SYNOPSIS

The problems of fluid flow, in most practical cases are turbulent in nature. The present day knowledge of the turbulent flow is very limited. As a result, the fluid dynamics of turbulent flow is still in a semi-empirical state. But the understanding of a laminar viscous flow provides a pre-requisite for the complete understanding of turbulent flow. In order to minimize the friction drag, as well as, the cooling requirements resulting from the aerodynamic heating, the maintenance of extensive laminar flow is highly desirable. Thus the study of the laminar flow of viscous fluids has become one of the most interesting problems of aeronautical engineers of recent times. Secondly, the study of heat transfer has received the attention of several authors, in view of its importance in several fields of engineering and technology. The laws of heat transmission are of controlling importance in the design and operation of many diverse forms of preheaters, exchangers and coolers, especially in the field of nuclear technology. In almost every branch of engineering, heat transfer problems are encountered, which are not amenable to solution by thermodynamic reasoning alone, but require an analysis based on the science of heat transfer.

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. In view of this, much work was done on the generalization of well known viscous flow solutions to take account of the additional effects of magnetic field when the fluid is electrically conducting, with special reference to heat transfer.

Another field which has acquired importance deals with problems on viscous fluids with suction or injection. The problem of boundary layer control with suction or injection has become important because of its application in aeronautical engineering in the design of aircraft wings, transpiration, cooling of rocket engine and in diffusion technology.

The purpose of the present thesis is to study the action of each of the above phenomena in establishing and modifying fluid flows. The thesis deals with a few problems of flow and heat transfer with and without magnetic fields. It is divided into six chapters. In Chapter I, a brief survey of literature mainly related to the thesis is given.

Chapter II consists of two parts. First part deals with the analysis of the hydromagnetic flow and heat transfer in a convergent channel with porous walls. The differential equations governing the flow is solved by Ritz's variational method. With the known velocity function, the energy equation is solved for the temperature distribution.

It is found that the skin friction increases with the applied magnetic field as well as the suction whereas the magnitude of the Nusselt number at the wall increases with the magnetic field but decreases with the increase of the suction. In the second part of this chapter, we have considered the heat transfer of the laminar flow between converging walls with temperature dependent heat sources. It is found that the temperature distribution depends upon the product of the Prandtl number and the heat source parameter but not on their individual values.

In Chapter III, we have discussed the combined natural and forced convection hydromagnetic flow in vertical channels under the influence of transversely applied magnetic field and external circuit. The walls of the channel are having the same temperature gradient along their lengths, but both are kept at different temperatures. The system of non-linear integro-differential equations governing the problem are solved by an iteration method and the shearing stress and Nusselt number at the walls are calculated. Consideration is given to heat sources present in the fluid. It has been found that the temperature dependent heat sources impose oscillatary behaviour on the temperature profiles and the heat transfer between the wall and the adjacent fluid changes its direction for different ranges of values of the heat source per unit volume. The magnetic field reduces the velocity but increases the temperature and the presence of linear variation of the wall temperature helps in cooling the walls.

Chapter IV is devoted to the study of the unsteady hydromagnetic boundary layer flow along a flat plate. Following Lighthill (1954) the two-dimensional boundary layer equations are separated into those representing steady and unsteady parts of the motion and they are solved in sequence. For the unsteady part of the motion two types of solutions are obtained, one for large times and the other for small times. Also the quasi-steady solution is obtained in terms of the steady solution. The skin friction and the tangential magnetic field at the plate are calculated. It is found that for small times the unsteady part of the tangential magnetic field at the plate remains negative (i.e. directed opposite to the main stream flow) whereas its quasi-steady value (for large times) is always positive. From this it is conjectured that at initial stages of motion the unsteady part of the surface magnetic field oscillates.

In Chapter V, an unsteady hydromagnetic forced flow against a rotating disk of infinite radius is investigated. The velocity components, the applied magnetic field and the angular velocity of the disk are all assumed to decay with time. A suitable set of similarity transformations is introduced and the system of reduced equations is solved by Kármán-Pohlhausen method. It is found that the unsteadiness reduces the boundary layer thickness, skin-frictions and the moment coefficient. Also, the magnetic field reduces the boundary layer thickness but increases the skin friction.

Chapter VI is devoted to a theoretical investigation of the problem of the flow and heat transfer of an elastico-viscous fluid in a porous channel. The constitutive equations used are those proposed by Oldroyd (1958). The temperatures of the walls are varying linearly along their lengths in the major flow direction. The velocity and the temperature profiles are obtained for various values of the suction and visco-elastic parameters and the corresponding viscous drags and the Nusselt number at the walls are computed. It has been found that near the wall with injection the suction Reynolds number flattens the velocity profiles and the visco-elastic parameter steepens them whereas reverse are the effects near the wall with suction. For large temperature gradients along the lengths of the walls, the wall at lower temperature is cooled whereas for small temperature gradients this wall is heated, but the wall with higher temperature is cooled always.

The numerical computations involved in this thesis are performed on the Electronic Digital Computer IBM 1620 installed at the Indian Institute of Technology, Kharagpur, India.

References

Lighthill, M.J. Proc.Roy.Soc.London, Ser.A, 244 (1954) 1.

Oldroyd, J.G. Proc.Roy.Soc.London, Ser.A, 245 (1958) 278.