ABSTRACT

MHD laminar boundary layer flows all the way through porous media have been attracting the attention of many researchers in current years because of their applications in several branches of science and engineering. For example, we find the applications of boundary layer flows in the field of agricultural engineering to examine the underground water resources, discharge of water in river beds; in the field of chemical engineering, particularly for filtration and decontamination process; and in petroleum technology, to know the progress of natural gas, water and oils through the oil reservoirs etc... The simultaneous occurrence of heat and mass transfer from different flow geometries through porous medium has applications in many areas of science, engineering and geophysics. For example, geothermal reservoirs, enhanced oil recovery, thermal insulation, packed-bed catalytic reactors, and underground energy transport. The importance of magneto hydrodynamics (MHD) is also concerned with geophysical and astrophysical problems. Especially, the possible applications of MHD, which affects a flow stream of an electrically conducting fluid for the purpose of propulsion and control, thermal protection etc. From the point of applications, many studies on the influence of magnetic field on convection flows have been carried out by several investigators. The concept of fluid flow and mass transfer past a porous medium in rotating environment play an important role in the application of geophysics, petrochemical engineering, meteorology, oceanography and aeronautics. The stimulus for scientific research on rotating fluid system is basically originated from geophysical and fluid engineering applications. Many aspects of the motion of terrestrial and planetary atmospheres are highly influenced by the effect of rotation. Rotation flow theory is utilized in determining the viscosity of the fluid in the construction of the turbine and other centrifugal machines.

When high temperatures attained in some engineering devices such as gas, for example, can be ionized and so becomes a good electrical conductor. The ionized gas or plasma that interacts with the magnetic field alters heat transfer and friction characteristics. Since some fluids emit as well as absorb thermal radiation, therefore it is of interest to study the effect of magnetic field on the temperature when the fluid is not
only an electrical conductor but also capable of emitting and absorbing thermal radiation. This is also interesting because of heat transfer by thermal radiation, has greater importance when we are concerned with space applications and higher operating temperatures. The growing need for chemical reactions in chemical and hydrometallurgical industries requires the study of heat and mass transfer in the presence of chemical reaction. The presence of a foreign mass in a fluid causes some kind of chemical reaction. This can be presented either by itself or as a mixture with the fluid. In many chemical engineering practices, a chemical reaction occurs between a foreign mass and a fluid in which the plate is moving. These processes take place in several industrial applications, such as, polymer production, manufacturing of ceramics or glassware and food processing. The study of heat and mass transfer with the effect of chemical reaction is one of the greatest practical importance to engineers and scientists because of its occurrence in many branches of science and engineering. Several researchers have analyzed incomprehensible variety of flows connected to MHD free convective flow through porous media of a rotating/ non-rotating fluid with heat and mass transfer. In a moving fluid, if heat and mass transfer occur simultaneously, the relations among the dynamic potentials and fluxes are of more considerable. It has been recognized that energy flux will be formed by temperature gradient as well as concentration gradients. The energy flux formed by a concentration gradient is treated as the diffusion- thermo (Dufour effect) effect. On the other hand, mass flux caused by temperature gradients is treated as thermal –diffusion effect (Soret effect). Soret and Dufour effects are neglected in several studies which belong to heat and mass transfer phenomena because of their smaller order of magnitude when compared with the effects described by Fourier’s and Fick’s laws. These become influenced when they are treated as second order phenomena in the fields of petroleum technology, hydrology, geosciences etc. For isotope separation and in mixture between gases with very less molecular weight and of average molecular weight, the Soret effect is used. In spite of the wide range of applications mentioned above, several authors contributed in this area of research; still there is a need to investigate various aspects of boundary layers flows.
The present thesis is an investigation on “Unsteady MHD free convection boundary layer flow of heat generating and chemically reacting fluid past a vertical porous plate”. In the thesis, a boundary layer flow of a viscous, incompressible and electrically conducting fluid past an infinite vertical porous plate has been considered. Exact solutions to the dimensionless governing equations have been obtained by using single and multiple parameter perturbation techniques, finite difference method and also Laplace transform method. The effects of various parameters on the flow quantities are studied with the help of graphs and tables.

The thesis is divided into seven chapters. The basics of heat and mass transfer and the basic governing equations related to conservation of mass, conservation of momentum, and energy and species diffusion are presented in chapter-1. In the second chapter, the detailed literature survey is presented.

