SYNOPSIS

The thesis deals with some problems on fluid flows in Magnetohydrodynamics (to be written as MHD hereafter). A brief review of previous work directly connected with the problems of this thesis is given in Chapter I along with the basic equations, approximations and boundary conditions for MHD flows. The rest is divided into two parts A and B. Part A (Chapters II - V) is devoted to the study of some unsteady MHD flows. In Part B (Chapters VI and VII) we have investigated some steady flows in MHD with special reference to heat transfer.

Chapter II presents an analysis of laminar flow of a conducting liquid in a long channel of rectangular cross section due to a periodic pressure gradient in the presence of a uniform transverse magnetic field. Exact solutions are obtained for two cases, (i) non-conducting walls parallel to the field and thin walls of arbitrary conductivity perpendicular to the field, and (ii) perfectly conducting walls perpendicular to the field and thin walls of arbitrary conductivity parallel to the field. In case (i), the behaviour of the asymptotic solutions for large Hartmann number (M) is discussed in the two Hartmann layers (of thickness of order M^{-1})

attached to the walls perpendicular to the field. In case (ii) asymptotic solutions for large Hartmann number in the form of rapidly convergent series in the boundary layers (of thickness of order $M^{-1/2}$) on the walls parallel to the field are obtained and it is found that the maximum root mean square velocity in these layers is greater than that at the core (V_c) and, in particular, is of order MV_c when these walls are non-conducting.

Chapter III is devoted to the study of the general unsteady flow past an infinite porous flat plate subjected to uniform suction in the presence of a transverse magnetic field. Exact solutions are obtained by Laplace-transform technique assuming that the magnetic Reynolds number is equal to the viscous Reynolds number and that the Alfvén velocity is less than the suction velocity. Among the particular cases considered are, (i) flow in which the free stream velocity is changed impulsively, (ii) uniform acceleration of the main stream from a constant value of the velocity, and (iii) flow in which the free stream velocity consists of a mean value with a superimposed decaying oscillation. In the first case, it is shown that the magnetic field delays the flow to settle down to its ultimate state. In the second case, it is observed that ultimately the skin friction consists of a quasi-steady part which is unaffected by the magnetic field and a part proportional to the product of the free stream acceleration and a 'virtual mass' which increases with the increase in the applied magnetic field. In the third case, the criterion for a phase lead or a phase lag between the skin friction and the main stream is indicated.

Chapter IV illustrates the effect of a magnetic field on the boundary layer separation on a cylinder moving uniformly in a direction perpendicular to its generators, being started impulsively from rest in a conducting fluid. For a circular cylinder in an aligned field (i.e. parallel to the direction of motion of the cylinder) separation first develops from the rear or front stagnation point according as the interaction parameter $N < 1.38$ or > 2.65, while, for $1.38 < N < 2.65$, it starts from a pair of symmetrically situated points on the rear part of the cylinder. The interval of time between the start of motion and the start of separation increases or decreases with an increase in N according as separation develops first on the rear half or on the front half of the cylinder.

Chapter V is devoted to the study of boundary layer growth on a cylinder moving with a velocity $V(t)$ [given by (i) $V(t) = At^{\alpha}$, and (ii) $V(t) = A e^{ct}$, A , c being positive constants and α a positive rational number_7 in a direction perpendicular to its generators in a conducting fluid in the presence of a magnetic field. In case (i) the method of solution for any rational number is indicated and explicit solutions for integral values of α are obtained. The general results obtained are applied to the special case of a circular cylinder for $\alpha = 2$. It is found that, for an aligned field, separation develops from the rear stagnation point for small values of the interaction parameter but with the increase of the interaction parameter beyond some critical value the starting position of separation shifts to a pair of symmetrically situated points on the rear part of the cylinder. The other important effect of the magnetic field is to delay separation. The results of case (ii) are similar to those of case (i).

In Chapter VI we have investigated the flow of an electrically conducting fluid past a porous, conducting flat plate kept at constant temperature in the presence of a transverse magnetic field. Exact solutions for velocity and temperature distribution are obtained and asymptotic results for large magnetic Prandtl number are deduced. It is shown that for large magnetic Prandtl number, the effect of wall conductivity will be confined within a thin layer near the plate.

The fully developed free convection flow of a viscous electrically conducting fluid through an annulus between two heated coaxial vertical pipes in the presence of a radial magnetic field is studied in Chapter VII. Two different temperature conditions at the walls viz., (i) linearly increasing wall temperatures, and (ii) constant wall temperatures, are considered. Exact solutions in case (ii) and approximate solutions in case (i) are obtained and the effect of various parameters on the flow and heat transfer characteristics of the problem is discussed.