Volume: 1, Issue: 1
Page: 81- 122
2019

Euro Afro Studies International Journal®
(EASIJ.COM)

ISSN

Time Dependent MHD Natural Convection flow of a Heat Generating/Absorbing Fluid near a Vertical Porous Plate with Ramped Boundary Conditions

Author(s), KHADIJAH. K. LAWAL and HARUNA. M. JIBRIL

Abstract:

In this work, the unsteady free convection flow of a viscous, incompressible and electrically conducting fluid near a vertical porous plate with ramped temperature and ramped motion in the presence of uniform transverse magnetic field is studied. A unified closed form analytic solution has been obtained for the velocity field and skin friction coefficient corresponding to the case of a magnetic field fixed relative to the fluid or the porous plate. It is assumed that the bounding plate has ramped temperature profile and ramped motion subject to a uniform transverse magnetic field under the assumption of negligible induced magnetic field. Laplace transform technique has been used to find the solutions of the velocity and temperature in Laplace domain. While, the closed form semi-analytical solution has been obtained using the Riemann-sum approximation method. The effect of the flow parameters such as the Prandtl number (Pr), Hartmann number (M), Heat sink parameter (S) and Suction/Injection (q) on the fluid temperature, velocity, Nusselt Number as well as the skin friction co efficient are

EASIJ
Accepted 1 December 2019
Published 7 December 2019
DOI: 10.5281/zenodo.3566758

presented with the help of graph. It was observed that Suction/injection increases the velocity of the fluid. This is because injection increase thickens the boundary layer which eventually increases the fluid velocity while suction causes a thinning of the boundary layer which leads to the decreases in the fluid velocity.

Keywords: Ramped Temperature, Ramped Motion, Natural Convection, Magnetic field, Vertical porous plate heat generating or absorbing,

About Author

Author(s), Department of Mathematics, Faculty of Science

Ahmadu Bello University, Zaria NIGERIA, Nigeria

(Corresponding Author) Email: alharun2004@yahoo.com ; kuburatlawal@yahoo.com

1.0 Introduction

Theoretical investigations of natural convection flow past a vertical porous plate has continued to receive attention in the literature due to its industrial and technological applications. These applications include; geothermal reservoirs, drying of porous solids, chemical catalytic reactors, thermal insulators, nuclear waste repositories, heat exchanger devices, enhanced oil and gas recovery, underground energy transport to mention a few. Several authors Georgantopolus (1979), Chandran (1998), Rapis (1983), and Sachet et al (1994) in their investigations, they obtained the analytical solutions assuming that the velocity and temperature conditions at the wall are continuous and well defined. Free convection flow past a vertical plate in the presence of a transverse magnetic field is investigated by several researchers under various physical situations. Mention may be made of the research studies of Ahmed et al (2011), Aldos et al (1995) and Takhar (2003) in all these studies, effect of heat absorption by the fluid is not taken into account. However, in industrial applications, such as underground disposal of radioactive waste materials, storage of food stuffs, exothermic and/or endothermic chemical reactions, heat removal from nuclear fuel debris and dissociating fluid in packed-bed reactors e.t.c , the heat generation or absorption effect are of much significance taking into account these facts, Chamkha [3] considered steady hydro magnetic boundary layer flow over an accelerating permeable surface in the presence of thermal radiation, thermal buoyancy force and heat generating or absorption. Sahoo et al [16] investigated unsteady MHD free convection flow of viscous in compressible and electrically conducting fluid past an infinite vertical porous plate in the presence of constant suction and heat absorption it was found that the magnetic field tends to retard the fluid velocity and also it has tendency to reduce mean skin friction and mean rate of heat transfer of the conducting fluid. In all the afore mentioned studies, the analytical or numerical solution is obtained assuming conditions for velocity and temperature at the interface of the plate as uniform, continuous and well defined, however, there exist several problems of physical interest which may require non-uniform or arbitrary wall conditions taking into consideration this fact, several researchers [8, 9] investigated the problem of free convection from a vertical plate with step discontinuities. The problems of magneto-hydrodynamic flow of heat transfer in porous and nonporous media have drawn the attention of many researchers due to the significant effects of magnetic field on the boundary layer flow control and on the performance of many systems using electrically conducting fluid. In addition, this type of flow find applications in the MHD power generation, MHD pumps, flow meters and accelerators, plasma studies, nuclear reactors using liquid metal coolant and geothermal energy extraction. Sahoo and Sahoo [17] analyzed the hydro magnetic free convection and mass transfer flow past and impulsively moving vertical plate through porous medium while Jha [9] considered this problem for uniform accelerated vertical plate. In these investigations the effects of radiation is not taken into account. Free and forced convection flow with thermal radiation find numerous applications in the science and engineering viz in glass manufacturing, furnaces design, high temperature aerodynamics thermo nuclear fusion, casting levitation Cosmical flight, propulsion system, plasma physics and space craft. Keeping in view this fact Chamkha [4] studied solar radiation assisted natural convection in a uniform porous medium supported by a vertical flat plate. Takhar et al [18] investigated the effects of radiation on MHD free convection flow of a gas past a semi- infinite vertical plate. Mbeledogu and ogulu [10] discussed heat and mass transfer of an unsteady MHD natural convection flow of a rotating fluid past a vertical porous plate in the presence of radiative heat transfer. In all these investigations the analytical or numerical solution is obtained assuming the velocity and temperature conditions at the interface of the plate are continuous and well defined. Several authors investigated the problem with step discontinuities. Seth and Ansari [15] considered hydro magnetic natural convection flow past an impulsively moving vertical plate embedded in a porous medium with ramped wall temperature in the presence of thermal diffusion with heat absorption. Later, Seth et al [14] extended the work of Seth and Ansari [15] to include the effect of rotation