In chapter-3, an investigation is carried out for a fully developed unsteady magnetohydrodynamic free convection flow of a viscous incompressible and electrically conducting Newtonian fluid through porous medium bounded by an infinite vertical porous plate in a rotating system in the presence of heat source and thermal diffusion. The porous plane and the porous medium are assumed to rotate in a solid body rotation, whereas the vertical surface is subjected to variable suction perpendicular to it and the temperature at this surface varies with respect to time about a nonzero constant mean. Analytical solutions for the distributions of velocity, temperature and concentration fields are obtained by using a regular perturbation technique. The effects of pertinent parameters like Grashof number (Gr), modified Grashof number (Gm), magnetic parameter (M), porosity parameter (Kp), rotation parameter (Ω), Suction parameter (A₁), Prandtl number (Pr), Schmidt number (Sc), chemical reaction parameter (Kc), Soret number (S₀), heat absorption parameter (Q) on these distributions are studied numerically with the help of graphs. With the aid of the above flow quantities the expressions for skin friction, Nusselt number and Sherwood number are derived. Variations in these distributions are presented in tables. It is noticed that the velocity boundary layer condenses with the increasing values of Schmidt number. Flow reversal is prevented for
low speed of rotation, high value of chemical reacting species and high value of magnetic parameter.

**Chapter - 4** considers an analytical investigation of unsteady MHD free convection flow of a visco-elastic, incompressible, electrically conducting fluid past a vertical porous plate through a porous medium with time dependent oscillatory porosity and suction in the presence of a uniform transverse magnetic field. The effects of radiation, heat generation/absorption, radiation absorption and homogeneous chemical reaction are considered. The novelty of the present study is to analyze the effects of time dependent suction and porosity parameter on a visco elastic fluid flow in the presence of radiation, heat generation/absorption, radiation absorption and chemical reaction. The coupled nonlinear partial differential equations are turned to be ordinary by superimposing a solution with steady and time dependent transient part. Finally, the set of ordinary differential equations are solved with a perturbation scheme to meet the inadequacy of boundary condition. The consequences of various physical parameters like magnetic parameter (M), modified Grashof number (Gm), Grashof number (Gr), Viscoelastic parameter ($\gamma$), frequency of oscillations parameter ($\omega$), Prandtl number (Pr), radiation absorption parameter (R), chemical reaction parameter (Kc), Schmidt number (Sc), heat absorption parameter (Q), porosity parameter (Kp) and radiation parameter (Nr) are studied numerically with the help of tables and graphs. Elasticity of the fluid and the Lorentz force reduce the velocity and it is more pronounced in case of heavier species. Most interesting observation in this study is the fluctuation of velocity near the plate due to the presence of sink and elastic element.

**In chapter - 5**, we have examined thermal diffusion and Joule heating effects of MHD free convective heat absorbing/generating viscous dissipative Newtonian fluid with the consideration of variable temperature and concentration. The governing equations related to the problem are solved for velocity, temperature and concentration by using numerical finite difference scheme. The variations in velocity, temperature and concentration under the effects of several physical parameters such as magnetic parameter (M), modified Grashof number (Gm), porosity parameter (Kp), Prandtl number
(Pr), Soret number \( (S_0) \), Schmidt number \( (Sc) \), radiation parameter \( (Nr) \), heat absorption parameter \( (Q) \), Eckert number \( (E) \), chemical reaction parameter \( (Kc) \), Grashof number \( (Gr) \) on the flow quantified are studied numerically with the help of graphs and tables. The numerical values for local skin friction, rate of heat transfer and rate of mass transfer are recorded and their characteristics are discussed.

In chapter–6, an unsteady hydrodynamic free convection flow of a viscous incompressible, electrically conducting, optically thick radiating and heat absorbing fluid past an accelerated moving vertical plate with variable ramped temperature is investigated. Exact solutions of the governing equations for the fluid velocity, fluid concentration and fluid temperature are obtained by Laplace transform technique. The numerical values of primary and secondary fluid velocities, fluid temperature and fluid concentration are displayed graphically where as those of shear stress and rate of heat transfer at the plate are presented in the tabular form for various values of pertinent flow parameters like radiation parameter \( (Nr) \), heat absorption parameter \( (Q) \), critical time for rampedness \( (t_1) \), chemical reaction parameter \( (Kc) \), Schmidt number \( (Sc) \), Grashof number \( (Gr) \), modified Grashof number \( (Gm) \), magnetic parameter \( (M) \), porosity parameter \( (Kp) \), Hall parameter \( (m_1) \), Prandtl number \( (Pr) \), etc.

In seventh chapter, summary, conclusions and scope for future study are presented.