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Steady Plane Poiseuille Flow of Viscous Incompressible Fluid Between two Porous Parallel Plates in Magnetic Field

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ABSTRACT
In this paper we have investigated the steady plane poiseuille flow of viscous incompressible fluid between two porous parallel plates in magnetic field. We have studied the velocity, average velocity, shearing stress, skin frictions, the volumetric flow, drag coefficients and stream lines.

Introduction

Nomenclature

u =Velocity component along x–axis
v = Velocity component along y–axis
t = The time
ρ = The density of fluid
P = The fluid pressure
K= The thermal conductivity of the fluid
μ = Coefficient of viscosity
υ = Kinematic viscosity
Q= The volumetric flow

We have investigated steady plane poiseuille flow of viscous incompressible fluid between two porous parallel plates through porous medium. Attempts have been made by several researchers i.e. A. Abouhamza & R. Pierre [1] a neutral stability curves for incompressible flows in a rectangular driven cavity. S. Akbal and F. Baytas [2] Effects of non-uniform porosity on double diffusive natural convection in a porous cavity with partially permeable wall. S. Albensoeder & H. C. Kuhlmann [3] accurate three-dimensional lid-driven cavity flow. S. Alchaar & P. Vasseur and E. Bilgen [4] affect of a magnetic field on natural convection in a shallow cavity heated from below. A.K.Al-Hadhrami, L. Elliot, M. D.Ingham & X. Wen [5] Flow through horizontal channels of porous materials. Z. Alloui & L. Dufau & H.Beji and P. Vasseur [6] multiple steady states in a porous enclosure partially heated and fully salted from below. M.A. Al-Nimr & M. Alkam [7] unsteady non-Darcian forced convection analysis in an annulus partially filled with a porous material. M. A. Al-Nimr & M. K. Alkam [8] unsteady non-Darcian fluid flow in parallel plate's channels partially filled with porous materials. R. A. Alpher [9] Heat transfer in magneto hydrodynamic flow between parallel plates. R.A. Alpher [10] Heat transfer in magneto hydrodynamic flow between parallel plates. K.A. Ames & C. Cobb [11] Penetrative convection in a Porous medium with internal heat sources. H. A. Attia [12] unsteady hydro magnetic coquette flow of dusty fluid with temperature dependent viscosity and thermal conductivity. H. A. Attia & N. A. Kotb [13] MHD flow between two parallel plates with heat transfer. H. A. Attia [14] Transient MHD flow and heat transfer between two parallel plates with temperature dependent viscosity. H. A. Attia [15] unsteady flow of a dusty conducting fluid between parallel porous plates with temperature dependent viscosity. In this paper we have investigated the velocity, average velocity, shearing stress, skin frictions a, the volumetric flow, drag coefficients and stream lines.

Formulation of Problem

Let us consider two infinite porous plates AB & CD separated by a distance 2h. The fluid enters in y-direction. The velocity component along x-axis is a function of y only. The motion of incompressible fluid is in two dimension and is steady then

$$u = u\,(y), \quad w = 0 \;\;\&\;\; \frac{\partial}{\partial t} = 0$$

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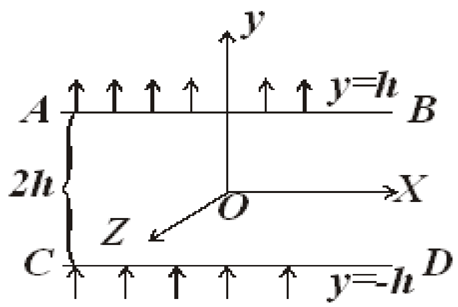


The equation of continuity for incompressible fluid

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0$$

Put w = 0 , $\frac{\partial u}{\partial x}=0$ & $\Rightarrow \frac{\partial v}{\partial y}=0$

v is independent of y but motion along y-axis. So we can say v is constant

Velocity i.e. $v=v_0$ or The fluid enters the flow region through one plate at the same constant velocity v_0

