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# 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 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 expressions for velocity and flow rate of the fluid are obtained in elegant forms. The effect of magnetic parameter and permeability parameter on the fluid flow is examined. The results are graphically represented.

**KEYWORDS:** Porous medium, magnetic field, permeability parameter, planar simple couette flow

## I. INTRODUCTION

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 Muskat [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  $\mu$  and  $K$  are coefficients of viscosity of the fluid and permeability of the porous medium.

## II. RELATED WORK

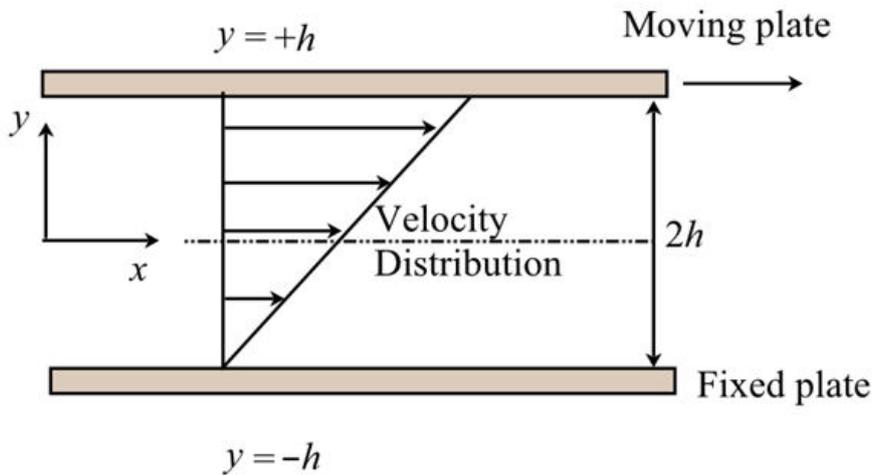
The applications of flows through porous medium bears wide spread interest in Geophysics, biology and medicine. In many of these areas the flow consists of more than one phase, such type of flows find applications in the inter disciplinary fields such as bio-medical engineering etc., the flow of blood 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 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 and flow rate of the fluid are obtained in elegant forms. The effect of magnetic parameter and permeability parameter on the fluid flow is examined.

III.MATHEMATICAL FORMULATION OF THE PROBLEM



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 region. 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 induced magnetic effect is negligible in comparison with the transverse magnetic field due to low magnetic Reynolds number, as a result of slightly conducting 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

$$\frac{d^2u}{dy^2} - \frac{u}{k} - \frac{\sigma\beta_0^2}{\mu}u = 0 \quad -h < y < h \quad \dots \quad (2.1)$$

$\nu$  is coefficient of viscosity of the fluid, k is permeability of the porous medium. using the following non-dimensional quantities.

$$u^* = \frac{uh}{\nu}, y^* = \frac{y}{h}, \beta^2 = \frac{h^2}{K}, M^2 = \frac{\sigma\beta_0^2 h^2}{\mu} \quad \dots \quad (2.2)$$

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

$$\frac{d^2u}{dy^2} - \alpha^2 u = 0; \quad -1 < y < 1 \quad \dots \quad (2.3)$$

$$\alpha^2 = \beta^2 + M^2, \quad \beta^2 = \frac{h^2}{K}, \quad M^2 = \frac{\sigma\beta_0^2 h^2}{\mu}$$

The boundary conditions are given by

$$\left. \begin{aligned} u &= 0 & \text{at } y &= -1 \\ u &= U & \text{at } y &= 1 \end{aligned} \right\} \quad (2.4)$$



**IV.SOLUTION OF THE PROBLE**

Solving the equations (2.3) employing boundary conditions (2.4) velocity of the fluid (u) and flow rare (Q) are given by

$$u = \frac{U}{2} \left( \frac{\cosh \alpha y}{\cosh \alpha} + \frac{\sinh \alpha y}{\sinh \alpha} \right) \quad \dots \quad (2.5)$$

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

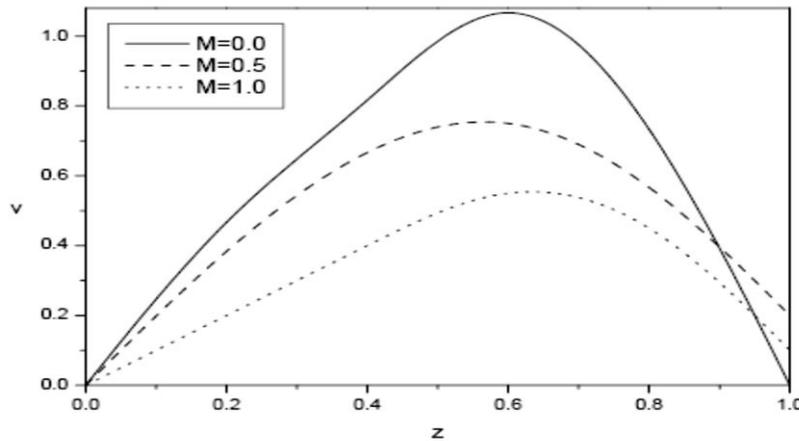
$$Q = U \frac{\text{Tanh} \alpha}{\alpha} \quad \dots(2.6)$$

$$\alpha^2 = \beta^2 + M^2, \quad \beta^2 = \frac{h^2}{K}, \quad M^2 = \frac{\sigma \beta_0^2 h^2}{\mu}$$

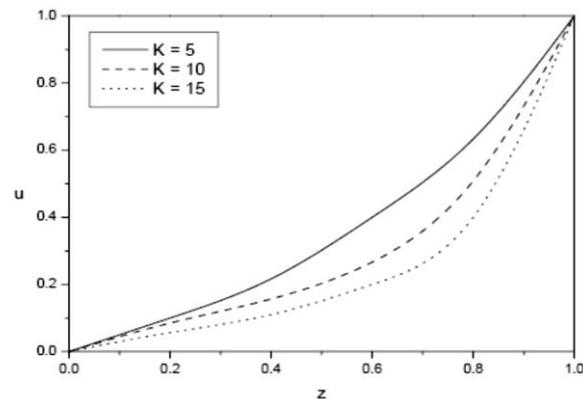
**V. CONCLUSION**

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..

Fig. 1 shows the velocity of the fluid is decreasing with increasing magnetic field values



In Fig. 2 it is observed that, the effect of the permeability of the porous medium is to decrease velocity of the fluid with increasing value of K



As viscosity of the fluid is increasing the velocity of the fluid is decreasing. Further it is also observed that as viscosity of the fluid is increasing, the flow rate of the fluid is increasing.

The results of the problem have great importance to the petroleum engineer concerned with the movement of oil, gas and water through the reservoir of an oil or gas field. Beyond this, the results of present problem are widely applicable in soil mechanics, water purification, ceramic engineering and power metallurgy.

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