Jha and Jibril [8 and 9] studied the MHD flow due to ramped motion of the boundary for both porous and non-porous boundary but these analyses did not take into consideration the effects of ramped temperature. Also Jha and Ajibade studied the natural convection of heat generating or absorbing flow near a vertical plate with ramped temperature again these analyses did not take into consideration the effect of ramped motion as well as the magnetic field.

The aim of the present investigation is to consider the unsteady natural convection flow of a heat generating or heat absorbing fluid near a vertical porous plate with ramped temperature and ramped motion. MHD natural convection flow resulting from such a plate with ramped temperature profile and ramped motion of the boundary plate is of relevance in several engineering applications, especially where the initial temperature profiles assume importance in designing of electro-magnetic devices.

2.0 MATHEMATICAL ANALYSIS

The flow considers unsteady MHD natural convection flow of viscous, incompressible and electrically conducting fluid due to ramped temperature and ramped motion near a vertical porous plate.

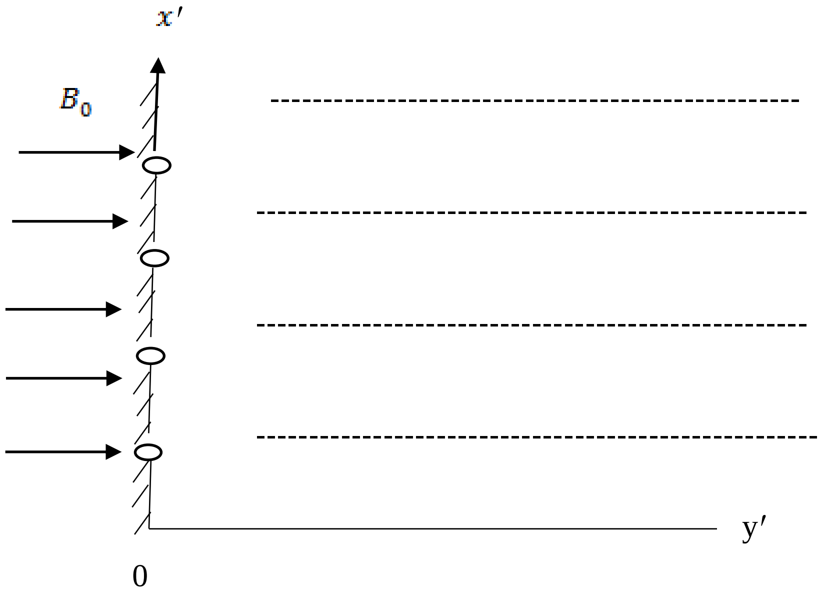


Figure 1 physical configuration

The motion of a viscous in compressible and electrically conductive fluid due to the ramped motion of an infinite vertical porous plate is considered. At time $t' \leq 0$. The fluid, the porous plate and the magnetic lines of force are assumed to be at rest. When the time is greater than zero that is $t' > 0$ the temperature of the plate is increased or decreased to $T'_\infty + \left(T'_w + T'_\infty\right)\frac{t'}{t_0}$, and it begins to move in its plane with a velocity proportional to $f\left(t'\right)$ when $t' \leq t_0$ and thereafter for $t' > t_0$ is maintained at constant temperature T'_w. A uniform magnetic field of strength B_0 applied perpendicular to the porous plate. The magnetic Reynolds's number of the flow is assumed to be small enough so that the induced magnetic field can be neglected. The flow is assumed to be in the x' direction along the porous plate and y' axis is normal to the porous plate as shown in the figure above.

