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EFFECT OF HEAT AND MASS TRANSFER ON UNSTEADY MHD FLOW OF RIVLIN-ERICKSEN FLUID OVER AN INCLINED CHANNEL WITH TWO PARALLEL FLAT PLATES MOVING WITH OSCILATORY MOTION WHILE ONE PLATE IS ADIABATIC

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Abstract: The unsteady magneto-hydrodynamic movement of the visco-elastic fluid (Rivlin-Ericksen) through an inclined channel with two parallel flat plates rotating with oscillatory motion under the influence of a magnetic field with heat and mass transfer, like heat generation or heat absorbing sinks, when one of these two plates is adiabatic. Perturbation method is applied to obtain the expression for the velocity,temperature and concentration distribution in oscillatory motion. The impacts of flow parameter on velocity, temperature and concentration distribution is deliberated with the assistance of graphs.

Key words: Rivlin-Ericksen fluid, Oscillatory flow, Perturbation method, inclined channel, adiabatic.

I. Introduction:

Unsteady flow of non-Newtonian fluids, which is of dynamic awareness, has like investigated by few researchers & scientists. From literary works, the non-Newtonian fluids are mainly classified based on their conduct in shear. A fluid with a linear connection between the shear stress & shear rate, giving rise to endless viscosity is permanently characterized to Newtonian fluid. Constructed knowledge of resolutions to Newtonian fluid, the various fluids can be stretched, like Maxwell fluid, Voigt fluid, Oldroyd-B fluid, Rivlin - Ericksen fluid or power-law fluid. The phenomenon of heat & mass transference MHD oscillatory flow of a visco-elastic fluid between two inclined plates has acknowledged great attention because of its wide applications in many engineering fields such as chemical process industries, food preservation, petroleum production, electro-static precipitation, polymer technology and power engineering.

Based on the analysis, we recommend to the 2ndimperative Rivlin-Ericken fluid, or so called 2nd grade fluid. Bhattacharjee et.al[2] presented A notice of Heat transfer between two porous plates in a hydro-magnetic stream,except oneremains zero, under continuous suction while the down plates are adiabatic.Unsteady MHD convective flow of Rivlin-ericksen fluid over an infinite vertical porous plate with absorption effect and variable suction was studied by BV Sankar et.al[3].Chakraborty and Borkakati[4] analyzed the inclined channel taking Rivlin-Eriksen second order fluids ,heat transfer and MHD flow through porous medium.G. Bodosa and Borkakati[5] discussed the impacts of the source and sink of MHD flow and heat transfer with Rivlin –Eriksen fluid through an inclined channel on the inclined one plate is adiabatic. The influence of the heat source and an oscillatory free stream on the continuously moving porous moving horizontal surface with an unsteady MHD flow and heat transfer was investigated by Sharma et.al[6].Makinde and Mhone, [7] studied on Heat transfer to MHD oscillatory flow in a channel filled with porous medium. Sharma RC and chand[8] deliberated Hall effects on thermal instability of Rivlin–Ericksen fluid.Hydromagneticsfree convective Rivlin–Ericksen flow through a porous medium with variable permeability was investigated by Humer et.al[9].Sekhar and Reddy[10] studied an effects of chemical reaction on MHD free convective oscillatory flow past a porous plate with viscous dissipation and heat sink.Reddy et.al[11] investigated an MHD &oscillatory flow of Rivlin-Ericksen fluid over an disposed channel.Heat transfer to MHD oscillatory dusty visco-elastic fluid Flow in an inclined channel filled with a porous mediumwas presented by Das[12].Hamza et.al[13]studied an unsteady heat transfer to MHD oscillatory flow through a porous

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medium under slip condition.Sravanthi and Gorla[14] discussed the Radiation absorption and chemical reaction effects on rivlin-ericksen flow past a vertical moving porous plate" International Journal of Applied Mechanics and Engineering, (2019), 24(3),pp.675-689.Nidhish Kumar Mishra[15] investigates an influence of Rivlin-Ericksen fluid on MHD fluctuating flow with heat and mass transfer through a porous medium bounded by a porous plate.Ravi Kumar et.al[16] discussed the Combined effects of heat absorption and MHD on convective Rivlin-Erickese flow past a semi-infinite vertical plate with variable temperature and suction.

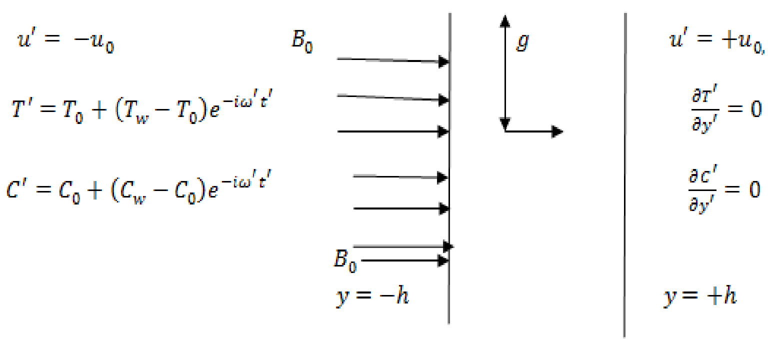
II. MATHEMATICAL FORMULATION:

Consider electrically incompressible 2-D displaying visco -elastic fluid movement in oscillatory gesture over motivated channel among two similarflat plates that remain 2h apart at a distance under the impact of a constant transverse magnetic field. Imagine x′-axis beside a straight-line mid-way among the two plates, y′–axis normal to it. It is predicted that a magnetic field with constantintensity B0 would be useful in the direction with y.Let's the velocity u' end component to end the pathof the x "– axis & the velocity's additional factors are zero.

Fig.1 **Model**

Principalcalculationsof the subsequent circumstances are measured:

(i). The platesparticularlyextended, so that the fluid velocity u′ is the function of y′& t′ only.



(ii). The temperature is constant within the fluid elements&the resistance force is measured in the equation of gesture of the fluid. The flow among the plates are fully developed.

(iv).The fluid conductivity calculated to be very minimal,such that the magnetic field produced is overlooked

(v). The Hall effect & viscous dissipation are expected to be abandoned.

(vi). Simply electro-magnetic body force (Lorenzforce) is measured.

(vii). Initially i.e., the plates & the fluid is at rest temperature at time $t = 0$& there is no flow within the channel. At time t>0 the temperature of the plate y= +h fluctuations to $\frac{\partial T}{\partial y} = 0$, and the temperature of the plate y = -h fluctuationscorresponding to $T = T_0 (T_w - T_o) e^{-i\omega t}$, where T_w and T_o are temperature of the plates.

