VOL. 4, NO. 12, December 2014 ISSN 2225-7217
ARPN Journal of Science and Technology

http://www.ejournalofscience.org

Steady Plane Coquette Flow of Viscous Incompressible Fluid between Two Porous Parallel Plates through Porous Medium

Anand Swrup Sharma
Dr., Associate Professor, Dept. of Applied Sciences, Ideal Institute of Technology, Ghaziabad (U.P.)
sharma.as09@gmail.com

ABSTRACT

In this paper, we have investigated the steady plane Coquette 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 streamlines.

Keywords: *Steady Coquette flow, viscous parallel plates, incompressible fluid and porous medium*

NOMENCLATURE

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

1. INTRODUCTION

We have investigated the steady plane Coquette flow of viscous incompressible fluid between two porous parallel plates through porous medium. Attempts have been made by several researchers i.e. R. Johari, R. Jha and A. M. Saxena [1] unsteady MHD flow through Porous medium and heat transfer past a Porous vertical moving plate with heat source. G.H. Junchu [2] a numerical study of steady viscous flow past a fluid spheres. J. N. Kanpur and R. C. Srivastava [3] Similar Solution of the boundary layer equations for Power–low fluids. P. Kaushik, C. Babir and A. Ashok [4] free connection oscillatory flow and of non Newtonian fluid past an impulsively started infinite vertical Porous post plate with time dependent suction in the presence of magnetic field. Y.

Kobayashi and I. Towhata [5] three dimensional analysis on lateral flow of liquefied ground and its mitigation. D.V. Krishna, G. Kathayani and C. Sankaraih [6] unsteady hydro magnetic generalized coquette flow of a couple stress fluids. D. V. Krishna, D. R. V. Prasada and M. Ravindra [7] Mangeto hydro dynamic connection flow through a porous medium with traveling thermal waves. D. V. Krishna, D. R. V. Prasada and M. Ravindra [8] Hydro magnetic Channel flow through Porous medium with prescribed discharge. A.

Kumar and K.K. Singh [9] a numerical steady of hydro magnetic flow of rivlin- ericksen fluid down an inclined porous plates.A. Kumar and K.K. Singh [10] a steady of hydro magnetic flow of rivlin-ericksen fluid through porous medium between the inclined parallel plates. A. Kumar and K.K. Singh [11] Effects of magnetic field on the motion under gravity of a viscous fluid down between two inclined parallel flat plates. M. Kumari, and G. Nath [12] development of 2–dimensional boundary layer due to an impulsive motion. A.S. Sharma, M.P. Singh and A.B. Chandramouli [13] Steady Laminar Generalized Plane Coquette Flow between Two parallel.

Plates through Porous Medium. A. S. Sharma, M. P. Singh and A. B. Chandramouli [14] Steady Laminar Generalized Plane Coquette Flow between Two parallel Plates under the Influence of Uniform Transverse Magnetic Field. A. S. Sharma, M. P. Singh and A. B. Chandramouli [15] Steady Laminar Generalized Plane Coquette Flow between Two parallel Plates through Porous Medium. In this paper we have investigated the velocity, average velocity, shearing stress, skin frictions, the volumetric flow, drag coefficients and stream lines.

2. 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

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

The equation of continuity for incompressible fluid

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

v is independent of ***y*** but motion along **y** – axis . So we can say v is constant velocity i.e. $\mathrm{v} = \mathrm{v}_0$
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

VOL. 4, NO. 12, December 2014 ISSN 2225-7217
ARPN Journal of Science and Technology

http://www.ejournalofscience.org

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

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

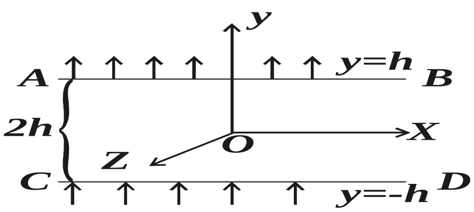

Fig 1

3. 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

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

Where $\frac{dp}{dx}$ = Constant = - P

$$\Rightarrow \frac{d^2u}{dy^2} - \frac{v_0}{\upsilon}\frac{du}{dy} + \frac{u}{K} = -\frac{P}{\rho\upsilon}$$

