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A THESIS ON
SOME ASPECTS OF HYDROMAGNETIC CHANNEL FLOWS

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CERTIFICATE

This is to certify that this thesis "Some Aspects Of Hydromagnetic Channel Flows", being submitted by Mr. Rao Balasubramanyam to the Indian Institute of Technology, Delhi for the award of the Degree of Doctor of Philosophy in Mathematics is a record of bonafide research work carried out by him under my supervision and guidance for the last three years and to my knowledge it has reached the standard fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted in part or in full, to any other university or institute for the award of any degree or diploma.

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A C K N O W L E D G E M E N T S

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(Rao Balasubramanyam)

S Y N O P S I S

The work reported in this thesis has been divided into the following four sections:

Section I: The effect of wall roughness on MHD channel flows (Chapters 1-3).

Section II: Heat transfer in two-dimensional MHD channel flows (Chapters 4-5).

Section III: MHD boundary layers (Chapters 6-7).

Section IV: Heat transfer in Hydromagnetic turbulent shear flows through porous walled channels (Chapter 8-9).

In the first chapter of Section I, we have obtained velocity, magnetic field and temperature distribution for steady state laminar hydromagnetic flow of an incompressible viscous electrically conducting fluid between two slightly non-parallel and infinitely extending walls in the presence of a uniform magnetic field transverse to the central line of symmetry by using the corresponding distributions for parallel wall problem by adopting the approach used by Erdogan (1964). The second chapter deals with slow viscous flow between two rotating concentric infinite cylinders with axial roughness in the presence of a radial magnetic field. Expression for velocity field and moments have been obtained.

In the last chapter of this section we have studied the effect of roughness of surfaces on the load-carrying capacity of a MHD inclined slider bearing in the presence of a transverse magnetic field. Here the distinction is made between waviness and roughness, the latter being treated as a random quantity which may be characterised by a probability density function, determined experimentally.. Results have been obtained in closed form in the case when roughness is represented by a Beta distribution.

Chapters 4 and 5 of Section II deal with heat transfer in two-dimensional hydromagnetic channel flows. In these chapters we have considered heat transfer in a two dimensional steady-state laminar flow of an incompressible, viscous and electrically conducting fluid through a porous circular pipe and a porous walled rectangular channel in the presence of a external uniform transverse magnetic field. The energy equation in these cases have been reduced to an ordinary differential equations by assuming temperature distributions of the form $A\xi+\theta(\zeta)$. The resulting differential equations have been solved numerically.

Chapter 7 of Section III deals with the oscillatory flow of an incompressible electrically conducting fluid over a semi-infinite porous flat plate with time dependent suction and time dependent magnetic field. It is assumed that both the suction and free stream velocities are fluctuating only in magnitude but not in direction. It is assumed that the plate is non conducting and the conductivity of the fluid is so small as to neglect the induced magnetic field. The resulting momentum and energy equations have been solved by perturbation technique. For the temperature distribution two cases have been considered namely (i) thermally insulated plate (ii) the plate maintained at a constant temperature. Radhakrishna (1968) has studied the MHD oscillatory flow over an infinite porous flat plate with time dependent suction.

In the last chapter of of Section III, we have studied MHD wedge flow with variable physical properties by the method of variational imbedding. The physical properties i.e. thermal conductivity, viscosity and electrical conductivity are assumed to be linear functions of temperature. Two coupled differential equations have been derived from the variational formulation and then solved numerically. Consequently, momentum boundary layer thickness, thermal boundary layer thickness, local Nusselt number and local friction factor have been found for the flow. Cheng S.C. and Kumar A (1972) have studied laminar wedge flow with variable properties by a variational method based on local potential theory.

Chapters 8 and 9 of section IV deal with heat transfer in hydromagnetic turbulent shear flows through porous walled channels.

Pai (1953) adopted the semi-empirical approach initiated by Prof. Kampede Feriet (1948) for studying turbulent shear flow of an incompressible viscous fluid between two parallel plates and through a circular pipe due to some serious limitations and inconsistencies in Prandtl's mixing theory. In view of close conformity of Pai's theoretical results with experimental observations made by Laufer (1950) and Nikurdse (1932), Mehta (1963) extended the same approach to investigate hydromagnetic turbulent shear flow of an incompressible viscous, electrically conducting fluid in the presence of a uniform external transverse magnetic field through three types of porous walled channels

(i) between porous parallel planes

(ii) porous circular pipe

(iii) porous walled annulus.

The solutions obtained here were compatible with the corresponding laminar hydromagnetic flows and are also valid across the entire cross-section of the channel unlike in the case of mixing-length theory when the mean velocity distributions holds true only in the central core region. Making use of the mean velocity distributions for the hydromagnetic turbulent shear flows in different geometries given by Mehta (1963), we have found analytical solutions for the mean temperature distribution for hydromagnetic turbulent shear flows through two types of porous-walled channels

(i) between porous parallel planes

(ii) porous-walled annulus.

C O N T E N T S