(viii) The attention at the platey= +h modifications $\frac{\partial C}{\partial y} = 0$, at the time t>0 & concentration at the plate y = -h modificationsconsequently to$C' = C_0 + (C_w - C_0)e^{-i\omega t}$, where Cw and Co are concentration at the plates & ω ≥ 0 and a real no's, representing decline factor.

Under givenrules, the principal Eq's. of stability, motion,energy & concentration for the unstable flow of viscoelastic in-compressible electricallydirecting fluid b/w two nonconducting similar plates in the occurrence of attractive fields are

$$\frac{\partial u'}{\partial x'} = 0 \qquad (1)$$

$$\frac{\partial u'}{\partial t'} = -\frac{1}{\rho}\frac{\partial p'}{\partial x'} + \nu\frac{\partial^2 u'}{\partial y'^2} + \frac{k_0}{\rho}\frac{\partial^3 u'}{\partial t' \partial y'^2} - \sigma\frac{B_0{}^2}{\rho}u' + g\sin\theta + g\beta(T' - T_0) + g\beta^*(C' - C_0) \qquad (2)$$

$$\frac{\partial T'}{\partial t'} = \frac{k}{\rho c_p}\frac{\partial^2 T'}{\partial y'^2} + S'(T' - T_0) \qquad (3)$$

$\frac{\partial C'}{\partial t'} = D\ \frac{\partial^2 C'}{\partial y'^2} - K_r(C' - C_0)$ (4)

The limitcircumstancesare specified as

$$\left.\begin{array}{l} t' > 0 u' = -u_0,\ T' = T_0 + (T_w - T_0)e^{-i\omega' t'}, C' = C_0 + (C_w - C_0)e^{-i\omega' t'}\ at\ y = -h \\ \qquad u' = +u_{0,} \frac{\partial T'}{\partial y'} = 0,\ \ \frac{\partial C'}{\partial y'} = 0 \quad at\ y = +h \end{array}\right\} (5)$$

So as Advantages of the Eq., consider the non-dimensionlessconstraints as specifiedas

$$\left.\begin{array}{l} S = \frac{S'\nu}{{u_0}^2},, p = \frac{p'}{\rho {u_0}^2},\ \ Fr = \frac{{u_0}^2}{gh}, K_1 = \frac{K_r \nu}{{u_0}^2}, Re = \frac{u_0 h}{\nu},\ \ \frac{h u_0}{\nu} = 1, C = \frac{C' - C_0}{C_w - C_0}, \\ \qquad Rc = \frac{k_0 {u_0}^2}{\rho \nu^2}, Sc = \frac{\mu}{\rho D}, Gr = \frac{\upsilon g \beta (T_w - T_0)}{u_0^3}, Gm = \frac{\upsilon g \beta^* (C_w - C_0)}{u_0^3} \end{array}\right\} \quad (6)$$

where ρ is density of the fluid, B_0 constant magnetic field usefulacross tothe plate,σ is fluid electrical conductivity ,quantity of kinematics viscosity υ, Gr Grashof number,exact fluid of the heat $c_{p,}$ constant of thermal extensionβ, Solutal expansion coefficient β^*, pressure p, factor of resistance k_0 , coefficient of viscosity η_0, the source or sink term S, g acceleration due to gravity, Kr, rate of chemical reaction ,D, chemical molecular diffusivity, M, magnetic parameter, Pr, Prandtl number, Fr, Froude's number, Re is Reynold's number,$Rc_,$ elastic parameter , Sc, Schmidt number , K_1, chemical reaction parameter, Gm, Solutal Grashof number.

Substituting the dimensionslessfactors in equations (1), (2), (3) and (4) we get,

$$\frac{\partial u}{\partial x} = 0 \quad (7)$$

$$\frac{\partial u}{\partial t} = -\frac{\partial p}{\partial x} + \frac{\partial^2 u}{\partial y^2} + Rc\frac{\partial^3 u}{\partial t \partial y^2} - Mu + \frac{\sin\theta}{FrRe} + GrT + GmC \quad (8)$$

$$\frac{\partial T}{\partial t} = \frac{1}{Pr}\frac{\partial^2 T}{\partial y^2} + ST \quad (9)$$

$$\frac{\partial C}{\partial t} = \frac{1}{Sc}\frac{\partial^2 C}{\partial y^2} - K_1 C \quad (10)$$

The boundary conditions of the problem in non-dimensional form are

$$\left.\begin{array}{l} t > 0;\ \ u = -1, T = e^{-i\omega t}, C = e^{-i\omega t}\ at\ y = -1 \\ \qquad u = 1,\ \ \frac{\partial T}{\partial y} = 0, \frac{\partial C}{\partial y} = 0\ at\ y = 1 \end{array}\right\}$$

(11)Similarly eq. (8) shown velocity u is liberated of x &, hence.

Letus$\frac{\partial p}{\partial x} = -h(t)$ (12)

Then eq. (8) becomes

$$\frac{\partial u}{\partial t} = h(t) + \frac{\partial^2 u}{\partial y^2} + Rc\frac{\partial^3 u}{\partial t \partial y^2} - Mu + \frac{\sin\theta}{FrRe} + GrT + GmC \quad (13)$$

Solutions of the equations:

Appropriate to resolve the Eq's (9),(10) & (13) under the conditions (11), consider$u = f(y)e^{-i\omega t}$, $T = g(y)e^{-i\omega t}$, $h = h_0 e^{-i\omega t}$, $C = l(y)e^{-i\omega t}$ (14)

The corresponding boundary conditions are

$$\left.\begin{array}{l} t > 0\ ;\ at\ y = -1, f(-1) = -e^{i\omega t}, g(-1) = 1, l(-1) = 1 \\ \qquad at\ y = +1, f(+1) = e^{i\omega t}, g'(+1) = 0, l'(+1) = 0 \end{array}\right\} (15)$$