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

$$A.E.\ m^2 - \frac{v_0}{\upsilon}m + \frac{1}{K} = 0$$

$$\Rightarrow m = \frac{\frac{v_0}{\upsilon} \pm \sqrt{\left(\frac{v_0}{\upsilon}\right)^2 - \frac{4}{K}}}{2}$$

$$= \frac{v_0}{2\upsilon} \pm \sqrt{\left(\frac{v_0}{2\upsilon}\right)^2 - \frac{1}{K}}$$

$$let \ \sqrt{\left(\frac{v_0}{2\upsilon}\right)^2 - \frac{1}{K}} = A$$

$$C.F. = e^{\frac{v_0}{2\upsilon}y}\left[C_1 Cosh\ Ay + C_2 Sinh\ Ay\right]$$

$$P.I. = -\frac{PK}{\mu}$$

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

Using boundary conditions:

u = 0 at **y = - h** and u = U at **y = h**

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

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

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

$$C_1 = \frac{1}{2Cosh\, Ah}\left[\left(U + \frac{PK}{\mu}\right)e^{-\frac{v_0}{2\upsilon}h} + \frac{PK}{\mu}e^{\frac{v_0}{2\upsilon}h}\right] \ \& \ C_2 = \frac{1}{2Sinh\, Ah}\left[\left(U + \frac{PK}{\mu}\right)e^{-\frac{v_0}{2\upsilon}h} - \frac{PK}{\mu}e^{\frac{v_0}{2\upsilon}h}\right]$$

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

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

VOL. 4, NO. 12, December 2014 ISSN 2225-7217
ARPN Journal of Science and Technology

http://www.ejournalofscience.org

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

Plane Coquette flow: In this case **P** = 0

$$u(y)=\frac{1}{Sinh2Ah}\left[Ue^{\frac{v_0}{2\upsilon}(y-h)}SinhA(y+h)\right]\;................(6)$$

The shearing stress at any point

$$\sigma_{xy}=\mu\frac{du}{dy}=\frac{\mu U}{Sinh2Ah}\left[\frac{v_0}{2\upsilon}e^{\frac{v_0}{2\upsilon}(y-h)}SinhA(y+h)+Ae^{\frac{v_0}{2\upsilon}(y-h)}CoshA(y+h)\right]$$

$$=\frac{\mu Ue^{\frac{v_0}{2\upsilon}(y-h)}}{Sinh2Ah}\left[\frac{v_0}{2\upsilon}SinhA(y+h)+ACoshA(y+h)\right]\;.............(7)$$

The skin frictions at Lower and Upper plate is given by

$$\left(\sigma_{xy}\right)_{y=h}=\frac{\mu Ue^{o}}{Sinh2Ah}\left[\frac{v_o}{2\upsilon}Sinh2Ah+ACosh2Ah\right]=\mu U\left[\frac{v_0}{2\upsilon}+ACoth2Ah\right]\;.........(8)$$

$$\left(\sigma_{xy}\right)_{y=-h}=\frac{\mu Ue^{-\frac{v_0}{\upsilon}h}}{Sinh2Ah}A=\frac{\mu UAe^{-\frac{v_0}{\upsilon}h}}{Sinh2Ah}\;...............(9)$$

The average velocity distribution in plane coquette flow:

$$(u)_{av}=\frac{1}{2h}\int_{-h}^{h}u(y)\,dy=\frac{1}{2h}\int_{-h}^{h}\frac{U}{Sinh2Ah}e^{\frac{v_0}{2\upsilon}(y-h)}SinhA(y+h)\,dy=\frac{U}{2h\,Sinh\,2Ah}\int_{-h}^{h}e^{\frac{v_0}{2\upsilon}(y-h)}\left\{\frac{e^{A(y+h)}-e^{-A(y+h)}}{2}\right\}dy$$

$$=\frac{U}{4hSinh2Ah}\int_{-h}^{h}\left\{e^{\frac{v_0}{2\upsilon}(y-h)+A(y+h)}-e^{\frac{v_0}{2\upsilon}(y-h)-A(y+h)}\right\}dy$$

$$=\frac{U}{4hSinh2Ah}\left\{\frac{e^{\frac{v_0}{2\upsilon}(y-h)+A(y+h)}}{\left(\frac{v_0}{2\upsilon}+A\right)}-\frac{e^{\frac{v_0}{2\upsilon}(y-h)-A(y+h)}}{\left(\frac{v_0}{2\upsilon}-A\right)}\right\}_{-h}^{h}=\frac{U}{4hSinh2Ah}\left[\frac{e^{2Ah}-e^{-\frac{v_0}{\upsilon}h}}{\left(\frac{v_0}{2\upsilon}+A\right)}-\frac{e^{-2Ah}-e^{-\frac{v_0}{\upsilon}h}}{\left(\frac{v_0}{2\upsilon}-A\right)}\right]$$

$$=\frac{U}{4hSinh2Ah}\left[\frac{\left(\frac{v_0}{2\upsilon}-A\right)\left[e^{2Ah}-e^{-\frac{v_0}{\upsilon}h}\right]-\left(\frac{v_0}{2\upsilon}+A\right)\left[e^{-2Ah}-e^{-\frac{v_0}{\upsilon}h}\right]}{\left\{\left(\frac{v_0}{2\upsilon}\right)^2-A^2\right\}}\right]$$