Also Navier-Stoke's equations for incompressible fluid in the absence of body force when flow is steady

$$v_0\frac{du}{dy}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\upsilon\frac{d^2u}{dy^2}+\frac{\sigma B_0^2\upsilon u}{\mu}\text{ ..... (1)}$$

$$-\frac{1}{\rho}\frac{\partial p}{\partial y}=0\text{ .... (2)}$$

Solution of the problem

Equation (2) Shows that the pressure does not depend on y hence p is a function of x only and so (1) reduces to

$$\frac{dp}{dx}=\rho\left[\upsilon\frac{d^2u}{dy^2}-v_0\frac{du}{dy}+\frac{\sigma B_0^2\upsilon u}{\mu}\right]$$ Where $\frac{dp}{dx}$ = Constant = - P

$$\Rightarrow\frac{d^2u}{dy^2}-\frac{v_0}{\upsilon}\frac{du}{dy}+\frac{\sigma B_0^2u}{\mu}=-\frac{P}{\mu}\qquad\Rightarrow\left(D^2-\frac{v_0}{\upsilon}D+\frac{\sigma B_0^2}{\mu}\right)u=-\frac{P}{\mu}$$

$$\text{A.E}\left(m^2-\frac{v_0}{\upsilon}m+\frac{\sigma B_0^2}{\mu}\right)=0\quad\Rightarrow\quad m=\frac{\frac{v_0}{\upsilon}\pm\sqrt{\left(\frac{v_0}{\upsilon}\right)^2-\frac{4\sigma B_0^2}{\mu}}}{2}\qquad=\frac{v_0}{2\upsilon}\pm\sqrt{\left(\frac{v_0}{2\upsilon}\right)^2-\frac{\sigma B_0^2}{\mu}}$$

$$C.F.=e^{\frac{v_0}{2\upsilon}y}\left[c_1Cosh\,Ay+c_2Sinh\,\,Ay\right]\qquad P.I=-\frac{P}{\sigma B_0^2}$$

$$here\;\;A=\sqrt{\left(\frac{v_0}{2\upsilon}\right)^2-\frac{\sigma B_0^2}{\mu}}\;\;and\;\;B=\frac{\sigma B_0^2}{\mu}$$

$$u(y)=e^{\frac{v_0}{2\upsilon}y}\left[c_1Cosh\,\,Ay+c_2Sinh\,Ay\right]-\frac{P}{B\mu}$$

using boundary conditions : u = 0 at y = - h and u = U at y = h

$$e^{-\frac{v_0}{2\upsilon}h}\left[c_1Cosh\,\,Ah-c_2Sinh\,\,Ah\right]-\frac{P}{B\mu}=0\text{ .... (3)}$$

$$U=e^{\frac{v_0}{2\upsilon}h}\left[c_1Cosh\,\,Ah+c_2Sinh\,\,Ah\right]-\frac{P}{B\mu}\text{ .... (4)}$$

$$or\qquad\frac{P}{B\mu}e^{\frac{v_0}{2\upsilon}h}=c_1Cosh\,Ah-c_2Sinh\,Ah$$

$$\left(U+\frac{P}{B\mu}\right)e^{-\frac{v_0}{2\upsilon}h}=c_1Cosh\,Ah+c_2Sinh\,Ah$$

$$c_1 = \frac{1}{2Cosh\,Ah}\left[\left(U+\frac{P}{B\mu}\right)e^{-\frac{v_0}{2\upsilon}h} + \frac{P}{B\mu}e^{\frac{v_0}{2\upsilon}h}\right]$$

$$c_2 = \frac{1}{2Sinh\,Ah}\left[\left(U+\frac{P}{B\mu}\right)e^{-\frac{v_0}{2\upsilon}h} - \frac{P}{B\mu}e^{\frac{v_0}{2\upsilon}h}\right]$$

$$u(y) = \frac{e^{\frac{v_0}{2\upsilon}y}Cosh\,Ay}{2Cosh\,Ah}\left\{\left(U+\frac{P}{B\mu}\right)e^{-\frac{v_0}{2\upsilon}h} + \frac{P}{B\mu}e^{\frac{v_0}{2\upsilon}h}\right\}$$

$$+\frac{e^{\frac{v_0}{2\upsilon}y}Sinh\,Ay}{2Sinh\,Ah}\left\{\left(U+\frac{\rho}{B\mu}\right)e^{-\frac{v_0}{2\upsilon}h} - \frac{P}{B\mu}e^{\frac{v_0}{2\upsilon}h}\right\} - \frac{P}{B\mu}$$

$$u(y) = \left(U+\frac{P}{B\mu}\right)\frac{e^{\frac{v_0}{2\upsilon}(y-h)}Sinh\,A(y+h)}{2Sinh\,Ah\;Cosh\,Ah} - \frac{P}{B\mu}\frac{e^{\frac{v_0}{2\upsilon}(y+h)}Sinh\,A(y-h)}{2Sinh\,Ah\;Cosh\,Ah} - \frac{P}{B\mu}$$

$$u(y) = \frac{1}{Sinh\,2Ah}\left[\left(U+\frac{P}{B\mu}\right)e^{\frac{v_0}{2\upsilon}(y-h)}SinhA(y+h) - \frac{P}{B\mu}e^{\frac{v_0}{2\upsilon}(y+h)}SinhA(y-h)\right] - \frac{P}{B\mu} \quad \text{..........}(5)$$