Substituting (14) in equations (9),(10) and (13), we get

$$(1 - i\omega Rc)\frac{\partial^2 f}{\partial y^2} - (M - i\omega)f = -h_0 - \frac{\sin\theta}{FrRe}e^{i\omega t} - Grg - Gml \quad (16)$$

$$\frac{\partial^2 g}{\partial y^2} + Pr(S + i\omega)g = 0 \quad (17)$$

$\frac{\partial^2 l}{\partial y^2} - Sc(K - i\omega)l = 0$(18) Solving above (16),(17) & (18) Eq's under the conditions (15), we get

$$f(y)=\begin{Bmatrix}\frac{-\cos\omega t\cosh d_1y}{\sinh d_1}+\frac{h_0\sinh d_1y}{M\sinh d_1}+\frac{e_1}{2\sinh d_1}\left(\frac{e^{d_1y}}{\cos 2a_1}-e^{d_1y}\right)\\ -\frac{f_1}{2\sinh d_1}\left[\frac{e^{d_1y}-(\cosh 2b_1)e^{-d_1y}}{2\cos 2b_1}\right]+\frac{e_1\cos[a_1(1-y)]}{\cos 2a_1}-\frac{f_1\cosh[b_1(1-y)]}{2\cos 2b_1}+\frac{j_1\cos\omega t}{M}\end{Bmatrix}+i\left\{\frac{j_1\sin\omega t\cosh l_1y}{2\omega\cosh l_1}+\frac{\sin\omega t\sinh l_1y}{2\sinh l_1}-\frac{j_1\sin\omega t}{\omega}\right\}(19)$$

$$u_{RP}=\left\{\frac{-\cos\omega t\cosh d_1y}{\sinh d_1}+\frac{h_0\sinh d_1y}{M\sinh d_1}+\frac{e_1}{2\sinh d_1}\left(\frac{e^{d_1y}}{\cos 2a_1}-e^{d_1y}\right)-\frac{f_1}{2\sinh d_1}\left[\frac{e^{d_1y}-(\cosh 2b_1)e^{-d_1y}}{2\cos 2b_1}\right]+\frac{e_1\cos[a_1(1-y)]}{\cos 2a_1}-\frac{f_1\cosh[b_1(1-y)]}{2\cos 2b_1}+\frac{j_1\cos\omega t}{M}\right\}\cos\omega t+\left\{\frac{j_1\sin\omega t\cosh l_1y}{2\omega\cosh l_1}+\frac{\sin\omega t\sinh l_1y}{2\sinh l_1}-\frac{j_1\sin\omega t}{\omega}\right\}\sin\omega t\ (20)$$

$$u_{IP}=\left\{\frac{\cos\omega t\cosh d_1y}{\sinh d_1}-\frac{h_0\sinh d_1y}{M\sinh d_1}-\frac{e_1}{2\sinh d_1}\left(\frac{e^{d_1y}}{\cos 2a_1}-e^{d_1y}\right)+\frac{f_1}{2\sinh d_1}\left[\frac{e^{d_1y}-(\cosh 2b_1)e^{-d_1y}}{2\cos 2b_1}\right]-\frac{e_1\cos[a_1(1-y)]}{\cos 2a_1}+\frac{f_1\cosh[b_1(1-y)]}{2\cos 2b_1}-\frac{j_1\cos\omega t}{M}\right\}\sin\omega t+\left\{\frac{j_1\sin\omega t\cosh l_1y}{2\omega\cosh l_1}+\frac{\sin\omega t\sinh l_1y}{2\sinh l_1}-\frac{j_1\sin\omega t}{\omega}\right\}\cos\omega t(21)$$

Here $u=u_{RP}+iu_{IP}$,$|u|=\sqrt{u_{RP}{}^2+u_{IP}{}^2}$, $g(y)=\frac{\cos[a_1(1-y)]}{\cos 2a_1}$, $T_{RP}=\frac{\cos[a_1(1-y)]\cos\omega t}{\cos 2a_1}$, $T_{IP}=\frac{-\cos[a_1(1-y)]\sin\omega t}{\cos 2a_1}$,$T=T_{RP}+iT_{IP}$$|T|=\sqrt{T_{RP}{}^2+T_{IP}{}^2}$,$l(y)=\frac{\cosh[b_1(1-y)]}{\cosh 2b_1}$ $C_{RP}=\frac{\cosh[b_1(1-y)]\cos\omega t}{\cosh 2b_1}$ $C_{IP}=\frac{-\cosh[b_1(1-y)]\sin\omega t}{\cosh 2b_1}$, $|C|=\sqrt{C_{RP}{}^2+C_{IP}{}^2}$

Where$a_1=\sqrt{PrS}$,$b_1=\sqrt{K_1Sc}$, $d_1=\sqrt{M}$, $e_1=\frac{Gr}{a_1{}^2+M}$, $f_1=\frac{Gm}{b_1{}^2-M}$, $j_1=\frac{\sin\theta}{FrRe}$,$l_1=\sqrt{\frac{1}{Rc}}$