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

$$(u)_{av} = \frac{UK}{4h\ Sinh\ 2Ah}\left[\frac{v_0}{2\upsilon}\left\{e^{2Ah} - e^{-\frac{v_0}{\upsilon}h} - e^{-2Ah} + e^{-\frac{v_0}{\upsilon}h}\right\} - A\left\{e^{2Ah} - e^{\frac{v_0}{\upsilon}h} + e^{-2Ah} - e^{-\frac{v_0}{\upsilon}h}\right\}\right]$$

$$= \frac{UK}{4h\ Sinh\ 2Ah}\left[\frac{v_0}{\upsilon} Sinh\ 2Ah - A\left\{2\ Cosh\ 2Ah - 2e^{\frac{v_0}{\upsilon}h}\right\}\right]$$

$$= \frac{UK}{2h\ Sinh\ 2Ah}\left[\frac{v_0}{2\upsilon} Sinh\ 2Ah - A\left\{Cosh\ 2Ah - e^{-\frac{v_0}{\upsilon}h}\right\}\right] \quad ....(10)$$

The volumetric flow: $Q = 2h\, u_{av}$

$$= \frac{UK}{Sinh\ 2Ah}\left[\frac{v_0}{2\upsilon} Sinh\ 2Ah - A\left\{Cosh\ 2Ah - e^{-\frac{v_0}{\upsilon}h}\right\}\right] \quad ....(11)$$

The drag coefficients:

$$C_f \ \& \ C_f' \ at\ y = h \ \& \ y = -h$$

$$C_f = \frac{\left(\sigma_{xy}\right)_{y=h}}{\frac{1}{2}\rho u^2{}_{av}} = \frac{\frac{\mu U}{Sinh\ 2Ah}\left[\frac{v_0}{2\upsilon} Sinh\ 2Ah + ACosh\ 2Ah\right]}{\frac{1}{2}\rho \frac{U^2K^2}{4h^2 Sinh^2\ 2Ah}\left\{\frac{v_0}{2\upsilon} Sinh\ 2Ah - ACosh\ 2Ah + Ae^{-\frac{v_0}{\upsilon}h}\right\}^2}$$

$$C_f = \frac{8h^2\mu\ Sinh\ 2Ah\left[\frac{v_0}{2\upsilon} Sinh\ 2Ah + ACosh\ 2Ah\right]}{\rho UK^2\left[\frac{v_0}{2\upsilon} Sinh\ 2Ah - ACosh\ 2Ah + Ae^{-\frac{v_0}{\upsilon}h}\right]^2} \quad ....(12)$$

$$C_f' = \frac{\left(\sigma_{xy}\right)_{y=-h}}{\frac{1}{2}\rho u^2{}_{av}} = \frac{\mu UAe^{-\frac{v_0}{\upsilon}h}}{Sinh\ 2Ah} \cdot \frac{8h^2 Sinh^2\ 2Ah}{\rho U^2K^2\left[\frac{v_0}{2\upsilon} Sinh\ 2Ah - ACosh\ 2Ah + Ae^{-\frac{v_0}{\upsilon}h}\right]^2}$$

$$C_f' = \frac{8\mu\ h^2 A\ e^{-\frac{v_0}{\upsilon}h}\ Sinh\ 2Ah}{\rho UK^2\left[\frac{v_0}{2\upsilon} Sinh\ 2Ah - ACosh\ 2Ah + Ae^{\frac{v_0}{\upsilon}h}\right]^2} \quad ....(13)$$

VOL. 4, NO. 12, December 2014 ISSN 2225-7217
ARPN Journal of Science and Technology

http://www.ejournalofscience.org

Equation of stream line in the plane coquette flow:

$$\frac{dx}{u} = \frac{dy}{v} = \frac{dz}{w}, \quad \bar{q} = u\,i + v\,j + w\,k$$

$$\frac{dx}{\frac{U}{Sinh\ 2Ah} e^{\frac{v_0}{2\upsilon}(y-h)} SinhA\ (y+h)} = \frac{dy}{v_0} = \frac{dz}{o}$$

Taking first two equations

$$\frac{v_0 Sinh\ 2Ah}{U}\int dx = \int e^{\frac{v_0}{2\upsilon}(y-h)} Sinh\ A(y+h)\ dy + C_1$$

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

$$x\ \frac{v_0}{U}\ Sinh2\ Ah - \frac{1}{2} \int \left\{ e^{\frac{v_0}{2\upsilon}(y-h)+A(y+h)} - e^{\frac{v_0}{2\upsilon}(y-h)-A(y+h)} \right\} dy = C_1$$

$$x\ \frac{v_0}{U} Sinh\ 2Ah - \frac{1}{2}\left[\frac{e^{\frac{v_0}{2\upsilon}(y-h)+A(y+h)}}{\left(\frac{v_0}{2\upsilon} + A\right)} - \frac{e^{\frac{v_0}{2\upsilon}(y-h)-A(y+h)}}{\left(\frac{v_0}{2\upsilon} - A\right)} \right] = C_1$$

$$\Rightarrow\ \frac{v_0}{U} Sinh\ 2Ah\ .\ x - \frac{K}{2}\left[\left(\frac{v_0}{2\upsilon} - A\right) e^{\frac{v_0}{2\upsilon}(y-h)} e^{A(y+h)} - \left(\frac{v_0}{2\upsilon} + A\right) e^{\frac{v_0}{2\upsilon}(y-h)} e^{-A(y+h)} \right] = C_1$$