Plane Poiseuille flow : In this case both plates are at rest so U = 0

$$\therefore\; u(y) = \frac{1}{Sinh\;2Ah}\left[\frac{P}{B\mu}e^{\frac{v_0}{2\upsilon}(y-h)}\;Sinh\;A(y+h) - \frac{P}{B\mu}e^{\frac{v_0}{2\upsilon}(y+h)}\;Sinh\;A(y-h)\right] - \frac{P}{B\mu}$$

$$u(y) = \frac{P}{B\mu\,Sinh\;2Ah}\left[e^{\frac{v_0}{2\upsilon}(y-h)}Sinh\;A(y+h) - e^{\frac{v_0}{2\upsilon}(y+h)}\;Sinh\;A(y-h) - Sinh\;2Ah\right] \quad \text{.......}(6)$$

Shearing stress at any point

$$\sigma_{xy} = \mu\frac{du}{dy} = \frac{P}{B\,Sinh\;2Ah}\left[\left\{\frac{v_0}{2\upsilon}e^{\frac{v_0}{2\upsilon}(y-h)}Sinh\;A(y+h) + Ae^{\frac{v_0}{2\upsilon}(y-h)}Cosh\;A(y+h)\right\}\right.$$

$$\left. -\frac{v_0}{2\upsilon}e^{\frac{v_0}{2\upsilon}(y+h)}Sinh\;A(y-h) - Ae^{\frac{v_0}{2\upsilon}(y+h)}Cosh\;A(y-h)\right]$$

$$\sigma_{xy} = \frac{P}{B\,Sinh2Ah}\left[\frac{v_0}{2\upsilon}\left\{e^{\frac{v_0}{2\upsilon}(y-h)}SinhA(y+h) - e^{\frac{v_0}{2\upsilon}(y+h)}SinhA(y-h)\right\}\right]$$

$$+\frac{PA}{B\,Sinh2Ah}\left\{e^{\frac{v_0}{2\upsilon}(y-h)}CoshA(y+h) - e^{\frac{v_0}{2\upsilon}(y+h)}CoshA(y-h)\right\} \text{....}(7)$$

Skin friction at lower & upper plates

$$\left(\sigma_{xy}\right)_{y=h} = \frac{P}{B\,Sinh\;2Ah}\left[\frac{v_0}{2\upsilon}\left\{Sinh\;2Ah\right\} + A\left\{Cosh\;2Ah - e^{\frac{v_0}{\upsilon}h}\right\}\right]$$

$$\left(\sigma_{xy}\right)_{y=h} = \frac{P}{B\,Sinh\;2Ah}\left[\frac{v_0}{2\upsilon}Sinh\;2Ah + ACosh\;2Ah - Ae^{\frac{v_0}{\upsilon}h}\right] \quad \text{.........}(8)$$

$$\left(\sigma_{xy}\right)_{y=-h} = \frac{P}{B\,Sinh\;2Ah}\left[\frac{v_0}{2\upsilon}Sinh\;2Ah + A\left\{e^{-\frac{v_0}{\upsilon}h} - Cosh\;2Ah\right\}\right]$$

$$\left(\sigma_{xy}\right)_{y=-h} = \frac{P}{B\,Sinh\;2Ah}\left[\frac{v_0}{2\upsilon}Sinh\;2Ah - ACosh\;2Ah + Ae^{-\frac{v_0}{\upsilon}h}\right] \quad \text{.........}(9)$$

