SYNOPSIS

The flow of a single-fluid system with porous boundaries and the flow of two-fluid system with solid or porous boundaries have continued to provide, during the last three decades, a focus for the attention of researchers. New data and information, ideas and hypotheses, facts and theories have been produced for the equations of motion for the flow through porous medium, for the boundary conditions at the nominal surface separating the porous medium from the clear region, and for the shape of the interface between two fluids. Except for the flows of single-fluid system past a rigid permeable surface where the effect of porosity is considered in the continuity of normal flux, the flow problems of a single or multilayered fluid system with permeable boundaries continue to give difficulties in their mathematical formulation and solution. This thesis uses certain assumptions and then discusses the flow problems of a single or two-layered Newtonian liquid with porous boundaries and the experimental investigation of the shape of the interface of two immiscible liquids.

The work has been divided into nine chapters and an appendix.

A brief account of some of the researches regarding the basic equations and conditions for the flow through and past porous surfaces and the flow of two-fluid system has been provided in chapter 1. The flow of two immiscible fluids with porous boundaries is the concern of four chapters and the flow of single fluid with porous boundaries is the concern of the remaining four chapters. The basic assumptions used are that the interface shape of two fluids is a plane surface, the boundary conditions at the nominal surface are the Beavers-Joseph conditions and the flow through porous medium is governed by Darcy's equation or Brinkman's equation depending upon the structure of the porous medium.

Thus, chapters 2 and 3 are devoted to investigating the pressure induced flow of two immiscible fluids in a channel bounded below by a permeable bed and above by an impermeable surface or a permeable surface. It is found that the velocity and mass flux increase due to the presence of permeable bed. The point of maximum velocity depending upon the values of the viscosities of the fluids, the permeability of the porous medium and a dimensionless quantity characterizing the structure of the porous material, can occur in any fluid, and this phenomenon is different from the one, that the maximum velocity can occur in the fluid of smaller viscosity, predicted earlier when both the walls are impermeable.

Chapters 4 through 6 deal with the unsteady flow in a channel formed by two walls of which the upper one is solid and the lower one is porous. Taking a single-fluid system and the pressure gradient varying exponentially with time it has been shown in chapter 4 that the mass flow rate for time-independent pressure gradient is greater than the mass flow rate for time-dependent pressure gradient and the velocity is found to attain maximum value at the porous interface. Furthermore, since the flow of two immiscible fluids under time-dependent pressure gradient finds application in the area of ground water technology and petroleum industry, chapters 5 and 6 have been devoted to the study of such flows. Considering the pressure gradient varying exponentially with time in chapter 5 and the pressure gradient oscillating with time in chapter 6, the flow characteristics like the velocity maximum of two layers, the velocity at the porous interface, the mass flow rate and the skin friction coefficients at the walls have been obtained and found to depend upon the product $\alpha\sigma$ where α is the slip parameter depending upon the structure of the porous medium and σ is the porosity parameter. It is observed that the maximum velocity will occur in upper or lower fluid depending upon whether α (or σ) is high or low; the velocity at the porous surface decreases as α (or σ) increases; the skin friction coefficient at the permeable bed increases with α (or σ) and the skin friction coefficient at the solid wall decreases as α (or σ) increases.

Chapter 7 through 9 consist of investigating the flow of an electrically conducting fluid with porous boundaries in the presence of an applied magnetic field. Accordingly, chapter 7 discusses the flow of an electrically conducting liquid between two rotating cylinders when the outer cylinder has an inner lining of porous material and there is imposed a magnetic field in the axial or radial direction. The analysis shows that the velocity increases with the porous lining thickness and decreases with the increase in the magnetic field. This effect is found to be more pronounced in the case when applied magnetic field is in the radial direction. Next, the problem of determining the shape of the free surface of a liquid contained in a rotating cylinder with porous curved surface has been examined in chapter 9. The analytical results indicate that the shape of the free surface is a paraboloid of revolution and gets distorted by the presence of magnetic field. The effect of increase in σ, the porous parameter or the magnetic field is found to flatten the free surface. The effect of radial magnetic field is again found to exceed that of the axial magnetic field.

Finally, chapter 8 investigates the effects of suction or injection when an electrically conducting liquid flows in a rectangular duct in the presence of an imposed transverse magnetic field. The porous walls are assumed to be non-conducting and at right angles to the magnetic field, and suction is applied at one wall and injection at the other wall. The flow rate is found to be a function of suction Reynolds number, magnetic Prandtl number and the Hartmann number. It is found that the effect of suction is to decrease the flow rate and this decrease in flow rate is quite substantial if both suction and magnetic field are present. Furthermore, aspect ratio is also found to play an important role in arriving at conclusions regarding the effect of suction or injection on the flow rate.

Besides the above mentioned theoretical investigations the appendix describes an experiment conducted to find the shape of the interface of two immiscible liquids contained in a rotating cylinder. From the experimental observations it is found that the shape of the interface is a paraboloid of revolution.