important area in Fluid Mechanics. The main interests in the analysis of hydrodynamic stabilities are to find when and how laminar flows breakdown and develop subsequently to become turbulent. In this thesis the stability of two-dimensional incompressible and compressible boundary layer flows under various circumstances is studied using the linear stability theory. The linear stability analysis of incompressible Falkner-Skan (FS) flow with imposed uniform shear is studied and the shear is found to enhance the stability of the flow in adverse pressure gradient too. In adverse pressure gradient flows at higher Reynolds numbers the larger growth rates move to the smaller wave numbers. Another class of incompressible boundary layer flow investigated in the thesis includes magnetohydrodynamic (MHD) stagnation point flow towards a stretching/shrinking flat plate with pressure gradient and suction. The magnetic field is found to stabilize the flow. The magnetic field increases the critical Reynolds number and shifts the instability to higher wave numbers. The stability analysis of incompressible free convection mass transfer boundary layer flow with chemical reactions over flat plate subjected to transverse magnetic field also reveal the stabilizing influence of magnetic field. The growth rate of the amplifying disturbances decreases as the magnetic field strengthens. The magnetic field at a fixed reaction rate parameter increases the critical Reynolds number for instability. The stabilizing effect of imposed magnetic field accrues from the induced larger shear towards the edge of the boundary layer. The chemical reaction rate parameter affects the critical Reynolds number marginally but shifts the instability to higher wave numbers.

In the compressible flow domain, the effects of flow Mach number, ambient temperature and Prandtl number on the stability of high-speed adiabatic boundary layers are investigated. At low ambient temperatures a second mode, called the fast mode, appears when the Mach number is between 3.8 and 4.8. At very large Mach numbers, $M \geq 8$, the upper branch of the stability curve assumes a large positive slope and moves away from the wave number axis. At a higher ambient temperature, the second mode appears from

Mach number 4 to 7. When, a distinct second (fast) mode appears it is the dominant one and dictates the flow instability. The flow instability increases with increase in the Prandtl number for a given Mach number and ambient temperature. Also, the second mode is suppressed at certain values of the Prandtl number. The thesis also includes a study on the effect of thermal radiation and heat transfer on the stability of compressible boundary layers. Thermal radiation exhibits a destabilizing influence on the flow. The growth rate of the fast mode increases due to radiation but that of the slow mode is mostly unaffected. Effect of radiation becomes more pronounced at higher Prandtl numbers within the range of 0.5 and 0.9.

Key Words: Linear Stability, Free-stream shear, Magnetic field, Reactive flow, Radiation, Hypersonic flow