III. Results and discussion:

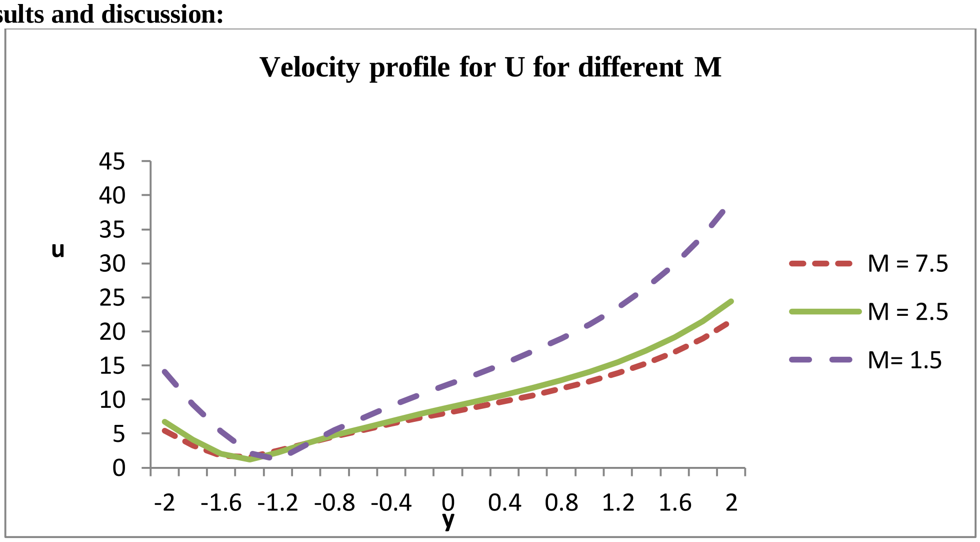


Fig.2:Mv/s Velocity

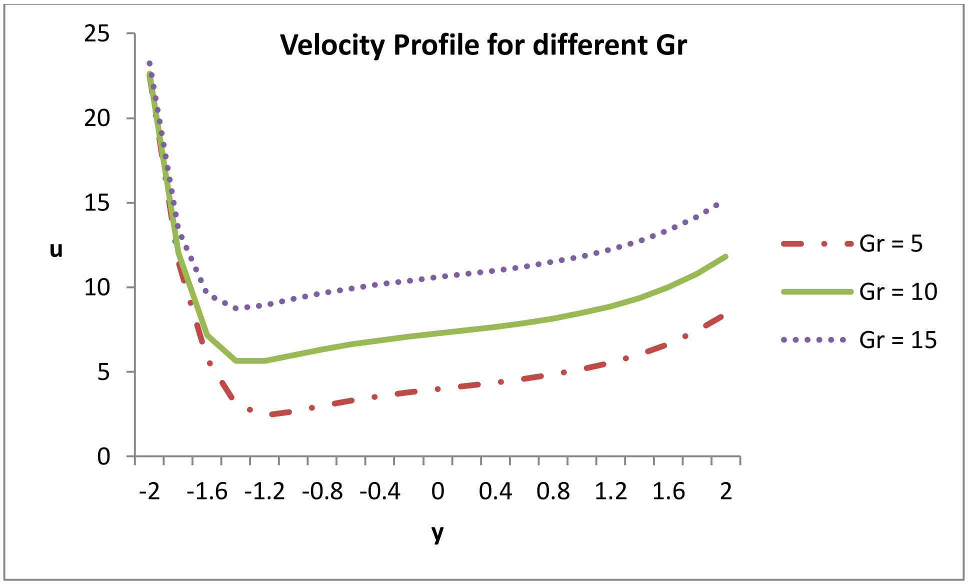


Fig. 3:Grv/s Velocity

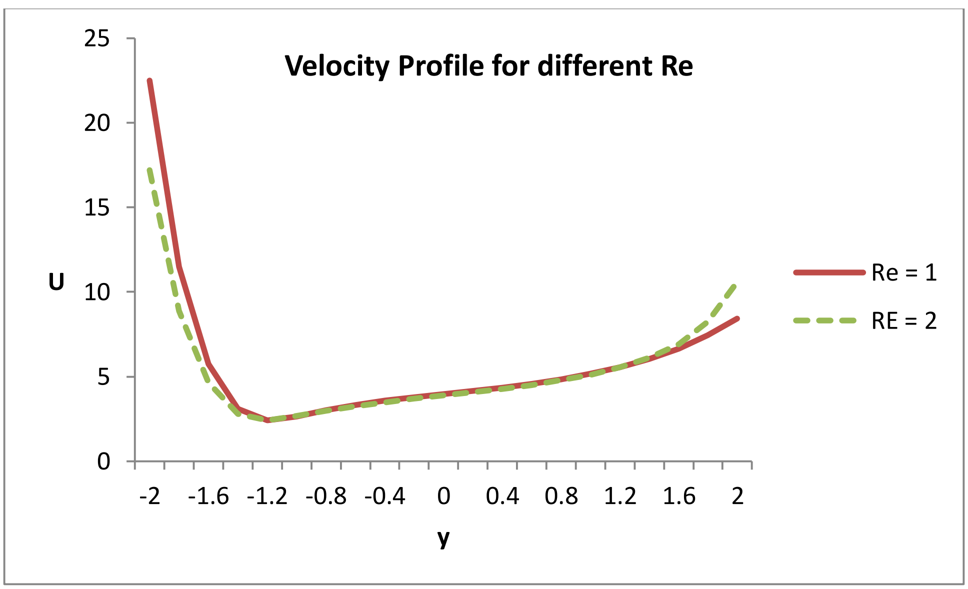


Fig. 4:Rev/s Velocity

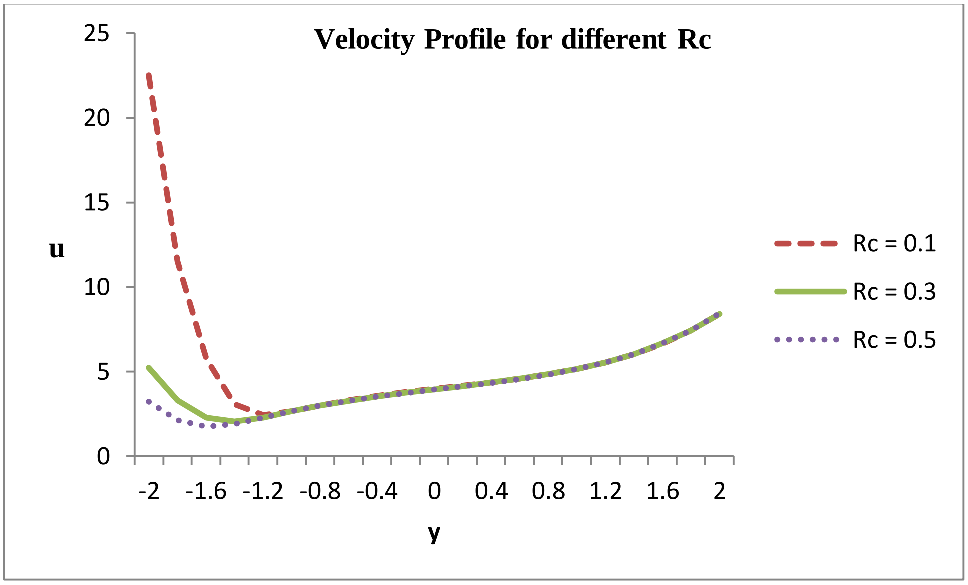


Fig.5:Rcv/s Velocity