The average velocity distribution in poiseuille flow:

$$u_{av} = \frac{1}{2h}\int_{-h}^{h} u(y)\,dy$$

$$= \frac{P}{2B\mu h\,Sinh\,2Ah}\int_{-h}^{h}\left[e^{\frac{v_0}{2\upsilon}(y-h)}Sinh\,A(y+h) - e^{\frac{v_0}{2\upsilon}(y+h)}Sinh\,A(y-h) - Sinh\,2Ah\right]dy$$

$$Now\ Let \quad I_1 = \int_{-h}^{h} e^{\frac{v_0}{2\upsilon}(y-h)}Sinh\,A(y+h)\,dy$$

$$= \frac{1}{2}\int_{-h}^{h}\left\{e^{\frac{v_0}{2\upsilon}(y-h)+A(y+h)} - e^{\frac{v_0}{2\upsilon}(y-h)-A(y+h)}\right\}dy = \frac{1}{2}\left[\frac{e^{\frac{v_0}{2\upsilon}(y-h)+A(y+h)}}{\left(\frac{v_0}{2\upsilon}+A\right)} - \frac{e^{\frac{v_0}{2\upsilon}(y-h)-A(y+h)}}{\left(\frac{v_0}{2\upsilon}-A\right)}\right]_{-h}^{h}$$

$$= \frac{1}{2}\left[\frac{e^{2Ah} - e^{-\frac{v_0}{\upsilon}h}}{\left(\frac{v_0}{2\upsilon}+A\right)} - \frac{e^{-2Ah} - e^{-\frac{v_0}{\upsilon}h}}{\left(\frac{v_0}{2\upsilon}-A\right)}\right]$$

$$= \frac{1}{2B}\left[\left(\frac{v_0}{2\upsilon}-A\right)\left(e^{2Ah} - e^{-\frac{v_0}{\upsilon}h}\right) - \left(\frac{v_0}{2\upsilon}+A\right)\left(e^{-2Ah} - e^{-\frac{v_0}{\upsilon}h}\right)\right]$$

$$= \frac{1}{2B}\left[\frac{v_0}{2\upsilon}\left\{e^{2Ah} - e^{-\frac{v_0}{\upsilon}h} - e^{-2Ah} + e^{-\frac{v_0}{\upsilon}h}\right\} - A\left\{e^{2Ah} - e^{-\frac{v_0}{\upsilon}h} + e^{-2Ah} - e^{-\frac{v_0}{\upsilon}h}\right\}\right]$$

$$I_1 = \frac{1}{B}\left[\frac{v_0}{2\upsilon}Sinh\,2Ah - ACosh\,2Ah + Ae^{-\frac{v_0}{\upsilon}h}\right]$$

$$I_2 = \int_{-h}^{h} e^{\frac{v_0}{2\upsilon}(y+h)}Sinh\,A(y-h)\,dy \quad = \frac{1}{B}\left[\frac{v_0}{2\upsilon}Sinh\,2Ah + ACosh\,2Ah - Ae^{\frac{v_0}{\upsilon}h}\right]$$

$$I_3 = \int_{-h}^{h} Sinh\,2Ah\,dy = 2h\,Sinh\,2Ah$$

$$\therefore u_{av} = \frac{P}{2B\mu\,Sinh\,2Ah}\left[I_1 - I_2 - I_3\right]$$

$$= \frac{P}{2B^2\mu\,h\,Sinh\,2Ah}\left[\frac{v_0}{2\upsilon}Sinh\,2Ah - A\,Cosh\,2Ah + A\,e^{-\frac{v_0}{\upsilon}h} - \frac{v_0}{2\upsilon}Sinh\,2Ah - A\,Cosh\,2Ah + A\,e^{\frac{v_0}{\upsilon}h} - 2hB\,Sinh\,2Ah\right]$$

$$u_{av} = \frac{P}{B^2\mu h\,Sinh\,2Ah}\left[A\left(Cosh\frac{v_0}{\upsilon}h - Cosh\,2Ah\right) - BhSinh\,2Ah\right] \quad ....(10)$$

The volumetric flow Q = 2 h uav

$$= \frac{2P}{B^2\mu\,Sinh\,2Ah}\left[A\left(Cosh\frac{v_0}{\upsilon}h - Cosh\,2Ah\right) - BhSinh\,2Ah\right] \quad ....(11)$$

The Drug coefficients: Cf & Cf' at y = h & y = -h

$$C_f = \frac{\left(\sigma_{xy}\right)_{y=h}}{\frac{1}{2}\rho(u_{av})^2} = \frac{2B^2\mu^2h^2\,Sinh\,2Ah}{\rho P}\left[\frac{\left\{\frac{v_0}{2\upsilon}Sinh\,2Ah + ACosh\,2Ah - Ae^{\frac{v_0}{\upsilon}h}\right\}}{\left\{A\left(Cosh\frac{v_0}{\upsilon}h - Cosh\,2Ah\right) - BhSin\,2Ah\right\}^2}\right] ....(12)$$

$$C_f{}' = \frac{(\sigma_{xy})_{y=-h}}{\frac{1}{2}\rho(u_{av})^2} = \frac{2B^2\mu^2h^2\ Sinh\ 2Ah}{\rho P}\left[\frac{\left\{\frac{v_0}{2\upsilon}Sin\ 2Ah - ACosh\ 2Ah + Ae^{-\frac{v_0}{\upsilon}h}\right\}}{\left[A\left(Cosh\frac{v_0}{\upsilon}h - Cos\ 2Ah\right) - BhSinh\ 2Ah\right]^2}\right] ....(13)$$

