S Y N O P S I S

The thesis deals with the macroscopic and non-relativistic study of gas flows that depart from thermodynamical equilibrium and are devoid of viscosity, heat conduction and diffusion. In all it comprises seven chapters. Chapter I, which is introduction to the thesis, is followed by remaining six chapters that are the result of the study of some flows in nonequilibrium gasdynamics. In particular, the problems of relaxing or singly reacting gas flows are considered in chapters II, III and IV; while in chapters V and VI the effect of electromagnetic coupling with relaxing gases is studied. The thesis ends with chapter VII, which contains some investigations of flow of an argon-like, partially ionized gas in which collisional-probabilities are dominant.

In chapter I, which is of introductory nature, the historical development and the critical survey of the work in nonequilibrium gasdynamics is presented. The fundamental equations governing flows that may depart from thermodynamical equilibrium, due to vibrational nonequilibrium of a single component gas or due to chemical nonequilibrium of a mixture in which a single reaction occurs, are also given.

In chapter II, the problem of an oscillating airfoil in a two-dimensional wind tunnel, under the small perturbation approximation for supersonic nonequilibrium flows, has been analysed. The solution to the problem has been obtained using Laplace transforms technique. The disturbances produced are exhibited in terms of image fields and the real gas effects are explicitly shown. The dynamic-stability derivatives for pitching oscillation, to the first order in reduced frequency, are obtained. It turns out that the lift coefficient, in the quasi-steady approximation, decreases with the small variation in the nonequilibrium parameter. Further, relaxation effects of the state of the gas on the oscillation of centre of pressure are determined.

Chapter III deals with the instability of inviscid jets in a relaxing gas with respect to three-dimensional disturbances. The eigen-value equations have been derived and the nature of the disturbances relative to both the jet and the free stream has been examined. The frozen flow turns out to be unstable when it is subjected to disturbances which are supersonic relative to the jet, but subsonic relative to the free stream. It turns out that the relaxation effects of the gases as well as the increase in the angle of wave propagation reduce the region of wavy nature of the disturbances. Further, a possibility of a region where the general nonequilibrium flow may be stable is indicated.

In chapter IV, an exact solution to the potential equation, which is satisfied by the perturbed velocity potential of a nonequilibrium flow whose thermodynamic properties depart only slightly from a uniform equilibrium flow, is obtained. The particular geometry adopted is that of an infinitely long cylinder whose surface bears regular corrugations with axial symmetry. Pressure coefficient on the surface of the cylinder is calculated.

A general theory of thin airfoils in nonequilibrium magnetogasdynamics has been developed in chapter V. The complete study has been divided into two parts: Part I deals with the nonequilibrium flows subjected to an aligned magnetic field; while part II is concerned with flows in which the applied magnetic field is transverse to the free stream direction. In part I, Green's function technique is used to obtain an exact solution of the perturbation velocity potential and the velocity at the airfoil surface is calculated for many significant cases. A critical study of the expressions for the velocity at the airfoil surface, for various physical situations, leads to results which have no counterpart in the corresponding non-magnetic study. In part II, the evaluation of the components of perturbation velocity and the magnetic field vectors has been reduced to an integral equation.

In chapter VI, the airfoil theory in nonequilibrium magneto-gasdynamics with non-uniform, nonequilibrium free stream is developed. A general result for the perturbation velocity potential is obtained with the help of Green's functions technique. Two specific examples, namely (i) a parallel nonequilibrium stream of constant velocity and (ii) a non-uniform, nonequilibrium stream, have been worked out and the effects of an aligned magnetic field and nonequilibrium free stream are clearly brought out.

The nonequilibrium flow of an argon-like, partially ionized gas over a wavy wall has been investigated in chapter VII for the case when the collisional probabilities are dominant. Simply appro-ximated, linearized expressions for collisional radiative reaction procéss and radiative energy are used to analyse the flow pattern of the gas, the pressure distribution and the drag coefficient for the three physically possible limiting cases, namely, (i) when energy emitted by a photon is small, but the emission rate is great, (ii) when the emission rate is small, but the energy emitted by a photon is great, and (iii) when the energy emitted by a photon as well as the emission rate are of the same order. It turns out that, for the supersonic case, the relativistic shift in the pressure coefficient due to moderate collisional reaction rate and radiative energy loss is slow as compared with the corresponding case of the simple relaxing and reacting gas flows.