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

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

First stream line

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

Second stream line

$$z = C_2 \quad ....(15)$$

ARPN Journal of Science and Technology

http://www.ejournalofscience.org

Now the curl $\bar{q} = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ u & v & w \end{vmatrix} = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ \frac{Ue^{\frac{v_0}{2\upsilon}(y-h)} Sinh\ A(y+h)}{Sinh\ 2Ah} & v_0 & o \end{vmatrix}$

$$= -\frac{U\ e^{\frac{v_0}{2\upsilon}(y-h)}}{Sinh\ 2Ah}\left[\frac{v_0}{2\upsilon} Sinh\ A(y+h) + ACosh\ A(y+h)\right]\hat{k} \neq \bar{0}$$ $\therefore$ **Motion of fluid is rotational**

Table for velocity: when the **y** & **h** are vary and other are fixed

$$let\quad U = 6,\quad \mu = .5,\quad K = \frac{1}{3},\ \frac{v_0}{2\upsilon} = 2,\ \&\ \sqrt{\left(\frac{v_0}{2\upsilon}\right)^2 - \frac{1}{K}} = \sqrt{4-3} = 1 = A$$

Table 1: (for velocity)

h	y	0	0.1	0.2	0.3	0.4	0.5	0.6
0.3	u(y)	1.575	2.595	4.021	6	8.732	12.49	17.63
0.4	u(y)	1.245	1.93	2.88	4.196	6	8.47	11.84
0.5	u(y)	0.979	1.46	2.126	3.04	4.29	6	8.33
0.6	u(y)	.762	1.11	1.59	2.24	3.13	4.35	6
0.7	u(y)	0.589	0.843	1.19	1.66	2.31	3.19	4.38

VOL. 4, NO. 12, December 2014 ISSN 2225-7217
ARPN Journal of Science and Technology

http://www.ejournalofscience.org

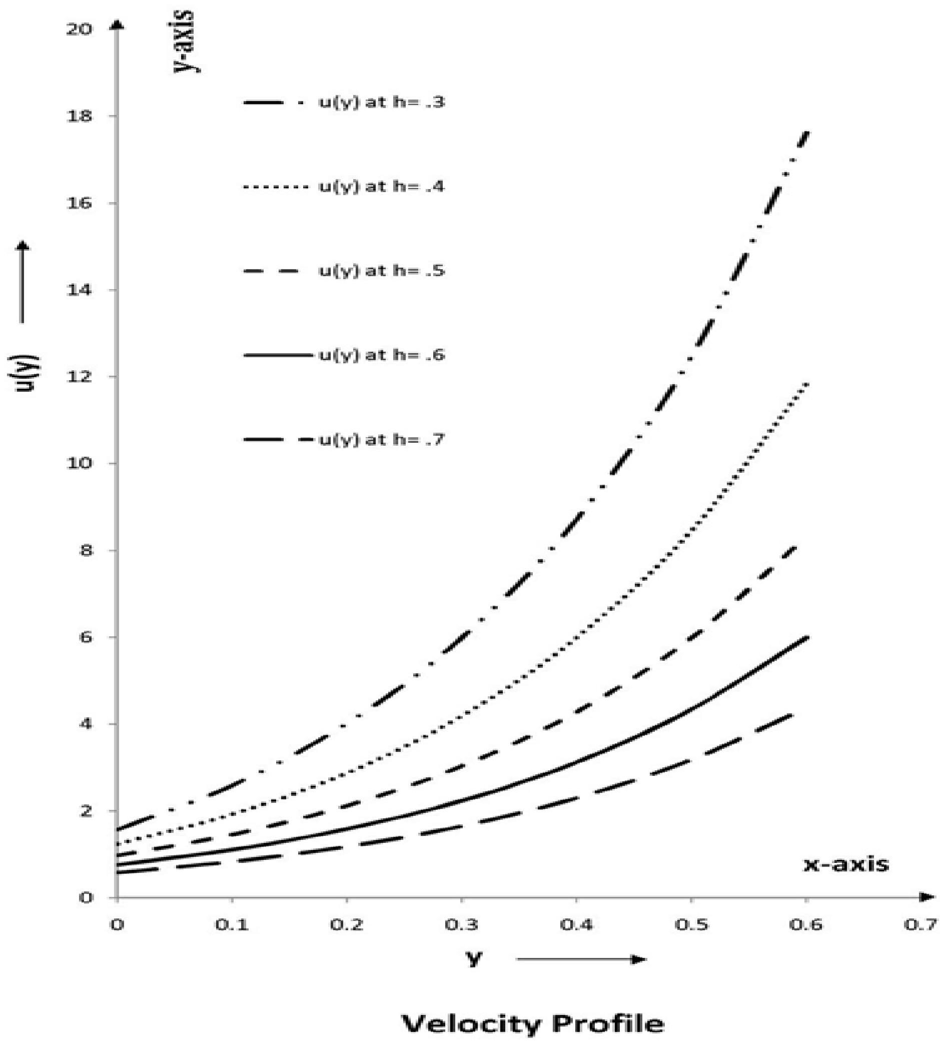

Fig 2

Table for skin friction:

