Abstract

This thesis mainly focuses on the effect of anisotropic permeability on fluid flow inside rectangular and wavy channel geometries filled with anisotropic porous material. However, these geometries appear in this thesis within the context of specific applications. **Chapter 1** of the thesis is introductory.

In **Chapter 2** we study the effect of anisotropic permeability on fluid flow through composite porous channel consisting of a fluid layer sandwiched between two porous layers. A generalized Brinkman-extended Darcy model for the porous layers and Navier-Stokes equation for the fluid layer are employed to investigate the flow in detail. We present some important findings such as velocity, skin friction and their dependency on anisotropic permeability ratio and anisotropic angle (orientation angle that permeability along principal axes makes with the horizontal direction).

In **Chapter 3** we study viscous flow through a symmetric wavy porous channel filled with anisotropic porous material. We assume the flow inside the porous bed is governed by anisotropic Brinkman equation. We assume that the ratio of the channel width to the wavelength is small. The key purpose of this study is to analyze the effect of the anisotropic permeability near the crests of the wavy channel which causes flow reversal. We present a detailed analysis of the flow reversal at the crests.

In **Chapter 4** we present an analytical study of two dimensional problem of lifting an object that is floating neutrally buoyant on top of a porous-liquid interface. We assume that the porous bed is anisotropic in nature. We assume the flow within the gap region between the object and the porous bed is governed by Stokes equation while the flow within the porous bed is governed by Brinkman equation. In this chapter, we discuss the impact of the vertical permeability on the breakout phenomenon (complete process to lift an object up from the porous bed).

In **Chapter 5** we consider a theoretical model of squeeze film between a flat plate (bearing) in the presence of a fully saturated anisotropic porous bed. We assume that the gap between the porous bed and the bearing is filled with a Newtonian fluid and is governed by Navier-Stokes equation. We assume Darcy's equation in the fluid filled porous region. Lubrication approximation is used to derive the corresponding thin film evolution equation in each of the regions. We discuss the impact of anisotropy on contact time, velocity, flux etc. As an application, we present some important findings (relevant to the knee joint) based on the anisotropic properties (due to arbitrary orientation of collagen fibres) of the human cartilage. For a prescribed load, we estimate the time duration during which a healthy human knee remains fluid lubricated.

The problem that we present in **Chapter 6** is an extension of the work done in **Chapter 5**. In **Chapter 5** we estimate the contact time for a prescribed load. In this chapter we estimate the load when a bearing approaches the porous bed with a constant vertical velocity. In this study we estimate a wide range of load a human knee can sustain.

Keywords : Darcy's equation; Brinkman's equation; Anisotropic permeability ratio; Anisotropic angle; Asymptotic solution.