SYNOPSIS

In recent years considerable interest has been evinced in the study of flow past a porous medium [1] because of its natural occurrence and importance in many engineering problems such as porous bearings [2, 3], porous rollers [4], porous layer insulation consisting of solid and pores [5] and, in bio-mechanics particularly, in the study of blood flow in lungs [6], in arteries [7], etc. It involves the study of fluid flow above and through the porous medium. The former flow is governed by the Navier-Stokes equation and the latter either by the Darcy [8] equation or the equation suggested by Brinkman [9] which is the generalization of Darcy’s equation. The equations governing these two flows are coupled through proper boundary conditions at the porous interface.

In many situations the fluid in the non-porous region say near the banks of a river due to presence of sand and clay particles water becomes muddy. Crude oil flowing inside the earth contains many compounds dissolved in it. Due to presence of these impurities the muddy water, crude oil etc. become heavier and hence behave as non-Newtonian fluids. Therefore, to discuss the flow of such fluids we have considered in this thesis the constitutive equation for second-order fluids suggested by Coleman and
In this thesis we have discussed two types of problems: One when the fluid flows through a porous medium past impervious bodies embedded in the medium and the other types when there is a free flow region adjacent to the porous medium. In the latter case the matching conditions suggested by Williams [11] have been used at their common surface. The thesis has been divided into seven chapters.

Chapter I deals with the introduction of the thesis. The outline of various theories proposed to explain the effect of porosity, permeability, viscosity etc. and their advantages and disadvantages have been discussed in this chapter. A brief deduction of the Brinkman - Oberbeck - Boussinesq equation has been done. A brief survey of the work in this field, done by various scientists, have been described. Lastly, the motivation and scope of the present thesis have been stated.

In Chapter II the flow of a second-order fluid confined between a rotating disk and a porous medium fully saturated with a viscous Newtonian fluid has been discussed. It is assumed that the flow in the free gap is governed by the constitutive equation suggested by Coleman and Noll [10] and that in the porous medium is governed by the equation suggested by Brinkman [9]. Both the flows are matched at the interface by conditions that tangential velocity components and shearing stress jump at the interface by constant factors. There is an axial flow in the porous medium at
a large distance from the interface and this flow is towards the surface of the interface, that is, the fluid is pumped out from the porous medium. The effect of non-Newtonian terms are to increase the magnitude of this axial flow as well as radial and rotational flow. The magnitude of this axial flow decreases with the increase of the distance of the rotating disk from the interface. The shearing stresses at the rotating disk have also been calculated. These shearing stresses increase with the increase of non-Newtonian parameter and decreases with porosity.

In Chapter III the flow of a second-order fluid over a porous medium inclined at a constant angle has been discussed. We have considered two regions of flows, region I: the free flow region in which a second-order fluid flows over an inclined porous plane with its upper surface open to atmosphere and region II: The inclined porous region of finite thickness. The region is bounded below by a hard surface with a small suction. In this porous region, flow is assumed to be governed by the Brinkman [9] equation. The velocities in both the regions have been calculated and matched at the interface by the conditions suggested by Williams [11]. Though the expressions for velocities have been found with the assumption that the thickness of the porous medium is of constant times than that of the free flow region but the graphical representation of the same have been made for equal thicknesses. The graphs show that the velocities in both the regions increases with the increase of both the permeability of the medium as well as non-Newtonian parameter. We have also calculated the mass flow rate in free flow region and compared it with that when the porous medium is absent. It has been found that the mass flow rate increases when there is
a porous surface below the free flow region.

In chapter IV the flow of a second-order fluid filling the annular space between an impervious solid circular cylinder rotating with a constant angular velocity and a co-axial cylindrical porous medium has been discussed. The two cases viz. (i) when the porous medium is of finite thickness and (ii) when the porous medium is of infinite extent have been considered. The flow in the annular free flow region is taken to be governed by the Navier-Stokes equation and that in the porous region by the Brinkman [9] equation. The solution for both the regions are obtained by using matching conditions at the surface of the interface. The graphs of the velocities for both the regions have been drawn. It has been observed that with the increase of the permeability of the porous medium the velocities in both regions increase. The expressions for torque on the surface of the inner cylinder and shearing stress at any point in the porous medium of infinite thickness have been obtained. It has been found that the torque on the surface of the inner cylinder decreases with the increase of the width of the annular region and increases with the decrease of the permeability of the porous medium.

In chapter V the steady incompressible flow of a viscous fluid past a sphere embedded in a constant porosity medium has been investigated. We have taken Brinkman [9] equation to govern the flow in the porous medium. A closed form exact solution is obtained for the governing equations. It has been found that the tangential velocity increases from zero at the surface of the sphere to a maximum at a small distance from its surface,
and then decreases to its asymptotic value far away from the sphere.

Chapter VI deals with the oscillatory free convection from an infinite horizontal cylinder embedded in a porous medium. The flow equations are formulated by using Blasius coordinates. We have taken Brinkman [9] equation to govern the flow in the porous medium. The flow and the rate of heat transfer have been calculated. The purely oscillatory temperature distribution of the cylinder induces a steady-state heat transfer rate from it. This steady state heat transfer rate increases with the increase of the permeability parameter as well as Prandtl number.

In chapter VII the Hele-Shaw flow of a second-order fluid through a porous medium around a circular cylindrical post confined between two stationary flat plates under the influence of transverse magnetic field and time dependent pressure function is obtained. Expressions for velocity components of the fluid are obtained by using the transform technique and the method of separation of variables.