$$let \quad U=6, \quad \mu=.5, \quad K=\frac{1}{3}, \ \frac{v_0}{2\upsilon}=2, \ \& \sqrt{\left(\frac{v_0}{2\upsilon}\right)^2-\frac{1}{K}}=\sqrt{4-3}=1=A$$

Table 2: (for skin friction)

h	**y**	**0**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**
0.3	σ_{xy}	4.28	6.01	8.37	11.59	15.96	21.89	29.93
0.4	σ_{xy}	2.89	4.02	5.57	7.67	10.52	14.38	19.62
0.5	σ_{xy}	2.04	2.82	3.88	5.32	7.29	9.94	13.53
0.6	σ_{xy}	1.47	2.03	2.78	3.8	5.19	7.06	9.56
0.7	σ_{xy}	1.08	1.48	2.02	2.76	3.75	5.10	6.92

VOL. 4, NO. 12, December 2014 ISSN 2225-7217
ARPN Journal of Science and Technology

http://www.ejournalofscience.org

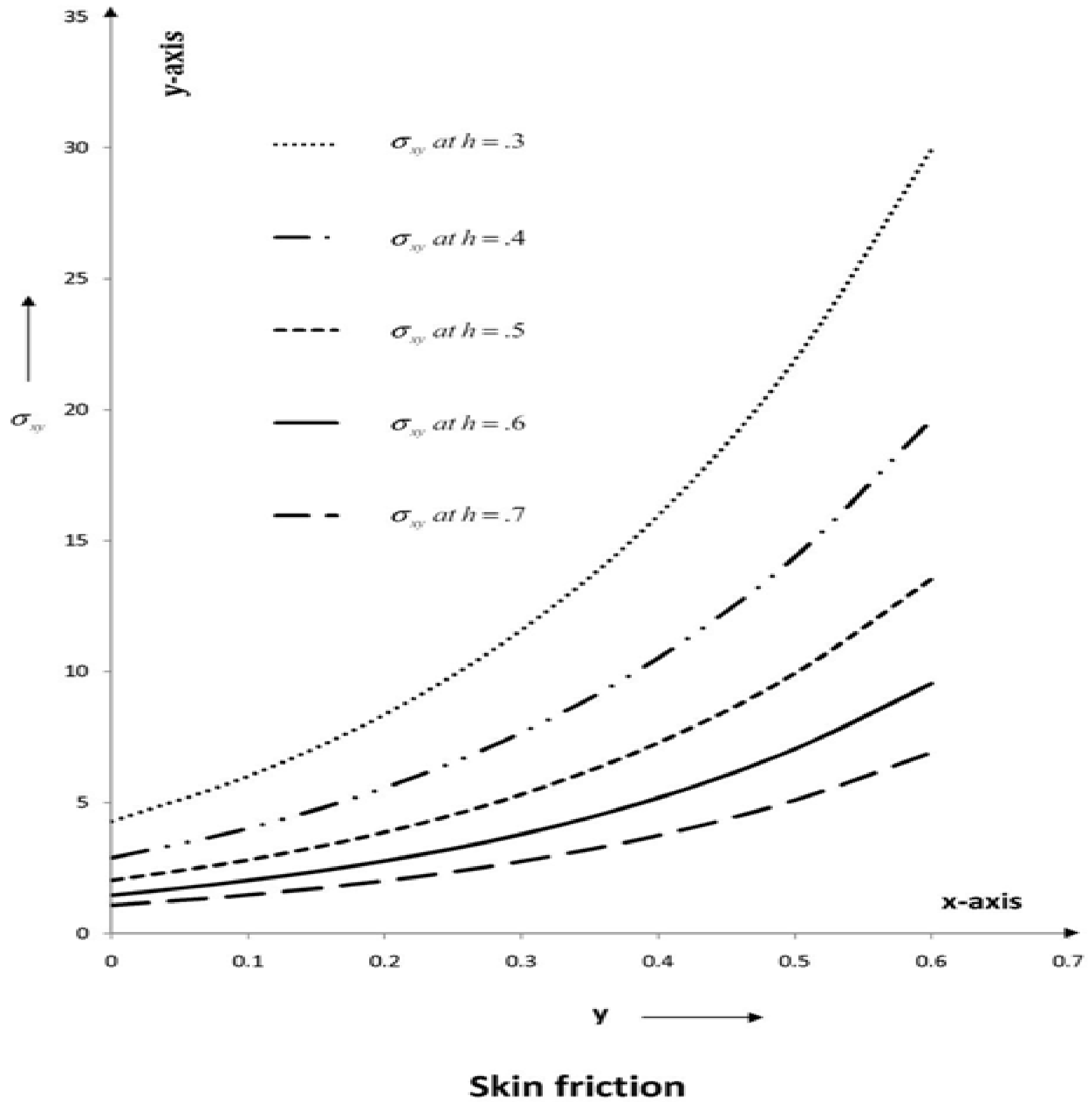

Fig 3

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