The main aim here is to analyze the MHD unsteady natural convective flow of heat generating or absorbing fluid with ramped temperature and ramped motion. The flow is assumed to be laminar and therefore, the effect of the convection and pressure gradient terms in the momentum and energy equations are neglected. Also the magnetic Reynolds number of the flow is assumed to be small enough so that the induced magnetic field can be neglected. In this case the velocity and temperature are functions of the time variable t' and the space variable y' only as a result of the boundary layer approximation, the governing equations for the flow problem in dimensional form are:

$$\frac{\partial u'}{\partial t'}+\frac{\partial u'}{\partial y'}=\upsilon\frac{\partial^2 u'}{\partial y^{12}}+g\beta(T'-T'_\infty)-\frac{\sigma B_0^2 u'}{\rho}$$

(1)

$$\frac{\partial T'}{\partial t'}+\frac{\partial T'}{\partial y'}=\frac{k}{\rho cp}\frac{\partial^2 T'}{\partial y^{12}}+\frac{QT'}{\rho cp}$$

(2)

Equations (1) and (2) are valid when the magnetic lines of force are fixed relative to the fluid. If the magnetic field is also having ramp motion with the same velocity as the porous plate, the relative motion must be accounted for. In this case equation (1) is replaced by:

$$\frac{\partial u'}{\partial t'}+V_o\frac{\partial u'}{\partial y'}=\upsilon\frac{\partial^2 u'}{\partial y^{12}}+g\beta(T'-T'_\infty)-\frac{\sigma B_0^2}{\rho}\left[u'-u_0 f(t')\right]$$

(3)

This is valid when the magnetic lines of force are fixed relative to the moving porous plate. Equation (1) and (3) can be combined together to obtain:

$$\frac{\partial u'}{\partial t'}+V_o\frac{\partial u'}{\partial y'}=\upsilon\frac{\partial^2 u'}{\partial y^{12}}+g\beta(T'-T'_\infty)-\frac{\sigma B_0^2}{\rho}\left[u'-Ku_0 f(t')\right]$$

(4)

The initial and boundary conditions to be satisfied are:

$u'=0,\ T'=T'_\infty$ For $y'\geq 0$ and $t'\leq 0$

$u' = 0$ At $y' = 0$ For $t' > 0$

$T' = T'_\infty + (T'_w - T'_\infty)\dfrac{t'}{t_0}$ At $y' = 0$ and $0 < t' \le t_0$

$T' = T'_w$ At $y' = 0$ For $t' > t_0$

$u' \to 0$, $T' \to T'_\infty$ as $y' \to \infty$ For $t' > 0$

$$t' > 0 : \begin{cases} u' = f(t'),\ y' = 0 \\ u' \to 0\ \ y' \to \infty \end{cases} \tag{5}$$

$$K = \begin{cases} 0 \text{ if the magnetic field is fixed relative to the fluid} \\ 1 \text{ if the magnetic field is fixed relative to the plate} \end{cases}$$

$$f(t') = \begin{cases} \frac{t}{t_0} \text{ if } 0 \le t \le t_0 \\ 1 \text{ if } t \ge t_0 \end{cases}$$

$$f(t') = H(t)\left(\frac{t}{t_0}\right) - \left(\frac{1}{t_0}\right)(t - t_0)H(t - t_0)$$

Where $H(t)$ is the Heaviside unit step function defined by $H(t) = \begin{cases} 0, t < 0 \\ 1, t \geq 0 \end{cases}$

Non-Dimensionalization quantities

$$y = \frac{y'}{\sqrt{\upsilon t_0}}, \qquad t = \frac{t'}{t_0}, \qquad u = u'\sqrt{\frac{t_0}{\upsilon}}, \qquad T = \frac{T' - T'_\infty}{T'_W - T'_\infty}, \qquad \Pr = \frac{\rho v c p}{k},$$

$$M^2 = \frac{\sigma B_0^2 \upsilon}{\rho} \qquad q = \frac{Q_0 \upsilon t_0}{k}$$

