Available online at www.elixirpublishers.com (Elixir International Journal)

Applied Mathematics

Elixir Appl. Math. 79 (2015) 30213-30222

ISSN: 2229-712X

Steady plane poiseuille flow of viscous incompressible fluid between two porous parallel plates through porous medium

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ARTICLE INFO

Article history:

Received: 4 December 2014;
Received in revised form: 20 January 2015;
Accepted: 2 February 2015;

Keywords

Steady poiseuille flow,
Viscous parallel plates,
Incompressible fluid,
Porous medium.

ABSTRACT

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

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

Introduction:

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. Agrawal and M.P Singh [1] a note on vorticity of unsteady laminar magneto hydrodynamic coquette flow with heat transfer between two parallel non-conducting plates under the action transfer magnetic field. R.S. Rivlin [2] on second order effects in Elasticity, Plasticity and fluid dynamics. T.R. Rogge and D.F. Young [3] Transient flow in Parallel plate channel and circular tubes with prescribed discharge. Anil Sharma and M.K. Sharma [4] unsteady flow and heat transfer along an infinite hot Porous vertical surface bounded by Porous medium. A .S. Sharma, M.P.Singh and A.B. Chandramouli [5] steady flow in pipes of elliptic cross – section through porous medium. B. Siddapa and S. Abel [6] a note on Visco- elastic flow Bulletin of Pure & applied Sciences. K.D. Singh and R.S. Sharma [7] Couette flow through a Porous medium. M.P. Singh , P.K . Mittal and A.D. Kothiyal [8] a note on vorticity of hydro magnetic rivlin-ericksion fluid flow down an inclined plane. P. Singh, A . Paul , J Kumar and P. Rajput [9] laminar steady flow between parallel plates at rest. K.R. Singh, A. Singh and V . K . Agarwal [10] Flow of a reiner-rivlin fluid in a uniformly Porous pipe. K.G. Singha and P. N. Deka [11] unsteady laminar magneto hydro dynamic coquette flow with heat transfer between two parallel non-conducting plates under the action of transverse magnetic field. K.G. Singha [12] The effect of heat transfer on unsteady hydro magnetic flow in a parallel plates channel of electrically conducting, viscous incompressible fluid. A .S. Sharma, M.P.Singh and A.B. Chandramouli [13] steady Laminar Plane Poiseuille Flow between Two parallel Plates under the Influence of Uniform Transverse Magnetic Field. A .S. Sharma, M.P. Singh and A.B. Chandramouli [14] steady Laminar Plane Poiseuille Flow between Two parallel Plates through Porous Medium under the Influence of Uniform Transverse Magnetic Field. 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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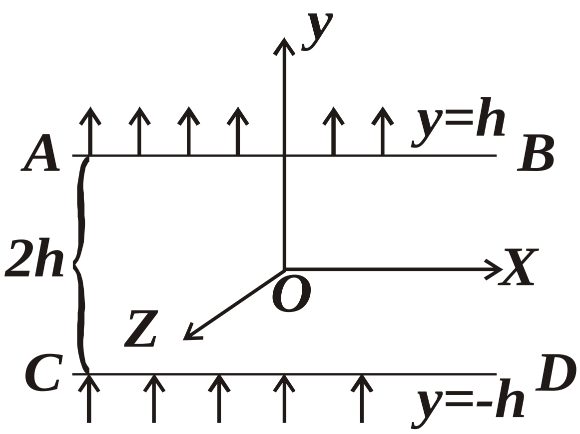


The equation of continuity for incompressible fluid

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

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

$$v_0\frac{du}{dy}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\upsilon\frac{d^2u}{dy^2}+\frac{\nu u}{K} \quad \ldots\ldots\ldots\ldots (1)$$