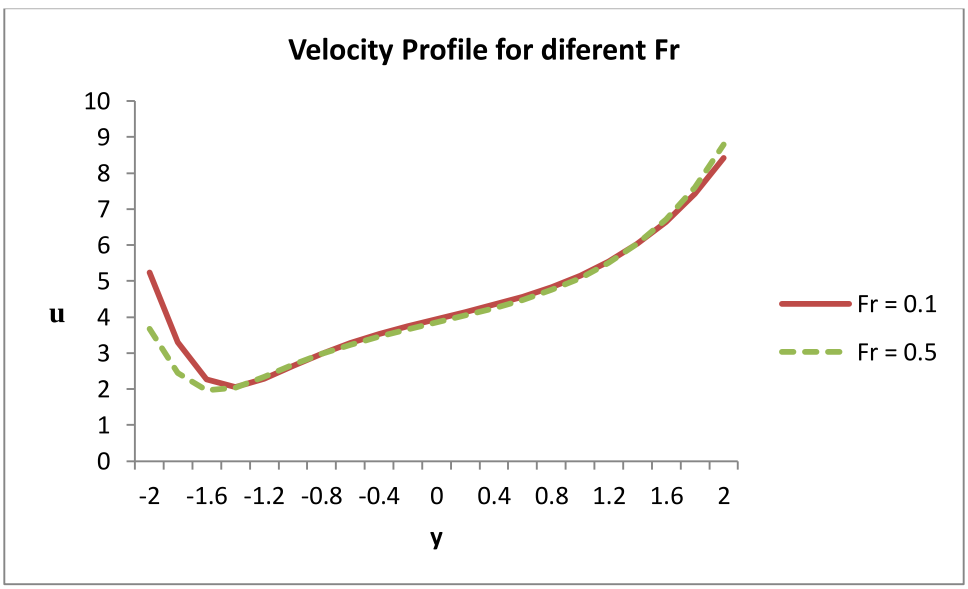


Fig. 6:Frv/s Velocity

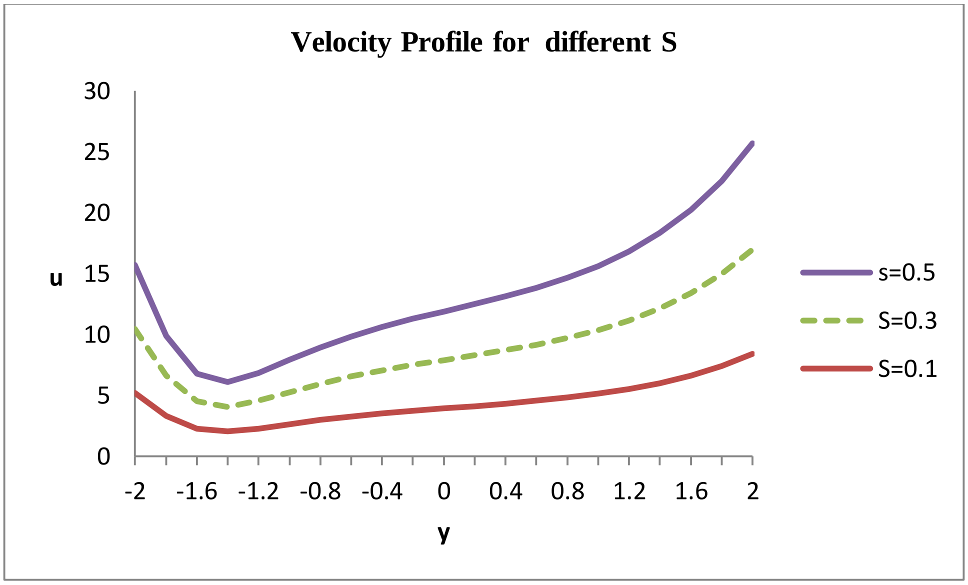


Fig. 7:Sv/s Velocity

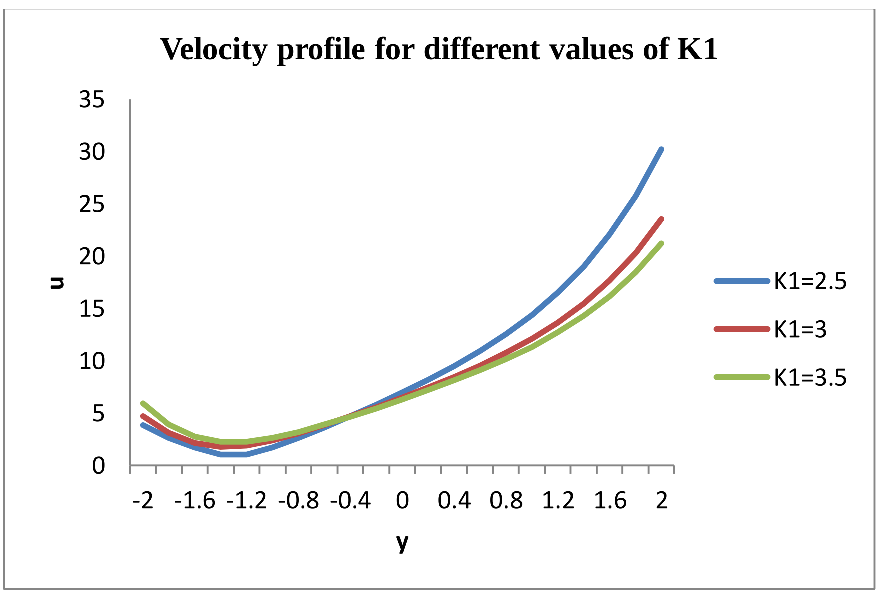


Fig.8:K1v/s Velocity

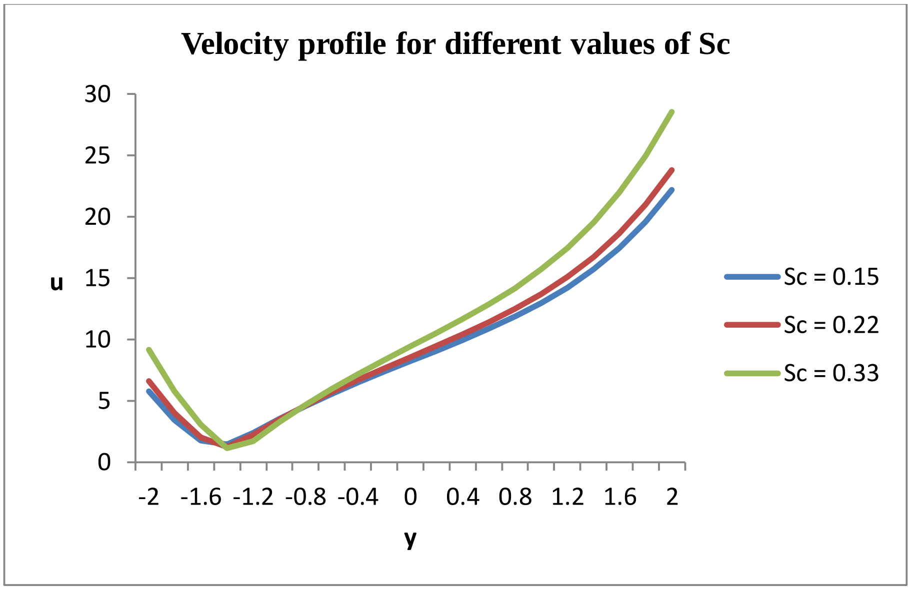


Fig.9:Scv/s Velocity