The stream line in the plane poiseuille flow: $\frac{dx}{u} = \frac{dy}{v} = \frac{dz}{w}$

$$\Rightarrow \frac{dx}{\frac{P}{B\mu\ Sinh\ 2Ah}\left\{e^{\frac{v_0}{2\upsilon}(y-h)}Sinh\ A(y+h) - e^{\frac{v_0}{2\upsilon}(y+h)}Sinh\ A(y-h) - Sinh\ 2Ah\right\}} = \frac{dy}{v_0} = \frac{dz}{o}$$

Taking first two

$$\frac{v_0B\mu\ Sinh\ 2Ah}{P}\ x - \int\left\{e^{\frac{v_0}{2\upsilon}(y-h)}Sinh\ A(y+h) - e^{\frac{v_0}{2\upsilon}(y+h)}Sinh\ A(y-h) - Sinh\ 2Ah\right\}dy = C_1$$

$$Let \quad I_1 = \int e^{\frac{v_0}{2\upsilon}(y-h)}Sinh\ A(y+h)\ dy$$

$$I_1 = \frac{1}{2}\left[\frac{e^{\frac{v_0}{2\upsilon}(y-h)+A(y+h)}}{\left(\frac{v_0}{2\upsilon}+A\right)} - \frac{e^{\frac{v_0}{2\upsilon}(y-h)-A(y+h)}}{\left(\frac{v_0}{2\upsilon}-A\right)}\right]$$

$$= \frac{e^{\frac{v_0}{2\upsilon}(y-h)}}{2B}\left[\left(\frac{v_0}{2\upsilon}-A\right)e^{A(y+h)} - \left(\frac{v_0}{2\upsilon}+A\right)e^{-A(y+h)}\right] \quad Since\left(\frac{v_0}{2\upsilon}\right)^2 - A^2 = B$$

$$= \frac{e^{\frac{v_0}{2\upsilon}(y-h)}}{B}\left[\frac{v_0}{2\upsilon}Sinh\ A(y+h) - ACosh\ A(y+h)\right]$$

$$I_2 = \int e^{\frac{v_0}{2\upsilon}(y+h)}Sinh\ A(y-h)\ dy = \frac{e^{\frac{v_0}{2\upsilon}(y+h)}}{B}\left[\frac{v_0}{2\upsilon}Sinh\ A(y-h) - ACosh\ A(y-h)\right]$$

$$I_3 = \int Sinh\ 2Ah\ .\ dy = y.\ Sinh\ 2Ah$$

$\therefore$ First stream line.

$$\frac{v_0B\mu\ Sinh\ 2Ah}{P}x - \{I_1 - I_2 - I_3\} = C_1$$

$$\Rightarrow \frac{v_0B\mu\ Sinh\ 2Ah}{P}x - \frac{e^{\frac{v_0}{2\upsilon}(y-h)}}{B}\left\{\frac{v_0}{2\upsilon}Sinh\ A(y+h) - A\ Cosh\ A(y+h)\right\}$$

$$+\frac{e^{\frac{v_0}{2\upsilon}(y+h)}}{B}\left\{\frac{v_0}{2\upsilon}Sinh\ A(y-h) - A\ Cosh\ A(y-h)\right\} + y\ Sinh\ 2Ah = C_1 \ ....(14)$$

$$z = c_2........(15)$$

Second stream line

Clearly the curl $\bar{q} \neq \bar{0}$ $\therefore$ the fluid is Rotational

Table for velocity: when y & A are vary and other are fixed

$$let \quad K=9, \quad \mu=.5, \quad \frac{v_0}{2\upsilon}=6, h=.5, \ \& \sqrt{\left(\frac{v_0}{2\upsilon}\right)^2 - \frac{\sigma B_0^2}{\mu}} = A \ \ where \ \frac{\sigma B_0^2}{\mu} = B$$

