SYNOPSIS

The study of heat transfer has, in recent years, acquired considerable importance in the fields of modern science and technology, such as aeronautics and nuclear power technology. With the motion of a body at high speeds, air gets ionized and electrically conducting and the superposition of a magnetic field is found to reduce the heat transfer. Moreover, with the advent of nuclear power, the mode of heat transfer by natural convection processes appears in many of the schemes for extracting heat energy from atomic piles. With the use of liquid metals as coolants in such heat transfer equipment, knowledge about the temperatures and heat transfer in thermal entry regions has been found to be highly useful. Neglecting the electrical conductivity of the walls and the Joule heating effect, a number of authors have shown that the superposition of a magnetic field on convection flows results in a reduction of heat transfer.

The purpose of this thesis is to investigate the phenomenon of heat transfer in hydromagnetic flows, taking into account the electrical conductivity of the walls and Joule heating. In view of the complicated nature of the system of equations involved, consideration has been

restricted to problems of steady state flow of incompressible electrically conducting, viscous liquids between infinite parallel walls.

In Chapter I, the basic equations : the Navier-Stokes equations, modified by the inclusion of the Lorentz Force; the electromagnetic equations of Maxwell, in Gaussian Units, with the displacement current neglected; and the energy equation, are given. The boundary conditions for the magnetic field in the liquid, as affected by the electrical conductivity of the walls, are also stated.

Chapter II deals with the problem of temperature distributions and heat transfer in thermal entry regions. The flow considered is that, in which a liquid flowing between parallel walls at rest and at a constant temperature upto a certain cross-section, enters a region with a different constant wall temperature. The use of orthogonal functions to solve the energy equation leads to an eigenvalue problem, in which the eigen-values are roots of an infinite determinant equation. The first ten eigen-values (five positive and five negative) have been determined. Two cases, one corresponding to a low Prandtl number or high Peclet number Pe , the other to be high Prandtl number or small Peclet number have been considered for different values of M (Hartmann number) and different conductivity conditions at the walls. It is found that, for large Pe, the upstream temperatures are not affected by the downstream temperature conditions, a thermal entry length being established in the downstream section only, while for small Pe, the temperatures in both regions are affected. The temperatures and heat transfer coefficients are seen to increase with the increase of M or with the increase of conductivities of the walls.

Fully developed natural convection flow between parallel walls at constant temperatures, oriented in the direction of the body force, with a transverse magnetic field superposed, has been investigated in Chapter III. The temperature and the velocity profile, in the case of strong magnetic field, have been determined with the help of an iteration procedure. It is found that, in the absence of heat sources, the Nusselt numbers and viscous drag are considerably diminished by the introduction of electrical conductivity conditions at the walls. The effect on the Nusselt numbers is relatively diminished in the presence of large heat sources.

Chapter IV contains the study of the combined natural and forced convection, hydromagnetic flows between wall with temperatures linearly varying along their lengths. The resulting non-linear boundary value problem has been solved in terms of even and odd functions depending on only two of the parameters involved, so that the solutions for a variety of conditions can be easily computed from the values of these basic functions. We notice that the effects of the electrical conductivity of the walls on the flow and heat transfer characteristics are considerable and that the cumulative effect of frictional and Joule heating is small.

Chapter V deals with the natural convection flow between parallel porous walls at constant temperatures, in the presence of a transverse magnetic field. Boundary conditions for the magnetic field in the liquid, taking into account the electrical conductivities of the walls and the cross flow velocity, have been deduced. For small values of Hartmann number, the temperature and the velocity profile have been determined, in terms of R_s , a Reynolds number characterising the cross flow velocity. The conductivity of the walls is found to increase the Nusselt numbers and decrease the viscous drag at the walls. The effect of the cross flow velocity is seen to be to increase the viscous drag and the heat transfer at the wall, where there is suction and to diminish them, where there is injection.

The computations of the results presented in this thesis have been carried out on the electronic digital computer 'National Elliott 803', installed at the Hindustan Aircraft Limited, Bangalore.