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

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

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

$$\Rightarrow \frac{d^2u}{dy^2}-\frac{v_0}{\upsilon}\frac{du}{dy}+\frac{u}{K}=-\frac{P}{\rho\upsilon} \qquad \Rightarrow \left(D^2-\frac{v_0}{\upsilon}D+\frac{1}{K}\right)u=-\frac{P}{\rho\upsilon}$$

$$A.E.\ m^2-\frac{v_0}{\upsilon}m+\frac{1}{K}=0 \quad \Rightarrow m=\frac{\frac{v_0}{\upsilon}\pm\sqrt{\left(\frac{v_0}{\upsilon}\right)^2-\frac{4}{K}}}{2} =\frac{v_0}{2\upsilon}\pm\sqrt{\left(\frac{v_0}{2\upsilon}\right)^2-\frac{1}{K}}$$

$$Let \quad \sqrt{\left(\frac{v_0}{2\upsilon}\right)^2-\frac{1}{K}} = A \ \ \& \ \frac{1}{K} = B$$

$$C.F.=e^{\frac{v_0}{2\upsilon}y}\left[C_1 Cosh\, Ay+C_2 Sinh\, Ay\right] \qquad P.I.=-\frac{PK}{\mu}$$

$$u(y)=e^{\frac{v_0}{2\upsilon}y}\left[C_1 Cosh\, Ay+C_2 Sinh\, Ay\right]-\frac{PK}{\mu}$$

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

$$e^{-\frac{v_0}{2\upsilon}h}\left[C_1 Cosh\, Ah-C_2 Sinh\, Ah\right]-\frac{PK}{\mu}=0 \quad \ldots\ldots\ldots\ldots (3)$$

$$U=e^{\frac{v_0}{2\upsilon}h}\left[C_1 Cosh\, Ah+C_2 Sinh\, Ah\right]-\frac{PK}{\mu} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

$$or \qquad \frac{PK}{\mu}e^{\frac{v_0}{2\upsilon}h}=C_1 Cosh\, Ah-C_2 Sinh\, Ah$$

$$\left(U+\frac{PK}{\mu}\right)e^{-\frac{v_0}{2\upsilon}h}=C_1 Cosh\,Ah+C_2 Sinh\,Ah$$

$$C_1=\frac{1}{2Cosh\,Ah}\left[\left(U+\frac{PK}{\mu}\right)e^{-\frac{v_0}{2\upsilon}h}+\frac{PK}{\mu}e^{\frac{v_0}{2\upsilon}h}\right]$$

$$C_2=\frac{1}{2Sinh\,Ah}\left[\left(U+\frac{PK}{\mu}\right)e^{-\frac{v_0}{2\upsilon}h}-\frac{PK}{\mu}e^{\frac{v_0}{2\upsilon}h}\right]$$

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

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

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

$$u(y)=\frac{1}{Sinh2Ah}\left[\left(U+\frac{PK}{\mu}\right)e^{\frac{v_0}{2\upsilon}(y-h)}SinhA(y+h)-\frac{PK}{\mu}e^{\frac{v_0}{2\upsilon}(y+h)}SinhA(y-h)\right]-\frac{PK}{\mu}\;..........(5)$$

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

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

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

Shearing stress at any point

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

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

$$=\frac{PK}{Sinh2Ah}\left[\frac{v_0}{2\upsilon}\left\{e^{\frac{v_0}{2\upsilon}(y-h)}SinhA(y+h)-e^{\frac{v_0}{2\upsilon}(y+h)}SinhA(y-h)\right\}+A\left\{e^{\frac{v_0}{2\upsilon}(y-h)}CoshA(y+h)-e^{\frac{v_0}{2\upsilon}(y+h)}CoshA(y-h)\right\}\right]\;.......(7)$$

Skin friction at lower & upper plates

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

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

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

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

The average velocity distribution in poiseuille flow:

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

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

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

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

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

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

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

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

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

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

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

$$= \frac{PK}{2\mu\,h\,Sinh\,2Ah}\left[\frac{Kv_0}{2\upsilon} Sinh\,2Ah - K\,A\,Cosh\,2Ah + K\,A\,e^{-\frac{v_0}{\upsilon}h} - \frac{Kv_0}{2\upsilon} Sinh\,2Ah - K\,A\,Cosh\,2Ah + KA\,e^{\frac{v_0}{\upsilon}h} - 2h\,Sinh\,2Ah\right]$$

$$u_{av} = \frac{PK}{\mu h\,Sinh\,2Ah}\left[AK\left(Cosh\frac{v_0}{\upsilon}h - Cosh\,2Ah\right) - hSinh\,2Ah\right] \ldots\ldots.(10)$$