Table 1

A	**y**	**0**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**
1	u(y)	4.08	6.09	8.43	10.31	9.44	0	-31.67
2	u(y)	3.11	4.5	6.07	7.29	6.6	0	-22.26
3	u(y)	2.19	3.03	3.93	4.59	4.09	0	-13.92
4	u(y)	1.51	1.984	2.464	2.78	2.43	0	-8.41
5	u(y)	1.05	1.31	1.56	1.69	1.45	0	-5.178

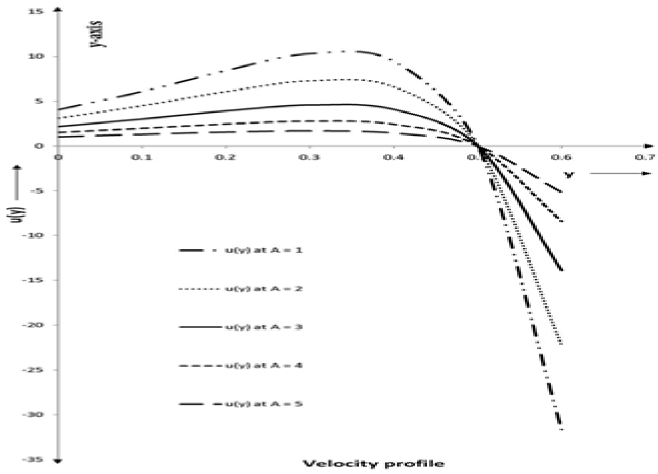
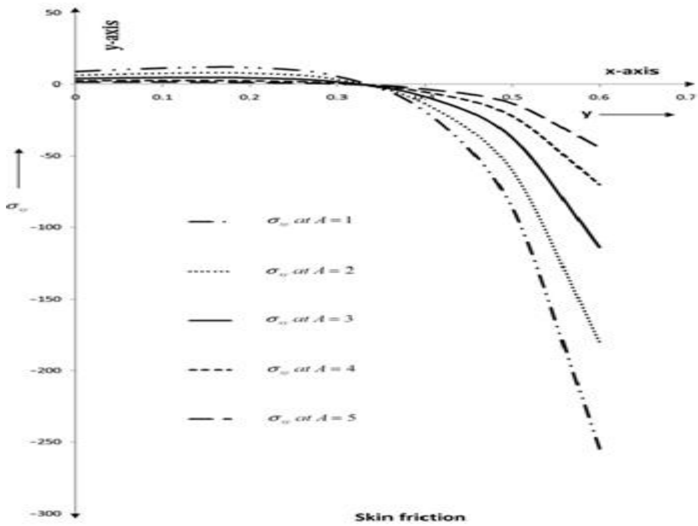


Table for skin friction: when y & A are vary and other are fixed

$$let \quad K=9, \quad \mu=.5, \quad \frac{v_0}{2\upsilon}=6, h=.5, \; \& \; \sqrt{\left(\frac{v_0}{2\upsilon}\right)^2-\frac{\sigma B_0^2}{\mu}}=A \;\; where \;\; \frac{\sigma B_0^2}{\mu}=B$$

Table 2

	y	**0**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**
1	σ_{xy}	8.83	11.18	11.62	5.44	-18.66	-86.39	-254.45
2	σ_{xy}	6.215	7.62	7.695	3.30	-13.27	-60.3	-180.09
3	σ_{xy}	3.855	4.496	4.328	1.56	-8.422	-37.26	-114
4	σ_{xy}	2.253	2.462	2.219	.567	-5.134	-22.11	-70.05
5	σ_{xy}	1.285	1.3	1.08	.107	-3.135	-13.24	-44



Case 1: $let \; \frac{1}{K}=\frac{\sigma B_0^2}{\mu}$ it is clear from chapter four and five that the graphs between porous medium and magnetic field coincide.

Case 2: when $\frac{1}{K} \text{f} \frac{\sigma B_0^2}{\mu}$ $let\ \frac{1}{K} = 35\ \ i.e\ A = 1\ and\ B = \frac{\sigma B_0^2}{\mu} = 20\ \ i.e\ \ A = 4$

Table 3

	y	0	.1	.2	.3	.4	.5	.6
$\frac{1}{K} = 35$ i.e A=1	u(y)	4.08	6.09	8.43	10.31	9.44	0	-31.67
$B = \frac{\sigma B_0^2}{\mu} = 20\ i.e\ \ A = 4$	u(y)	1.51	1.984	2.464	2.78	2.43	0	-8.41

