CHAPTER IX

Concluding Remarks

Flows through porous medium are of principal interest because these are quite prevalent in nature. Such flows have many scientific and engineering applications, viz., in the fields of agricultural engineering to study the underground water resources; seepage of water in river beds; in chemical engineering for filtration and purification processes; in petroleum technology to study the movement of natural gas, oil and water through the oil reservoirs. Convective flows in porous media are of interest in many varied situations for example in geothermal energy resources, oil-reservoir modeling in the analysis of insulating systems and in flows through tobacco rods.

Motivated by the applications of free convective flows through porous medium, this thesis attempts to throw light on the heat and mass transfer of steady convective flows through porous medium.

Chapter I introduces various preliminary concepts required for the study. Chapter II summarizes the significant earlier contributions related to the present study.

In Chapter III, we have the investigation of the effect of magnetic field on steady boundary layer slip flow along with heat and mass transfer over a flat porous plate embedded in a porous medium.

The following conclusions are drawn from this study:

- Skin-friction decreases rapidly and approaches zero as the velocity slip parameter δ increases.
- The rate of heat transfer $\theta'(0)$ decreases, with increase in the velocity slip parameter δ and magnetic field M. Rate of heat transfer $\theta'(0)$ increases, with increase in the thermal slip parameter β.
- The rate of mass transfer $\phi'(0)$ decreases, with increase in slip parameters δ, β and magnetic parameter M. It is also observed that the rate of mass transfer $\phi'(0)$ increases, with increase in slip parameter ς.

Chapter IV discusses the effect of Hall current on heat and mass transfer of free convective flow over a flat porous plate embedded in porous medium. We have

concluded that all the instantaneous flow characteristics are affected by the Hall current parameter m.

In this study the following conclusions are set out:

- The velocity profiles f', f, g decrease with increase in magnetic parameter M.
- Temperature and concentration profiles increase with increase in magnetic parameter M.
- The velocity profiles f', f increase with increase in Hall current m, in the case of temperature and concentration reverse trend is observed.
- Velocity components and concentration profiles decrease with increase in the Schmidt number Sc.
- Skin-friction increases due to increase of Hall current parameter m, and decreases with increasing magnetic parameter M.
- The rate of heat transfer $\theta'(0)$ and the rate of mass transfer $\phi'(0)$ decrease, with increase in Hall current parameter m while increase in the magnetic parameter increases the heat and mass flux.

In Chapter V we have considered the combined effects of Hall and ion-slip currents on steady free-convective flow of an incompressible viscous and electrically conducting fluid with heat and mass transfer over a porous flat plate embedded in porous medium.

In this study the following conclusions are brought out:

- All the instantaneous flow characteristics are affected by the ion-slip parameter β_i.
- The velocity profiles $f'(\eta), f(\eta)$ increase with increasing ion-slip parameter β_i. The velocity distribution i.e., cross flow velocity $g(\eta)$ decreases with increasing values of β_i.
- Skin-friction increases with increasing ion-slip β_i and Hall current β_e.
- Shear stress in z-direction $g'(0)$ increases with increasing values of β_e when $\beta_e \leq 1$, but decreases with increasing values of Hall current parameter when β_e greater than unity.
- The rate of heat transfer $\theta'(0)$ decreases, with increase of ion-slip β_i and Hall current β_e .

- The rate of mass transfer $\phi'(0)$ decreases with increase of ion-slip β_i and increases with increase of Hall current β_e.

Chapter VI deals with the thermal diffusion and magneto hydrodynamic effects on heat and mass transfer of steady, viscous incompressible, electrically conducting fluid in a rotating disk embedded in a porous medium.

The following conclusions are drawn from this study:

- Radial and tangential velocities decrease when magnetic field increases, whereas the axial velocity increases, when magnetic field increases.
- The temperature and the concentration fields increase, when magnetic field increases. However, the effect of the magnetic field on the concentration distribution is not very significant.
- The increase in Schmidt number Sc and Soret number Sr causes an increase in concentration profiles.
- The axial skin-friction $F'(0)$ and tangential skin-friction $G'(0)$ decrease, as increase in Darcy number D_a and magnetic parameter.
- Increasing Darcy number and magnetic parameter increase the rate of heat transfer and decrease the rate of mass transfer.

Chapter VII investigates the heat and mass transfer of a three dimensional MHD free convective flow over a flat porous plate embedded in a porous medium. The results are obtained for the velocity, temperature and concentration profiles, the skin-friction coefficient, Nusselt number and the Sherwood number. Effect of various non-dimensional parameters on the fluid flow, heat and mass transfer characteristics are examined.

The following conclusions are drawn from the present study:

- Main flow and cross flow velocities decrease when magnetic field increases, whereas temperature and concentration increase, when magnetic field increases.
- The skin-friction $f''(0)$ and $g''(0)$ decrease with an increase in stretching ratio parameter and magnetic parameter.
- Increase in magnetic field and stretching ratio cause an increase in the rate of heat and mass transfer.

In Chapter VIII, we have presented a numerical investigation of the effect of thermal radiation and chemical reaction on three dimensional MHD fluid flows in a porous medium. From this study, we conclude that an increase in radiation parameter N causes an increase in temperature $\theta(\eta)$ profile, and an increase in chemical parameter β causes decrease in concentration $\phi(\eta)$ profile. Skin-friction coefficient, local Nusselt number and local Sherwood number are discussed for different values of non-dimensional parameters.

In this study the following conclusions are set out:

- Magnetic parameter reduces skin-friction and increase the rate of heat and mass transfer.
- Radiation parameter enhances the rate of heat transfer and decrease rate of mass transfer.
- Increase in chemical reaction parameter decreases the rate of mass transfer.
- Increase in stretching ratio reduces skin-friction and rate of heat transfer.
- Due to increase in stretching ratio rate of mass transfer increases.

Suggestions for Future Research

In the following we indicate problems that can be pursued in future as a sequel of the present investigation.

- The work in this dissertation deals mainly with steady, free convective flows. Assumption of time variation for the temperature and concentration at the plate will make the flow unsteady. Numerical study of unsteady free convective flows may lead to interesting results.
- Use of Lattice Boltzman methods to study these problems often a novel probability.
- Presence of time varying heat source may lead to an open problem. A Fourier series type solution may be tried.
- Mathematical models can be developed to discuss mass transfer of free convective flows with a system of parallel fracture situated in the porous matrix.
- Setting up of some experimental facilities to validate these models is a very useful problems.

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