The volumetric flow *Q = 2 h uav*

$$= \frac{2PK}{\mu\,Sinh\,2Ah}\left[AK\left(Cosh\frac{v_0}{\upsilon}h - Cosh\,2Ah\right) - hSinh\,2Ah\right] \ldots\ldots\ldots(11)$$

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

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

$$C_f{}' = \frac{(\sigma_{xy})_{y=-h}}{\frac{1}{2}\rho(u_{av})^2} = \frac{2\rho\upsilon^2 h^2\ Sinh\ 2Ah}{PK}\left[\frac{\left\{\frac{v_0}{2\upsilon}Sin\ 2Ah - ACosh\ 2Ah + Ae^{-\frac{v_0}{\upsilon}h}\right\}}{\left[AK\left(Cosh\frac{v_0}{\upsilon}h - Cos\ 2Ah\right) - hSinh\ 2Ah\right]^2}\right] \ldots\ldots\ldots(13)$$

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

$$\Rightarrow \frac{dx}{\frac{PK}{\mu Sinh 2Ah}\left\{e^{\frac{v_0}{2\upsilon}(y-h)}Sinh\ A(y+h) - e^{\frac{v_0}{2\upsilon}(y+h)}Sinh\ A(y-h) - Sinh\ 2Ah\right\}} = \frac{dy}{v_0} = \frac{dz}{0}$$

Taking Ist two

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

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

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

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

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

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

$\therefore$ **Ist stream line.**

$$\frac{v_0\mu\ Sinh\ 2Ah}{PK}x - \{I_1 - I_2 - I_3\} = C_1$$

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

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

Second stream line

$$z = c_2\ldots\ldots\ldots(15)$$

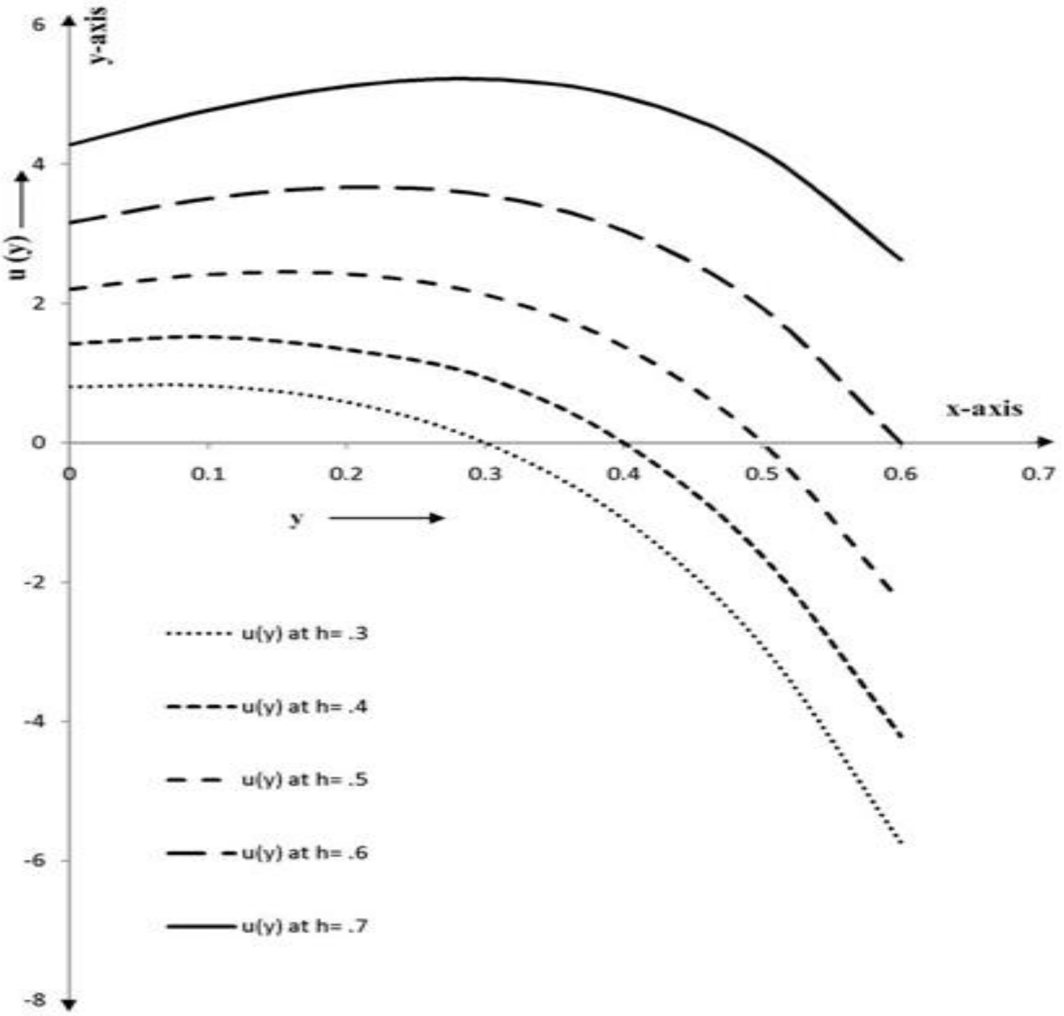
Clearly the curl $\bar{q} \neq \bar{0}\ \therefore$ the fluid is Rotational