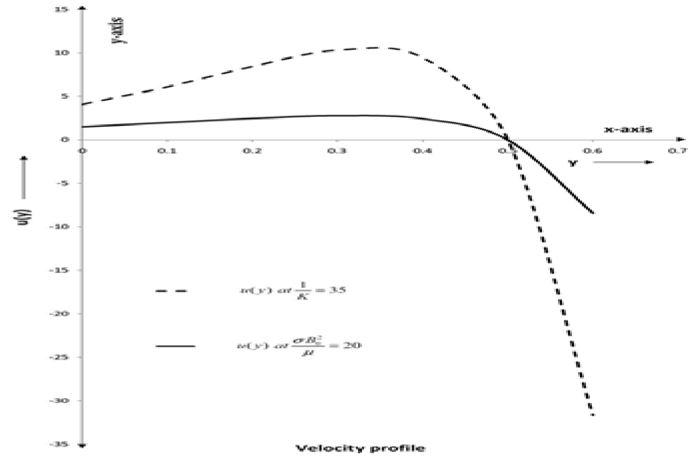


Table for skin friction:

when $\frac{1}{K} \text{f} \frac{\sigma B_0^2}{\mu}$ $let\ \frac{1}{K} = 35\ \ i.e\ A = 1\ and\ B = \frac{\sigma B_0^2}{\mu} = 20\ \ i.e\ \ A = 4$

Table 4

	y	0	.1	.2	.3	.4	.5	.6
$\frac{1}{K} = 35$ i.e A=1	σ_{xy}	8.83	11.18	11.62	5.44	-18.66	-86.39	-254.46
$B = \frac{\sigma B_0^2}{\mu} = 20\ i.e\ \ A = 4$	σ_{xy}	2.253	2.462	2.219	.567	-5.134	-22.11	-70.05

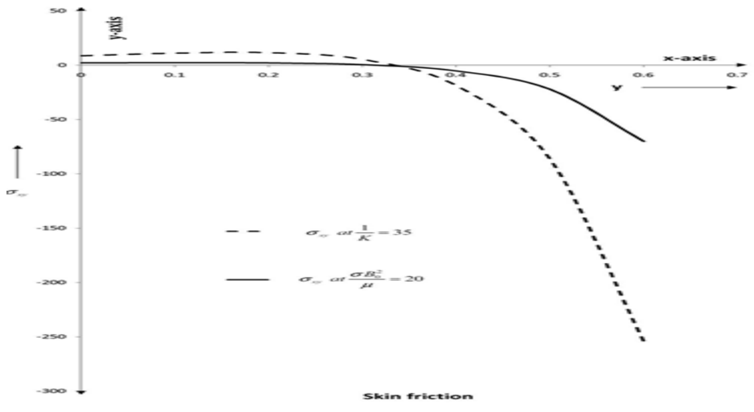


Table for velocity:

Case 3: when $\frac{1}{K} \text{p} \frac{\sigma B_0^2}{\mu}$ $let\ \frac{1}{K} = 11\ \ i.e\ \ A = 5\ and\ B = \frac{\sigma B_0^2}{\mu} = 32\ \ i.e\ \ A = 2$

Table 5

	y	0	.1	.2	.3	.4	.5	.6
$\frac{1}{K}=11$ i.e A=5	u(y)	1.05	1.31	1.56	1.69	1.45	0	-5.178
$B=\frac{\sigma B_0^2}{\mu}=32\ i.e\ \ A=2$	u(y)	3.11	4.5	6.07	7.29	6.6	0	-22.26

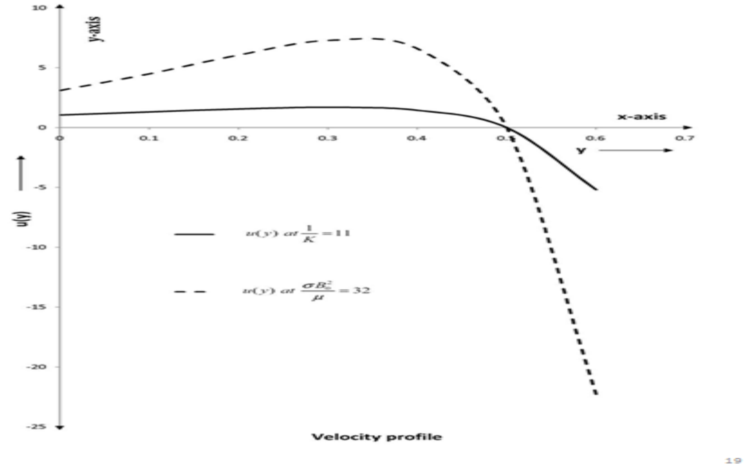
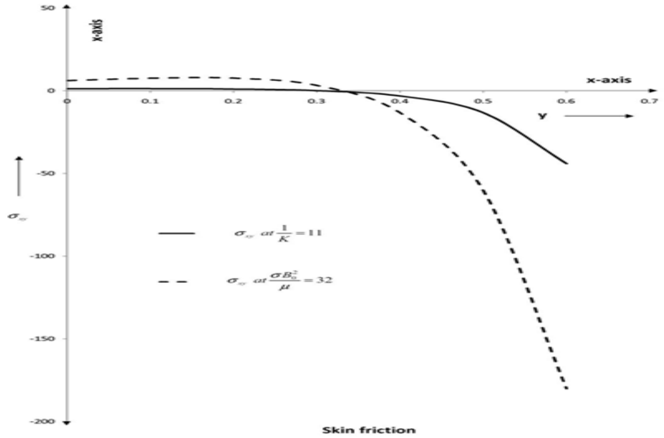


