ELECTRICALLY CONDUCTING PLANAR SIMPLE COUETTE FLOW OF AN INCOMPRESSIBLE VISCOUS FLUID THROUGH POROUS MEDIUM BETWEEN TWO SEMI-INFINITE PARALLEL PLATES UNDER TRANSVERSE MAGNETIC FIELD

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Abstract: The aim of the present paper is to investigate effect of magnetic field on electrically conducting planar simple couette flow of an incompressible viscous fluid between two semi-infinite parallel plates. Planar simple couette flow between parallel plates is a classical problem that has important applications in various industrial processing.The space between the parallel plates is filled with porous medium ,upper plate is moving with velocity U and lower plate is at rest. Transverse magnetic field is applied perpendicular to the length of the plates. The flow of an electrically conducting incompressible viscous fluid under Transverse magnetic field produces induced electric current on which mechanical forces are exerted by the magnetic field. The induced current produces induce magnetic field and thus original magnetic field is also changes. Thus there is two way interactions between flow field and the magnetic field, the magnetic field exerts force on the fluid by producing induced current and the induced current changes the original magnetic field. The expressions for velocity of the fluid, flow rate of the fluid, induced magnetic field and current density are obtained in elegant forms.
Keywords: electrically conducting incompressible viscous fluid, porous medium, magnetic field, permeability parameter.

1. INTRODUCTION

Electrically conducting planar simple couette flow of an incompressible viscous fluid between parallel plates is a classical problem that has important applications in various industrial processing.The study of flow through porous medium assumed importance because of the interesting applications in the diverse fields of science, Engineering and Technology. The practical applications are in the percolation of water through soil, extraction and filtration of oils from wells, the drainage of water, irrigation and sanitary engineering and also in the inter disciplinary fields such as biomedical engineering etc.. The classical Darcy's law Musakat [1] states that the pressure gradient pushes the fluid against the body forces exerted by the medium which can be expressed as

$$\vec{V} = -\left(\frac{k}{\mu}\right)\nabla P$$

The law gives good results in the situations when the flow is uni-directional or the flow is at low speed. In general, the specific discharge in the medium need not be always low. As the specific discharge increases, the convective forces get developed and the internal stress generates in the fluid due to its viscous nature and produces distortions in the velocity field. In the case of highly porous medium such as fiber glass, papus of dandelion the flow occurs even in the absence of the pressure gradient.

Modifications for the classical Darcy's law were considered by the Beavers and Joseph [2], Saffman [3] and others. A generalized Darcy's law proposed by Brinkmann [4] is given by

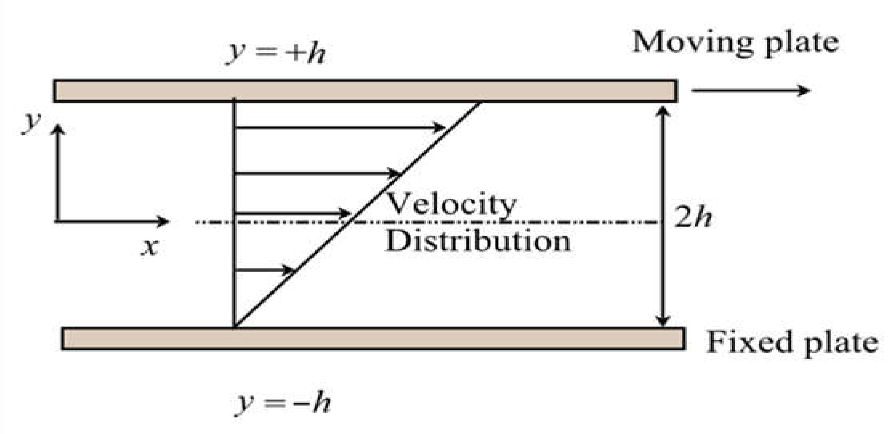
$$O = -\nabla P - \left(\frac{\mu}{K}\right)\vec{v} + \mu \nabla^2 \vec{v}$$

Where μ and K are coefficients of viscosity of the fluid and permeability of the porous medium. The applications of flows through porous medium bears wide spread interest in Geophysics, biology and medicine. In many of these areas the flow consists of more than one phase, such type of flows find applications in the inter disciplinary fields such as bio-medical engineering etc., the flow of blood is one such application. The blood may be represented as Newtonian fluid and the flow of the blood is in two layered. Lightfoot [5], Shukla *et al.* [6] and Chaturani

[7].Bird *et al.* [8] found an exact solution for the laminar flow of two immiscible fluids between two parallel plates. Earlier Narasimhacharyulu et *al*. [9] studied Two phase flow of an Incompressible Viscous fluid between two semi-infinite parallel plates under transverse magnetic field

In this present paper we are considering an electrically conducting planar simple couette flow of an incompressible viscous fluid between two semi-infinite parallel plates. The space between the parallel plates is filled with porous medium,upper plate is moving with velocity U and lower plate is at rest. Transverse magnetic field is applied perpendicular to the length of the plates**.** The expressions for velocity of the fluid, flow rate of the fluid, induced magnetic field and current density are obtained.