Table for velocity:

$$P = 9, \mu = .5, \frac{v_0}{2\upsilon} = 2, k = \frac{1}{3}, A = \sqrt{\left(\frac{v_0}{2\upsilon}\right)^2 - \frac{1}{k}} = \sqrt{4-3} = 1\ are\ same\ for\ all\ but\ h\ change$$

Table 1

h	y	0	0.1	0.2	0.3	0.4	0.5	0.6
0.3	u(y)	0.804	0.818	0.587	0	-1.096	-2.912	-5.734
0.4	u(y)	1.423	1.524	1.34	0.94	0	-1.623	-4.21
0.5	u(y)	2.21	2.42	2.43	2.131	1.385	0	-2.29
0.6	u(y)	3.164	3.51	3.67	3.56	3.045	1.94	0
0.7	u(y)	4.282	4.778	5.122	5.226	4.969	4.181	2.63



Velocity Profile

Table for skin friction:

$$P=9, \mu=.5, \frac{v_0}{2\upsilon}=2, k=\frac{1}{3}, A=\sqrt{\left(\frac{v_0}{2\upsilon}\right)^2-\frac{1}{k}}=\sqrt{4-3}=1 \text{ are same for all but } h \text{ change}$$

Table 2

h	y	0	0.1	0.2	0.3	0.4	0.5	0.6
0.3	σ_{xy}	0.532	-0.465	-1.936	-4.059	-7.076	-11.318	-17.229
0.4	σ_{xy}	0.936	0.016	-1.356	-3.36	-6.21	-10.25	-15.89
0.5	σ_{xy}	1.445	0.62	-0.632	-2.48	-5.14	-8.92	-14.24
0.6	σ_{xy}	2.05	1.34	0.225	-1.44	-3.88	-7.37	-12.31
0.7	σ_{xy}	2.75	2.163	1.21	-0.26	-2.45	-5.62	-10.14