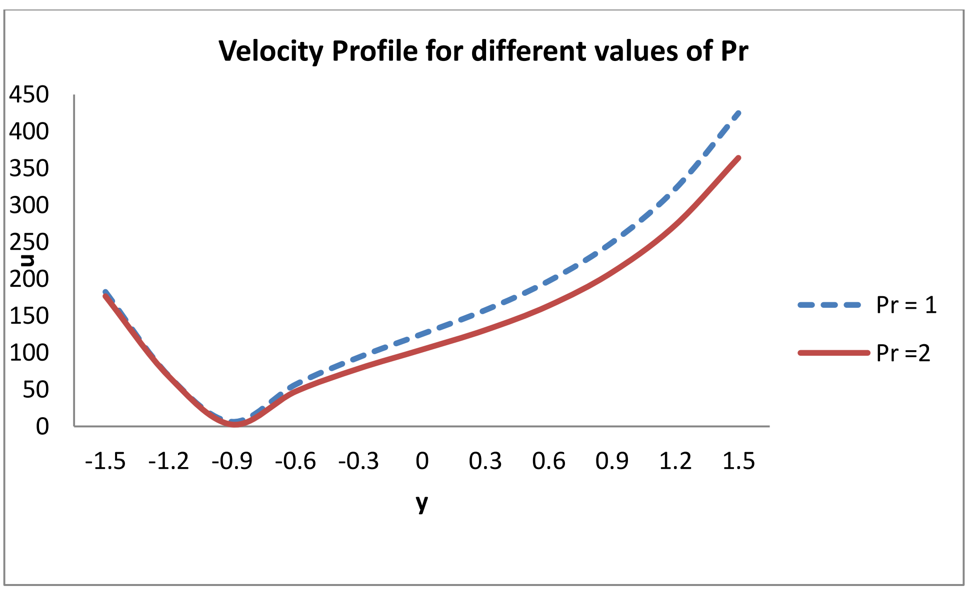


Fig. 10:Prv/s Velocity

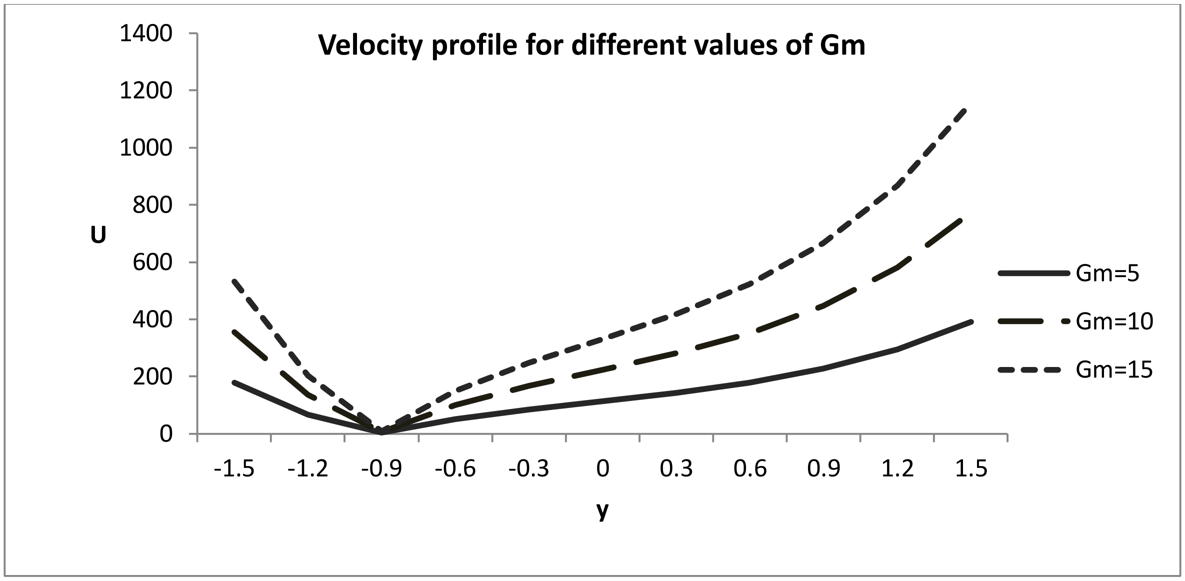


Fig. 11: Gmv/s Velocity

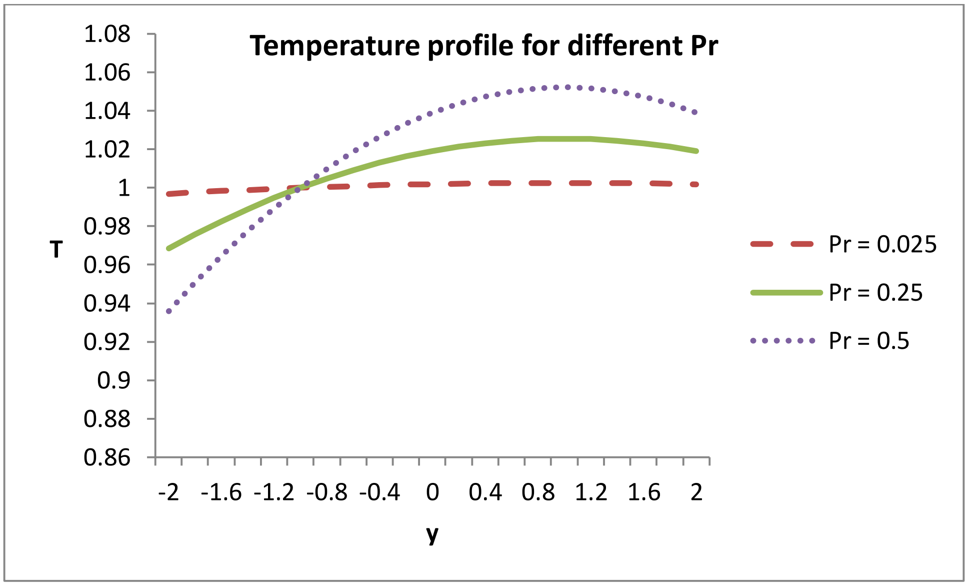


Fig. 12: Pr v/s Temparature

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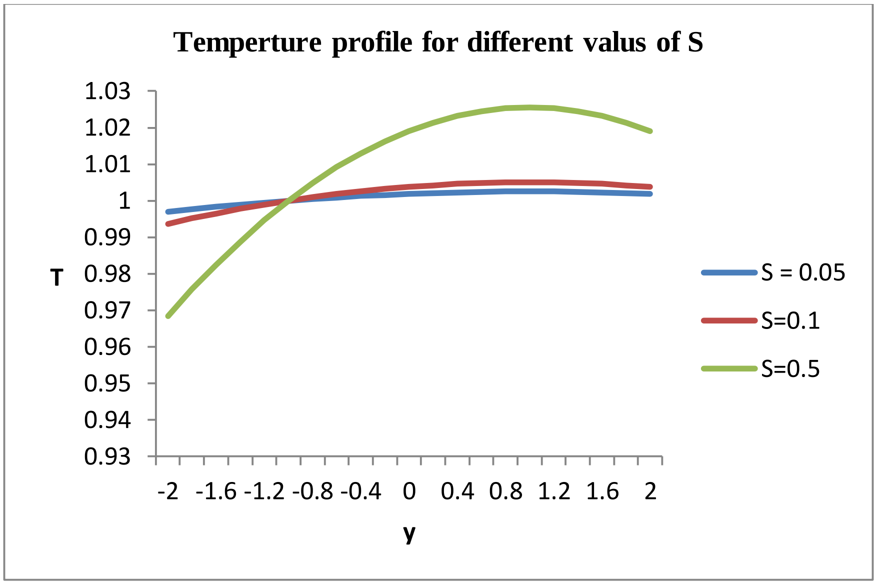