2. MATHEMATICAL FORMULATION OF THE PROBLEM



Electrically conducting planar simple couette flow of an incompressible viscous fluid is considered between two semi infinite parallel plates given by. $y = \pm h$

The space between the plates is filled with porous medium.. The coordinate system is taken such that x-axis lies parallel to the length of the plates and y-axis perpendicular to the length of the plates. A transverse magnetic field is applied perpendicular to the flow of the fluid. The velocity of the fluid satisfies the equation of continuity, the physical quantities depend on y only.

. The equation of motion is given by

$$\frac{d^2u}{dy^2} - \frac{u}{k} - \frac{\sigma\mu_e H_0}{\mu} u = 0 \qquad -h < y < h \tag{2.1}$$

Induced magnetic field is given by the equation

$$\frac{1}{\mu}\frac{d^2h_x}{dy^2} + H_0\frac{du}{dy} = 0 \qquad ,,(2.2)$$

ν is coefficient of viscosity of the fluid, k is permeability of the porous medium h_x is induced magnetic field, μ_e magnetic permeability, σ electric conductivity, H_0 magnetic field strength component

using the following non-dimensional quantities.

$$u^* = \frac{uh}{\nu},\ y^* = \frac{y}{h},\quad \beta^2 = \frac{h^2}{K},\quad M^2 = \frac{\sigma\mu_e^2 H_0^2 h^2}{\mu} \tag{2.3}$$

After removing *, the non-dimensional form of equation of motion is

$$\frac{d^2u}{dy^2} - \alpha^2 u = 0; \qquad -1 < y < 1 \tag{2.4}$$

$$where\ \alpha^2 = \beta^2 + M^2,\quad \beta^2 = \frac{h^2}{K},\quad M^2 = \frac{\sigma\mu_e^2 H_0^2 h^2}{\mu}$$

The boundary conditions are given by

$$u = 0,\ h_x = 0 \quad \text{at} \quad y = -1\}$$

$$u = U, h_x = 0 \quad \text{at} \quad y = 1\} \tag{2.5}$$

3. SOLUTION OF THE PROBLEM

Solving the equations (2.2)and (2.4) employing boundary conditions (2.5)

Velocity of the fluid $$u = \frac{U}{2}\left(\frac{\cosh \alpha y}{\cosh \alpha} + \frac{\sinh \alpha y}{\sinh \alpha}\right) \quad (2.6)$$

$$Q = \int_{-1}^{1} u\,dy$$

$$Flow \quad rate \quad (Q) = U\frac{Tanh \quad \alpha}{\alpha} \quad (2.7)$$

Induced magnetic field is given by

$$h_x = \frac{\mu H_0 U}{2\alpha}\left(yTanh \quad \alpha + \coth \alpha - \frac{\sinh(\alpha y)}{\cosh \alpha} - \frac{\cosh(\alpha y)}{\sinh \alpha}\right) \quad ..(2.8)$$

Current density

$$J = -\frac{dh_x}{dy} = \frac{\mu U H_0}{2}\left(\frac{\cosh(\alpha y)}{\cosh \alpha} + \frac{\sinh(\alpha y)}{\sinh \alpha} - \frac{Tanh \ \alpha}{\alpha}\right) \quad (2.9)$$

$$where \quad \alpha^2 = \beta^2 + M^2, \quad \beta^2 = \frac{h^2}{K}, \quad M^2 = \frac{\sigma\mu_e^2 H_0^2 h^2}{\mu}$$

CONCLUSION

Planar simple couette flow of an incompressible viscous fluid between two semi-infinite parallel plates. is examined. The space between the parallel plates is filled with porous medium. Upper plate is moving with velocity U and lower plate is at rest. Transverse magnetic field is applied perpendicular to the length of the plates..

From the obtained analytical solutions, it is observed that as magnetic field increases the velocity of the fluid, flow rate , induced magnetic and current density are decreasing. Further it is also observed that as as upper plate velocity increases velocity of the fluid, flow rate, induced magnetic field, and current density are also increasing..

When fluid moves through a magnetic field, an electric field and consequently a current may be induced, and in turn the current interacts with the magnetic field to produce a body force on fluid. The production of this current has led to MHD power generators, MHD devices, nuclear engineering and the possibility of thermonuclear power has created a great practical need for understanding the dynamics of conducting fluids.

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