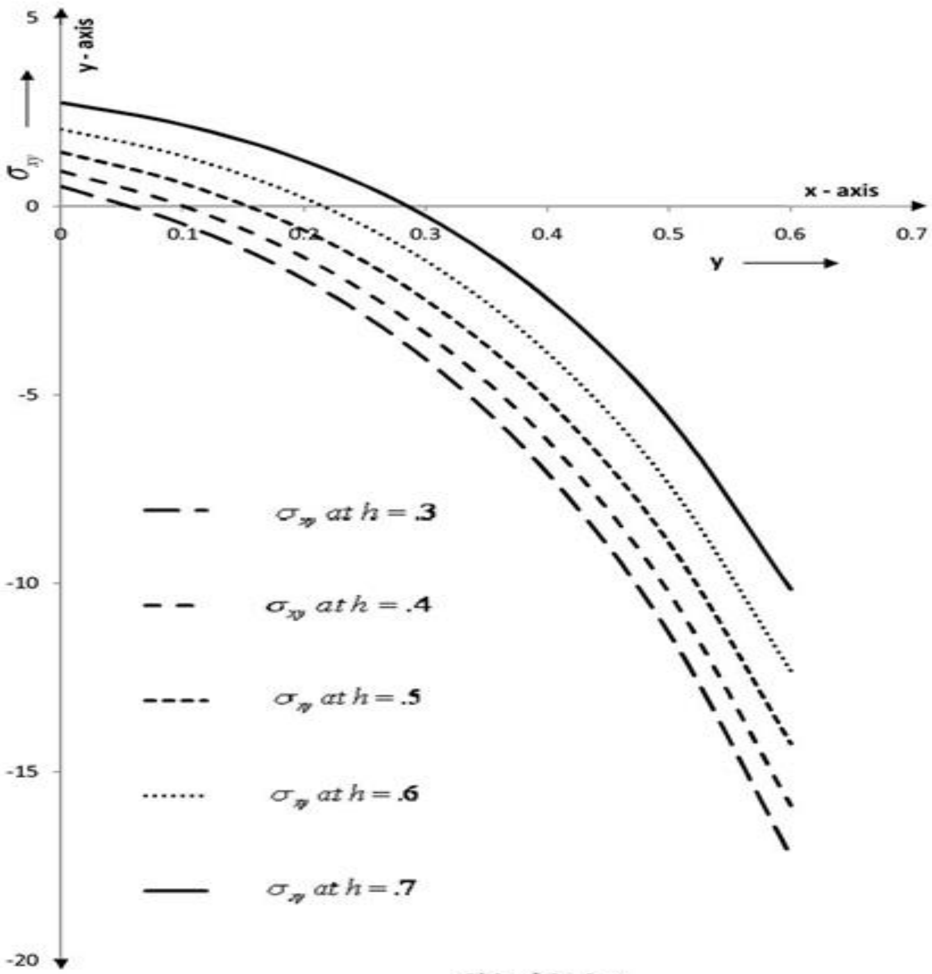


Table for velocity: when y & A are vary and other are fixed

$$let \quad P=9, \quad \mu=.5, \quad \frac{v_0}{2\upsilon}=6, h=.5, \; \& \sqrt{\left(\frac{v_0}{2\upsilon}\right)^2-\frac{1}{K}}=A$$