Fig. 13: S v/s Temperature

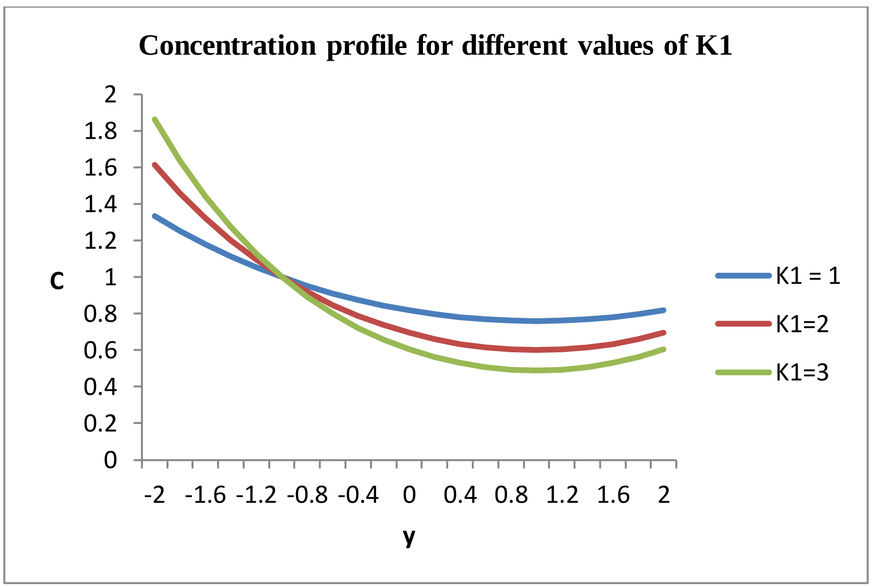

Fig. 14 : K1 v/s Temparature

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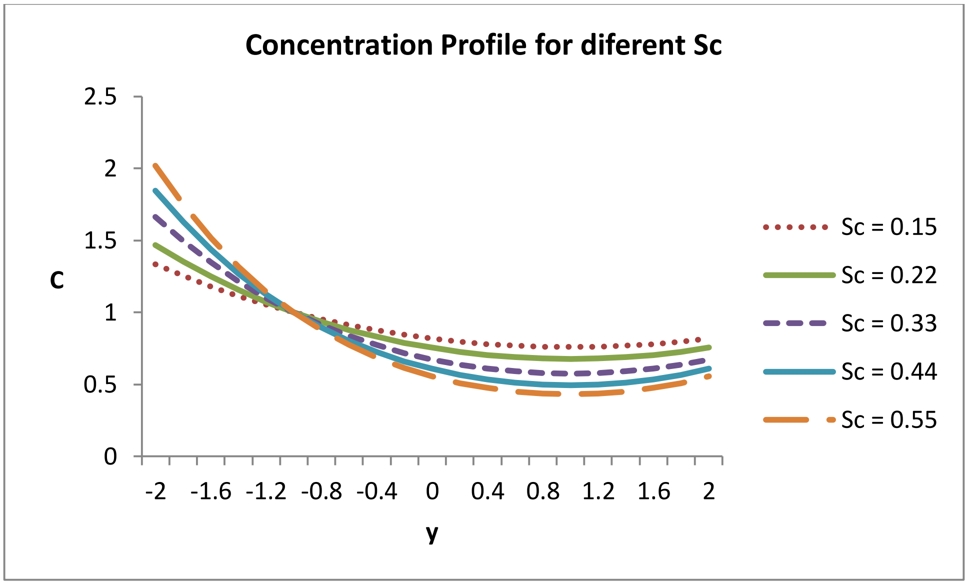

Fig. 15:Sc v/s Concentration

IV. RESULTS AND DISCUSSI0N

In this section the role of the flow parameters is very important. The outcomes of the velocity, temperature and concentration profiles are presented through graphs with the help of the various values of the flow parameter ,viz., M=1.5,$Pr = 0.5, S = 0.5, Rc = 0.3, Fr = 3.0, h_0 = 1, , Re = 1.0, \omega = 7.2, t = 1.0, Gr = 5.0\ Gm = 5.0, Sc = 0.6, K1 = 1.0\ and\ \theta = 30^0$. The variations ara as :

Velocity profile for different values of magnetic parameter M.

The velocity profile for various values of Magnetic parameter is plotted among the variable y in figure 2. The velocity profile escalationsdecrease of Magnetic parameter Mdue to theLorentz force.

Velocity curves for multiple values of Grashof number Gr:

The influence of the Grashof number on the velocity profile is presented in figure 3. With an increase of Gr the result in velocity increases.

Reynold's number Reimpact on velocity profile.

Velocity differences is drawn among y for different Revalues in figure 4. The velocity distribution isattained by drawing the graph nearby the variable y for different numbers of Re. The velocity profile increases with the decrease in Reynolds number nearby the non-adiabatic plate $y = -2$ and enhances with the increase in Reynolds number near the adiabatic plate $y = 2$.

Velocity profile for different values of Elastic parameter Rc.

The velocity profile for different values of Elastic parameter Rc is plotted among the variable y in figure 5. This is shown velocity profile reduces considerably between the plates $y = -2$&$y = -1.2$& improvessignificantly from the plate $y = -1.2$. The velocity increases automatically reduce in Rc in oscillatory motion near the non-adiabatic plate $y = -2$, whereas the velocity profile is almost same near the adiabatic plate $y = 2$.

For the change values of Froude's numberFr versus Velocity curves.

For changed values of Fr number impact on the velocity is depicted in figure 6. It is found from the figure that the velocity increases with the decrease in Frnear the plate $y = -2$. It is observed that the velocity is almost same for $Fr = 0.1$ and $Fr = 0.5$ near the adiabatic plate $y = 2$.