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

Table 3: (for velocity)

A	y	0	0.1	0.2	0.3	0.4	0.5	0.6
1	u(y)	.132	.295	.64	1.367	2.88	6	12.42
2	u(y)	.092	.227	.52	1.184	2.67	6	13.44
3	u(y)	.063	.16	.398	.99	2.43	6	14.77
4	u(y)	.04	.11	.298	.811	2.21	6	16.31
5	u(y)	.024	.073	.221	.665	1.997	6	18.025

VOL. 4, NO. 12, December 2014 ISSN 2225-7217
ARPN Journal of Science and Technology

http://www.ejournalofscience.org

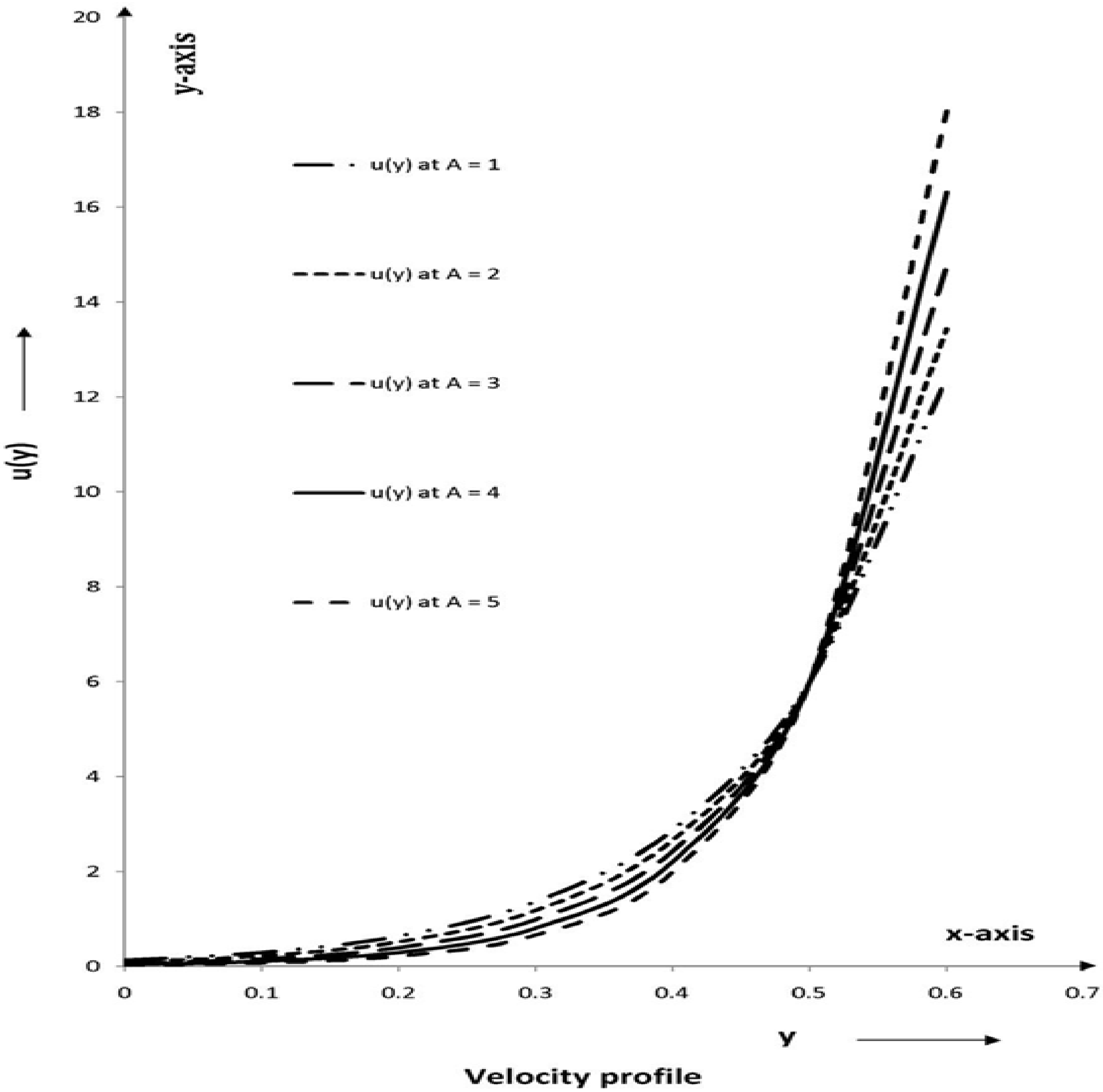

Fig 4

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

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

VOL. 4, NO. 12, December 2014 ISSN 2225-7217
ARPN Journal of Science and Technology

http://www.ejournalofscience.org

Table 4: (for skin friction)