Table 3

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

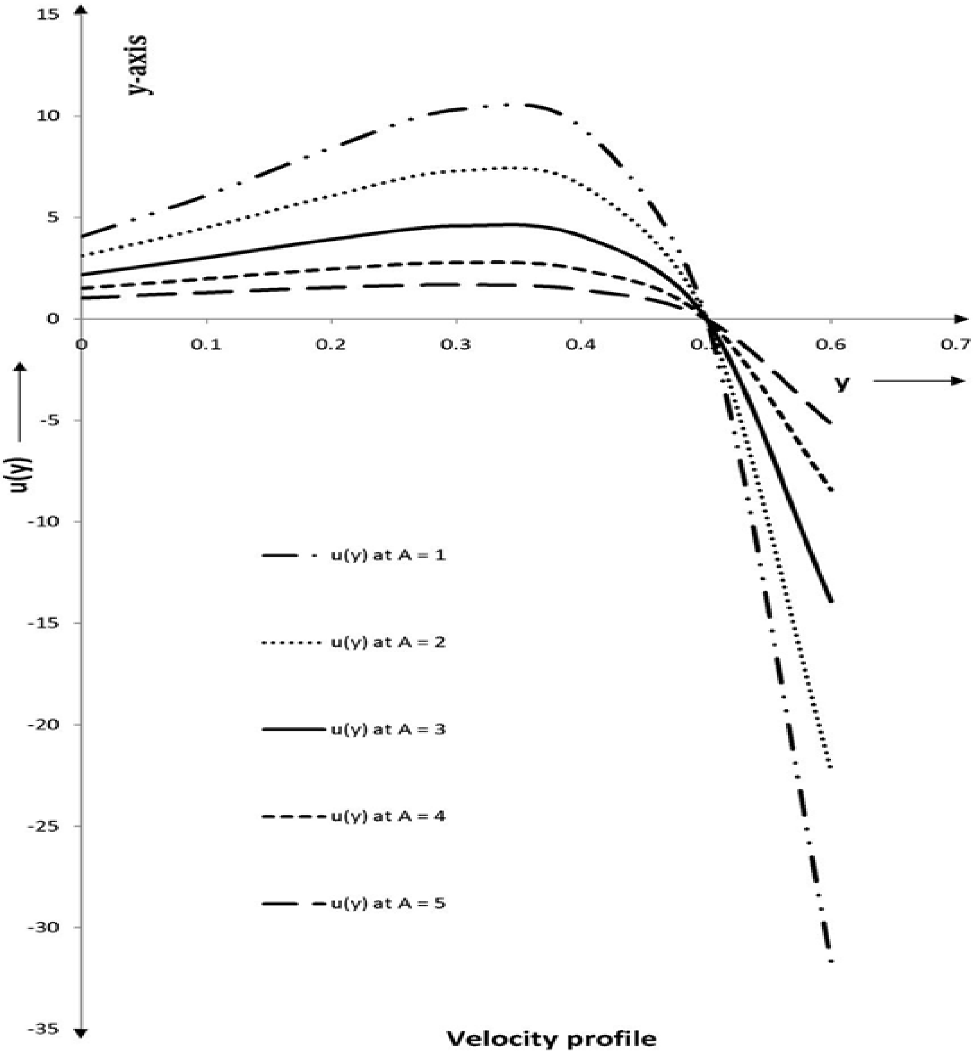
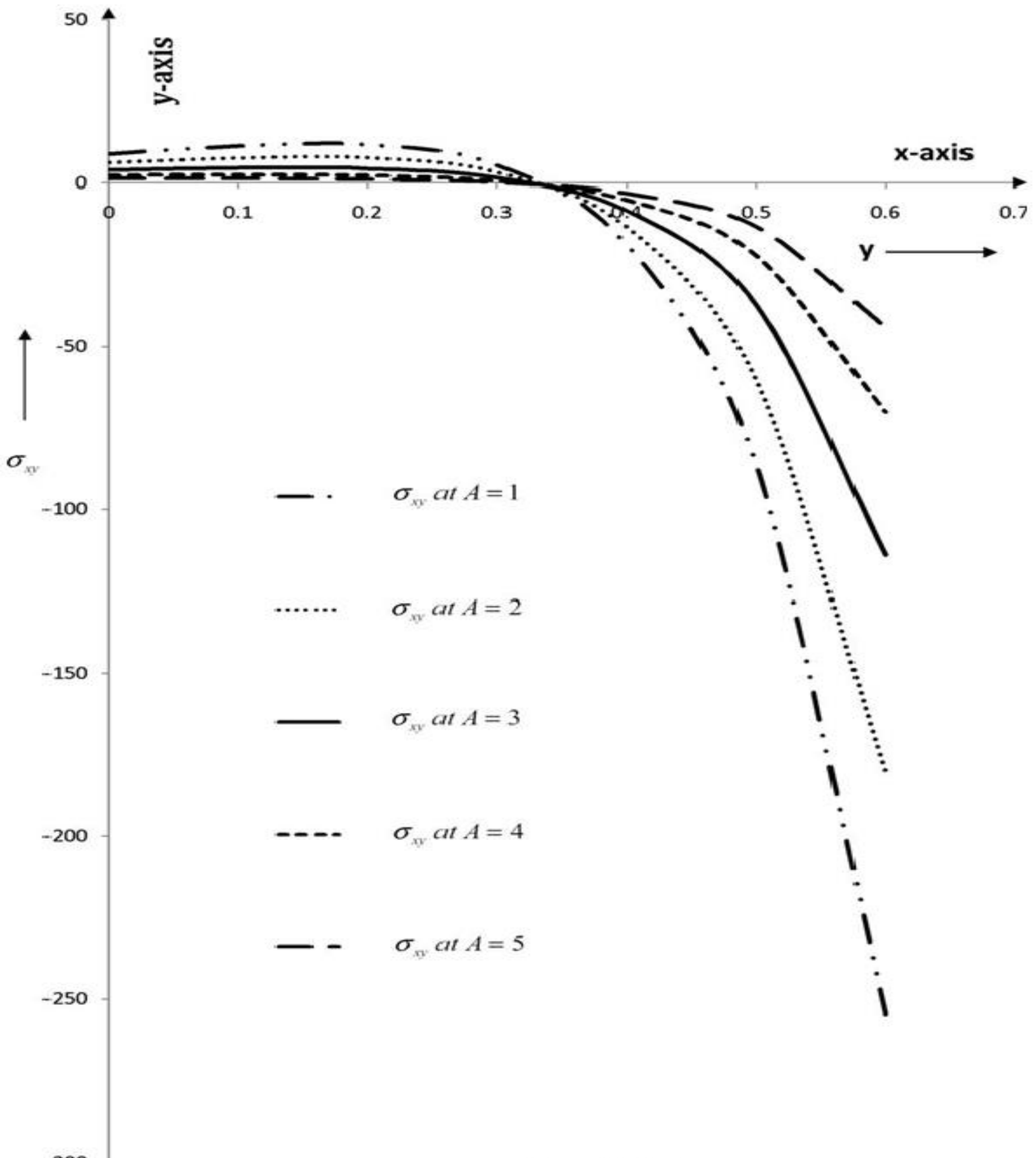