Table for skin friction:

when $\frac{1}{K}\text{p}\frac{\sigma B_0^2}{\mu}\quad let\ \ \frac{1}{K}=11\ \ i.e\ \ A=5\ and\ \ B=\frac{\sigma B_0^2}{\mu}=32\ \ i.e\ \ A=2$

Table 6

	y	0	.1	.2	.3	.4	.5	.6
$\frac{1}{K}=11$ i.e A=5	σ_{xy}	1.285	1.3	1.08	.107	-3.135	-13.24	-44
$B=\frac{\sigma B_0^2}{\mu}=32\ i.e\ \ A=2$	σ_{xy}	6.215	7.62	7.695	3.30	-13.27	-60.3	-180.09



Conclusion and Discussion

In this paper, we have investigated the velocity by the graph of table -1 of equation (5) between velocity and distance in magnetic field. It is clear that the velocity increases in the interval $0\le y\le .3$, the velocity decreases in the interval $.4\le y\le .5$ for all values of A and velocity is negative at $y=.6$ for all values of A. Clearly $y=.5$ is a stagnation point since velocity is zero at $y=.5$ for all A. The value of velocity decreases correspondingly for all values of y when A increases from 1 to 5.

Again from the table-2 it is clear that the skin friction decreases with positive sign correspondingly in the interval $0\le y\le .3$ when A is increases from 1 to 5 and decreases with negative sign correspondingly in the interval $.4\le y\le .6$ when A increases from 1 to 5.

Again it is clear from the table-3 the values of velocity in porous medium at $\frac{1}{K}=35$ is greater than the corresponding values of velocity in magnetic field at $\frac{\sigma B_0^2}{\mu}=20$ in the interval $0 \le y \le .4$, velocity is zero in both mediums at $y=.5$ and velocity (negatively) in porous medium is greater than the velocity in magnetic field at $y=.6$

Again it is clear from the table-5 the values of velocity in porous medium at $\frac{1}{K}=11$ is less than the corresponding values of velocity in magnetic field at $\frac{\sigma B_0^2}{\mu}=32$ in the interval $0 \le y \le .4$, velocity is zero in both mediums at $y=.5$ and velocity (negatively) in porous medium is less than the velocity in magnetic field at $y=.6$.

Again from table-4 the values (positively) of skin friction in porous medium at $\frac{1}{K}=35$ is greater than the corresponding values of skin friction in Again from magnetic field at $\frac{\sigma B_0^2}{\mu}=20$ in the interval $0 \le y \le .3$ and the values (negatively) of skin friction in porous medium at $\frac{1}{K}=35$ is greater than the corresponding values (negative) of skin friction in magnetic field at $\frac{\sigma B_0^2}{\mu}=20$ in the interval $.4 \le y \le .6$.

Again from table-6 the values (positively) of skin friction in porous medium at $\frac{1}{K}=11$ is less than the corresponding values of skin friction in magnetic field at $\frac{\sigma B_0^2}{\mu}=32$ in the interval $0 \le y \le .3$ and the values (negatively) of skin friction in porous medium at $\frac{1}{K}=11$ is less than the corresponding values (negatively) of skin friction in magnetic field at $\frac{\sigma B_0^2}{\mu}=32$ in the interval $.4 \le y \le .6$. Also we have investigated the shear stress , volumetric flow and drag coefficients and stream lines given by the equation (7), (9), (11), (12), (13) (14) and (15) respectively.

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