A	y	0	0.1	0.2	0.3	0.4	0.5	0.6
1	σ_{xy}	.541	1.159	2.45	5.125	10.64	21.94	45.04
2	σ_{xy}	.417	.95	2.15	4.835	10.84	24.22	54.08
3	σ_{xy}	.295	.733	1.81	4.46	10.99	27.04	66.54
4	σ_{xy}	.20	.549	1.49	4.06	11.04	30.01	81.57
5	σ_{xy}	.135	.405	1.22	3.66	10.98	33	99.14

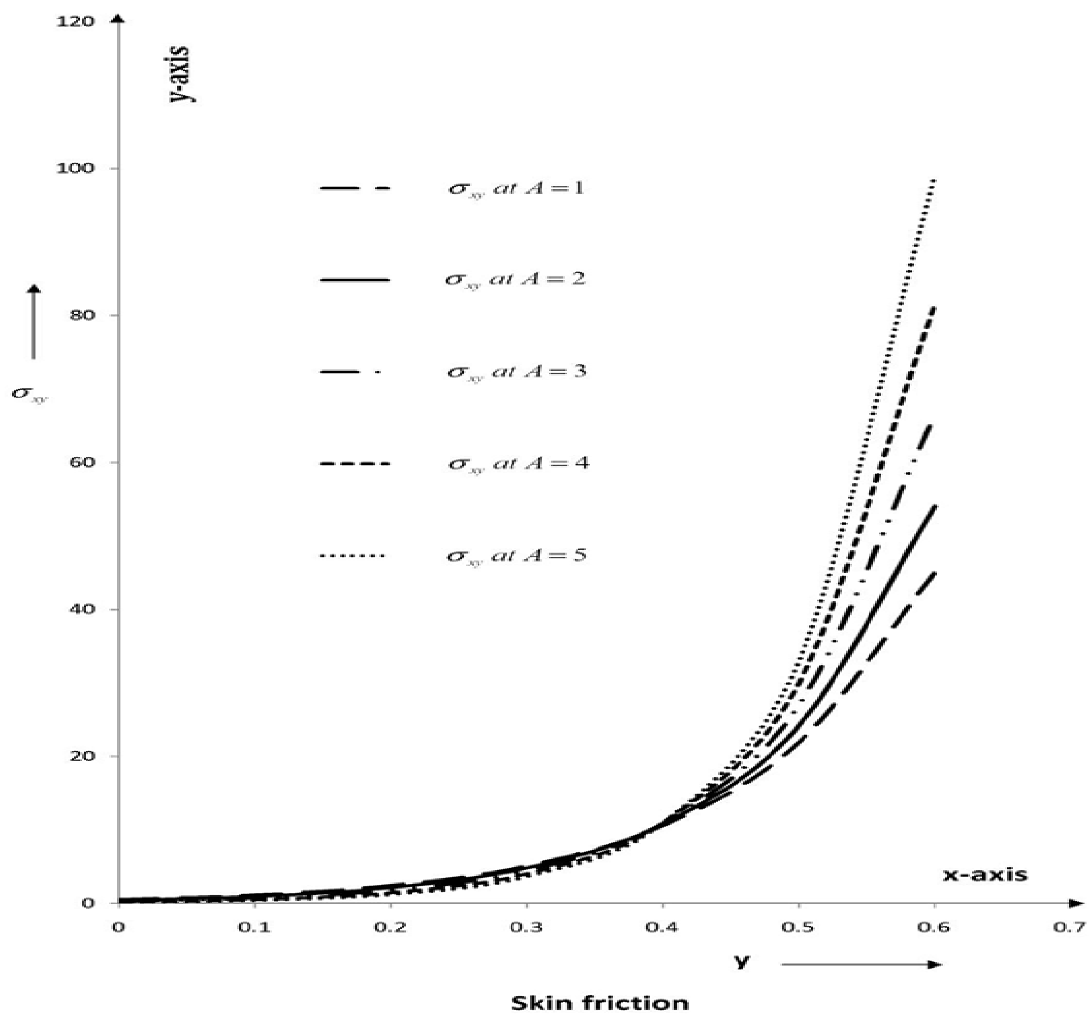

Fig 5

4. 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. The velocity increases in the interval $0 \le y \le .6$ at each value of **h** lies between 0.3 to 0.7. Again value of velocity decreases correspondingly at each value of y from 0 to 0.6 when **h** increases.