Table for skin friction:

$$let \quad P=9, \quad \mu=.5, \quad \frac{v_0}{2\upsilon}=6, h=.5, \ \& \ \sqrt{\left(\frac{v_0}{2\upsilon}\right)^2-\frac{1}{K}}=A$$

Table 4

A	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



Skin friction

Conclusion and discussion:

In this paper, we have investigated the velocity by the graphs of table -1 of equation (5) between velocity and distance in porous medium. Velocity increases in the interval $0 \le y \le .1$ at $h = .3$,velocity decreases in the interval $.1 \le y \le .3$ at $h = .3$,and velocity increases with negative sign at h=.3 in the interval $.4 \le y \le .6$,Again velocity increases in the interval $0 \le y \le .1$, velocity decreases in the interval. $.2 \le y \le .4$,and increases with negative sign in the interval $.5 \le y \le .6$ at $h = .4$,Velocity increases in the interval $0 \le y \le .2$, decreases in the interval $.3 \le y \le .5$, and velocity is negative at $y = .6$ at the height $h = .5$ Again velocity increases at $h = .6$ in the interval $0 \le y \le .2$ and decreases in the interval $.3 \le y \le .6$ at $h = .6$. Again the velocity increases in the interval $0 \le y \le .3$ and decreases in the interval $.4 \le y \le .6$ at $h = .7$. The points with zero velocity are stagnation point. The value of velocity increases correspondingly in the interval $0 \le y \le .6$ when **h** increases.

Again from the table -3 the velocity decreases correspondingly in the interval $0 \le y \le .6$ when **A** increases from 1 to 5. Since the velocity is zero at $y = .5$ for all values of **A**, $y = .5$ is a stagnation point.

Again from the table -2 the value of skin friction increases correspondingly in the interval $0 \le y \le .2$ and the values of skin friction decreases with negative sign in the interval $.3 \le y \le .6$ when **h** increases from .3 to .7.

Again from the table -4 it is clear that the skin friction decreases with positive sign in the interval $0 \le y \le .3$ when A 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.Also we have investgated the shearing stress, , the volumetric flow, drag coefficients and stream lines by equations (7), (9), (11), (12),(13), (14) and (15).The fluid is rotational.

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