SYNOPSIS

The study of Magneto-fluiddynamics which describes the interaction between the flow field and the electromagnetic field has analysed a number of problems in nature, and has been found to be useful in various industries. Several problems of hydromagnetic flow, heat transfer, lubrication and stability have been studied and the subject has developed in different directions.

In the present thesis, our interest is to investigate some flow and heat transfer problems in magneto-hydrodynamics as well as in magnetogasdynamics.

In Chapter I, we have introduced the topic and have made a critical study of the basic concepts underlying the interaction between the flow field and the magnetic field. The basic equations and boundary conditions of magneto-fluiddynamics are given along with a brief survey of the relevant literature.

Chapter II presents an analysis of hydromagnetic flow in a curved channel of rectangular cross section in the presence of a magnetic field applied at right angles to the horizontal planes. We have considered the problem in the cases when the flow takes place i) due to a constant pressure gradient along the channel and ii) due to rotation of the outer curved wall with a constant angular velocity. Analytical solutions are obtained in both the cases by using finite Hankel transforms. The effects due to finite height of the channel are discussed with the help of numerically computed results.

In Chapter III, we have studied the effects due to Hall currents on the hydromagnetic flow in an annulus between two co-axial cylinders under the influence of a radial magnetic field. Since the system of equations governing the flow is not amenable to a closed form solution, we have numerically solved by employing Runge-Kutta-Merson method. The centrifugal force arising due to Hall currents has given rise to increase in axial velocity and the fluid particles are found to be swirling round the inner cylinder.

Chapter IV deals with the analysis of Hall effects on a rotating hydromagnetic flow due to an oscillating plane. Analytical expressions are obtained for velocity and induced magnetic field distributions. While examining the growth of the boundary layer, it is observed that the boundary layer thickness essentially depends upon the magnetic mode and this thickness increases with the Hall parameter N and the magnetic parameter α ; and decreases as the Rossby number δ increases. The transient velocity is found to decrease as the Hall parameter N increases.

In Chapter V, we have considered the steady laminar free and forced convection in uniformly heated vertical pipes, subject to a radial magnetic field. The governing magnetohydrodynamic equations together with the equation of energy constitute a sixth order boundary value problem. And this problem is numerically solved by adopting Runge-Kutta-Merson method. For Rayleigh number $Ra < 0$, that is, when the temperature of the pipes decreases with height, the onset of instability is found to be delayed due to the presence of the magnetic field. On the other hand, when $Ra > 0$ which corresponds to the case where an upflow is heated (or a down flow cooled) back flow is seen with increase in Ra.

In Chapter VI, we have investigated the effects of combined free and forced convection on the flow through a parallel plate channel subject to rotation and a transverse magnetic field. Assuming linear variation of temperature along the channel walls, an exact solution of the governing equations is obtained. The influence of rotation on such a physical system is found to stabilise the flow field. While analysing the phenomenon of heat transfer, the conflicting tendencies of rotation and magnetic field are noticed.

Chapter VII is devoted to the study of laminar convective flow of a viscous, compressible and electrically conducting fluid past an infinite porous plate subject to a transverse magnetic field. For small Mach number flows, a solution for the problem is obtained in closed form. This investigation reveals a peculiar phenomenon as far as the characteristic features of the velocity and induced magnetic field are concerned. It is observed that, under the influence of buoyancy force, the fluid velocity is enhanced as the magnetic parameter increases; and the magnetic lines deflect backwards.

In Chapter VIII, the viscous compressible flow over an infinite flat plate with suction is extended to a slightly rarefied gas by introducing velocity slip and temperature jump conditions at the surface. The effect of the rarefaction parameter (Knudsen number) is found to reduce the skin friction and the rate of heat transfer considerably.

In Chapter IX, the steady flow of a slightly rarefied and slightly ionised gas over an infinite porous plate, in the presence of a transverse magnetic field, is considered. The dependence of viscosity and electrical conductivity on temperature is taken as

$$\frac{\mu}{\mu_\infty} = \sqrt{\frac{T}{T_\infty}} \quad \text{and} \quad \frac{\sigma}{\sigma_\infty} = \left(\frac{T}{T_\infty}\right)^{3/2}$$

Adopting the well known continuum approach, an analytical solution for the problem is presented for small Mach number flows. The effect of Knudsen number is found to enhance the fluid velocity. The impact of applied magnetic field is clearly felt in retarding the flow field. The influence of magnetic pressure number, temperature ratio and suction on the flow characteristics is discussed in detail underlining the effects of gas rarefaction. Finally, a comparative study concerned to slip and no-slip conditions is also made.