Again from the table-3 the velocity increases in the interval. $0 \le y \le .6$ at each value of A lies between 1 to 5, velocity is equal $\{u(y) = 6\}$ at $y = .5$ at each value of **A**. But the velocity decreases correspondingly in the interval $0 \le y \le .4$ and the velocity increases at $y = .6$ at each value of **A** lies from 1 to 5.

Similarly from the table-2 the value of skin friction increases in the interval $0 \leq y \leq .6$ at each value of h lies from 0.3 to 0.7. Again skin friction decreases correspondingly at each value of y when h increases from .3 to .7.

Again from the table-4 the value of skin friction increases in the interval $0 \leq y \leq .6$ at each value of **A** increases 1 to 5. Again skin friction decreases correspondingly in the interval $0 \leq y \leq .3$ and increases in the interval $.4 \leq y \leq .6$ when **A** increases from 1 to 5. Also we have investigated shearing stress, the volumetric flow, drag coefficients and stream lines by the equations (7), (9), (11), (12), (13), (14) and (15) respectively

REFERENCES

[1] Johari R., R. Jha and A. M. Saxena, Unsteady MHD flow through Porous medium and heat transfer past a Porous vertical moving plate with heat source. Acta ciencia Indica, Vol. XXXIV M, No. 4, pp 1683. (2008).

[2] Junchu, G. H., A numerical study of steady viscous flow past a fluid spheres. Int. J. Heat and fluid flow, Vol. 20, pp 414 – 421. (1999).

[3] Kanpur J. N. and R. C. Srivastava, Similar Solution of the boundary layer equations for Power–low fluids. ZAMP, Vol. 14, pp 383 – 389. (1963).

[4] Kaushik P., C. Babir and A. Ashok, Free connection oscillatory flow and of non Newtonian fluid past an impulsively started infinite vertical Porous post plate with time dependent suction in the presence of magnetic field. Acta Ciencia Indica, Vol XXVIIIM, No. 2, pp 199. (2002).

[5] Kobayashi Y. and I. Towhata, Three dimensional analysis on lateral flow of liquefied ground and its mitigation. Int. J. of Comp. fluid dynamics, Vol. 19, No. 1, pp 93-100. (2005).

[6] Krishna D. V., G. Kathayani and C. Sankaraih, Unsteady hydro magnetic generalized coquette flow of a couple stress fluids. Acta ciencia Indica, Vol. XXXIV M, No. 4, pp 1965. (2008).

[7] Krishna D. V., Prasada D. R. V. and M. Ravindra, Magneto hydro dynamic connection flow through a porous medium with traveling thermal waves. Acta ciencia Indica, XXVIII 3, pp 403. (2002).

[8] Krishna D. V., D.R.V. Prasada Rao and M. Ravindra, Hydro magnetic Channel flow through Porous medium with prescribed discharge. Acta Ciencia Indica, Vol. XXVIII Vol. 4, pp 615-624. (2002).

[9] Kumar A. and K. K. Singh, A numerical steady of hydro magnetic flow of rivlin- ericksen fluid down an inclined porous plates. Acta ciencia Indica, Vol. XXXIV M, No. 4, pp 1617. (2008).

[10] Kumar A. and K. K. Singh, A steady of hydro magnetic flow of rivlin-ericksen fluid through porous medium between the inclined parallel plates. Acta ciencia Indica, Vol. XXXIV M, No. 4, pp 1585. (2008).

[11] Kumar A. and K. K. Singh, Effects of magnetic field on the motion under gravity of a viscous fluid down between two inclined parallel flat plates. Acta ciencia Indica, Vol. XXXIV M, No. 4, pp 1573. (2008).

[12] Kumari M. and G. Nath, Development of 2–dimensional boundary layer due to an impulsive motion. Indian J Pure and appl. math.,Vol. 20, pp 695–708. (1999).

[13] Sharma A. S., Singh M. P & Chandramouli A. B., Steady Laminar Generalized Plane Coquette Flow between Two parallel Plates through Porous Medium.Int. J. of Acta ciencia Indica Vol.XXXVIII M, No.1, pp 183-188. (2012).

[14] Sharma A. S., Singh M. P & Chandramouli A. B., Steady Laminar Generalized Plane Coquette Flow between Two parallel Plates under the Influence of Uniform Transverse Magnetic Field.Int. J. of Acta ciencia Indica Vol.XXXVIII M, No.2, pp 189-194. (2012).

[15] Sharma A. S., Singh M. P & Chandramouli A. B., Steady Laminar Generalized Plane Coquette Flow between Two parallel Plates through Porous Medium. Int. J. of Acta ciencia Indica Vol.XXXVIII M, No.2, pp 317-322. (2012).