Influence of the source/sink(S) on the velocity profile.

The impact of the varied values of source and sink on the velocity profile is depicted against the variable y in figure 7. Clearly, Itcan be seen that the parameter S increases while the velocity increases.

For varied values of Chemical reaction parameter$K1$ effect is show on velocity profile.

Velocity profile for different values of $K1$ parameter is drawn against the y in figure 8. It is noticed that velocity profile increases with the increase in chemical reaction parameter near the non-adiabatic plate while velocity profile decreases with the increase in chemical reaction parameter near the adiabatic plate.

Velocity profile for changed values ofSchmidt numberSc:

The influence of the various values of Schmidt number Sc on velocity distribution is depicted in the figure 9. Clearly, it can be seen that with an increase of Sc the velocity curves are increases.

Influence of the Prandtl number Pr onVelocity profile

The impact of the several values of Pr against the velocity curves is represent in figure 11. It is found that the fluid velocity decrease with an increase of Pr values.
Physically this is true because the increase in the Pr number in the viscosity ofthe fluid, that makes the fluid thick & hence reduce in the velocity of the fluid.

Velocity profile for different values of solutal Grashof number Gm:

In figure 10, the velocity profile for the impact of various values of solutal Grash number Gm is illustrated against the vector y. It is noticed that velocity profile increases with the increase in Gm.It is possible because an increase in Gm has the tendency to increase the mass buoyancy forces.

Prandtl number Pr v/s.Temperature profile,

Pr v/s Temperature profile is illustrated against the variable y, in figure 12. With the increase in Prandtl number, the thermal conduction in the flow field is lowered and the viscosity of the flowing fluid becomes higher. Consequently, the molecular motion of the fluid elements is lowered down and therefore, the flow field suffers a decrease in temperature near the plate $y = -2$ and itannouncement that the temperature ascends with the expansion in Pr in oscillatory movement close to the adiabatic plate y= 2.

For various values of sink/source (S) on temperature profile.

The various values of source of sink term S is plotted against the variable y in figure 13. It is observed that the enhanced in S temperature increases in oscillatory movement.

Concentration profile for different values of Chemical reaction parameter $K1$.

Concentration profile for different values of Chemical reaction parameter $K1$is plotted against the variable y in figure 14. It is observed that concentration of the fluid decreases with the increase in chemical reaction parameter K1 near the adiabatic plate $y = 2$.

Concentration profile for different values ofSchmidt numberSc.

Concentration profile for various values of Schmidt numberSc is illustrated against the variable y in figure 15. It is reported concentration of the fluid decreases with the increase in Schmidt number Sc near the adiabatic plate $y = 2$.

V. References

1. Schlichting, H. Boundary-layer theory. McGraw-Hill publication, sixth edition. (1968) p.1-72.
2. Bhattacharjee. A and Borkakati, A. K. “A note in heat transfer in a hydro magnetic flow between two porous disks one rotating and the other at rest, under uniform suction, when the lower plate is adiabatic. Bulletin of Calcutta mathematical society (1984).76; p.209-215.

3. B.Veera Sankar and B.Rama Bhupal Reddy "Unsteady MHD convective flow of Rivlin-ericksen fluid over an infinite vertical porous plate with absorption effect and variable suction", Int. J. of Applied Engineering Research ISSN 0973-4562 Volume 14, Number 1 (2019) pp. 284-295.
4. Chakraborty S. and Borkakati A. K. "MHD flow and heat transfer of dusty Rivlin-Eriksen second order fluids in an inclined channel in porous medium". Ganita,(1998), 49(2),173.
5. G. Bodosa and A. K. Borkakati MHD flow and heat transfer of Rivlin –Eriksen fluid through an inclined channel, with heat sources or sinks when the plates are moving with transient velocity while the one of these two plates is adiabatic. Bulletin of pure and applied sciences (2002),21E(2) p.451-460.
6. P. R. Sharma, Y. N. Gaur and R. P. Sharma "Unsteady MHD flow and heat transfer over a continuous porous moving horizontal surface in the presence of an oscillating free stream and heat source". Journal of Indian Acad. Mathematics (2004) 26(1) p. 105-114.
7. O. D. Makinde, P. Y. Mhone, Heat transfer to MHD oscillatory flow in a channel filled with porous medium, Rom. Journ. Phys., 50 (2005) , pp.931–938.
8. Sharma RC, Sunil Suresh chand. "Hall effects on thermal instability of Rivlin–Ericksen fluid". Indian J Pure Appl Math, (2000),3(1), pp49-59.
9. Humera N., Ramana Murthy M.V., Reddy C.K., Rafiuddin M., Ramu A. and Rajender S. "Hydromagneticsfree convective Rivlin–Ericksen flow through a porous medium with variable permeability",. Int.J. Comput. Appl. Math., (2010), 5(3), pp.267-75.
10. Sekhar, D. V., and Reddy, G. V., , "Effects of chemical reaction on MHD free convective oscillatory flow past a porous plate with viscous dissipation and heat sink," Advances in Appl. Science Research, (2012) 3 (5), pp. 3206–3215.
11. P. R. Reddy, A. Neelima, K. RamaRao and S. Thiagarajan "MHD and oscillatory flow of Rivlin-Ericksen fluid through an inclined channel". Journal of Energy, Heat and Mass Transfer 35(2013) p.149-163.
12. U.J. DAS "Heat transfer to MHD oscillatory dusty visco-elastic fluid Flow in an inclined channel filled with a porous medium", Latin American Applied Research,(2017), 47,pp.145-150.
13. Hamza, M. M., Isah, B. Y., and Usman, H., "Unsteady heat transfer to MHD oscillatory flow through a porous medium under slip condition," Int. J. Computer Appl.,(2011),33(4),pp.12-17.
14. C.S. Sravanthi and R.S.R. Gorla "Radiation Absorption and Chemical Reaction Effects on Rivlin-Ericksen Flow Past a Vertical Moving Porous Plate" International Journal of Applied Mechanics and Engineering, (2019), 24(3),pp.675-689.
15. Nidhish Kumar Mishra.," Effect of Rivlin-Ericksen fluid on MHD fluctuating flow with heat and mass transfer through a porous medium bounded by a porous plate", International Journal of Mathematics Research,8(3) (2016), pp. 143-154.
16. Ravi Kumar V., Raju M.C. and Raju G.S.S." Combined effects of heat absorption and MHD on convective Rivlin-Erickese flow past a semi-infinite vertical plate with variable temperature and suction", Ain ShamsEngineering Journal, (2014), 5(3), pp.867-875.