(6)

Using equations (6) in (4) and (2), the momentum and energy equation are presented in dimensionless form as

$$\frac{\partial u}{\partial t} + q\frac{\partial u}{\partial y} = \frac{\partial^2 u}{\partial y^2} + T - M^2(u - Kf(t))$$

(7)

$$\Pr\left[\frac{\partial T}{\partial t} + q\frac{\partial T}{\partial y}\right] = \frac{\partial^2 T}{\partial y^2} - ST$$

(8)

Where

q =Suction/injection parameter , S =heat sink, u =dimensional velocity and M =magnetic parameter

In the present work $f(t)$ is specified as the ramp function

$$f(t) = \begin{cases} \frac{t}{t_0} \; if \; 0 \le t \le t_0 \\ 1 \; if \; t \ge t_0 \end{cases} \quad (9)$$

Where $f(t) = H(t)\left(\frac{t}{t_0}\right) - \left(\frac{1}{t_0}\right)(t - t_0)H(t - t_0)$

Where $H(t)$ is the Heaviside unit step function defined by $H(t) = \begin{cases} 0, t < 0 \\ 1, t \ge 0 \end{cases}$

According to the above non-dimensional process, the characteristic time t_o can be defined as

$$t_0 = \left(\frac{\nu}{g\beta\left(T'_w - T'_\infty\right)^2}\right)^{1/3} \quad (10)$$

And the boundary conditions (5) becomes

(i) $u = 0, T = 0, for \; y \ge 0 \; and \; t \le 0$

(ii) $u = 0, at \; y = 0, for \; t > 0$

(iii) $T = t, at\ y = 0\ for\ 0 < t \leq 1$

(iv) $T = 1\ at\ y = 0\ for\ t > 1$

$(v)\ u \to 0, T \to 0, as\ y \to \infty\ for\ t > 0$

$$t > 0: \begin{cases} u = f(t)\, at\ y = 0 \\ u \to 0\ as\ y \to \infty \end{cases}$$

(11)

Applying Laplace transforms technique to equation (7) and (8) with the help of (11i) we obtain

$$\frac{\partial^2 \overline{U}}{\partial y^2} - q\frac{d\overline{U}}{dY} - (P + M^2)\overline{U} = -\overline{T} - M^2 K \overline{f}(P)$$

(12)

$$\frac{\partial^2 \overline{T}}{\partial y^2} - Prq\frac{d\overline{T}}{dy} - (S + Pr)\overline{T} = 0$$

(13)

Where, $\overline{T}(Y,P) = \int_0^\infty T(y,t)e^{-pt}\,dt$, And $\overline{U}(Y,P) = \int_0^\infty T(y,t)e^{-pt}\,dt$

$P > 0$ (P being Laplace transforms parameter)

The boundary conditions (11ii) to 11(v) become

$$\overline{U} = \overline{f}(p), T' = \left(\frac{1 - e^{-P}}{P^2}\right)\ y = 0$$

$$\bar{f}(p) = \left(\frac{1 - e^{-p}}{p^2}\right)$$

$$\overline{U} \to 0, \qquad \overline{T} \to 0 \qquad y \to \infty$$

(14)

The solution of equation (12) and (13) subject to the boundary conditions (14) are given by

$$\overline{T}(y,p) = e^{\frac{Prqy}{2}} \times \frac{(1-e^{-P})}{p^2} \times e^{\frac{-Y\sqrt{pr^2q^2+4(Prp+S)}}{2}}$$

(15)

$$\overline{U}(y,P) = e^{\frac{prqy}{2}} \times \frac{1-e^{-p}}{p^2} \times e^{\frac{-Y\sqrt{q+4(P+M^2)}}{2}} + \frac{(1-e^{-P})e^{-Y\frac{Prq-\sqrt{pr^2q^2+4(prp+S)}}{2}}}{\left(\frac{Pr\lambda-\sqrt{Pr^2q^2+4(PrP+S)}}{2}\right)^2 - \lambda\frac{(Pr\lambda-\sqrt{Pr^2q^2+4(PrP+S)}}{2} - (P+M^2)} + \frac{(1-e^{-P})M^2k}{P^2[1+q+P+M^2]}$$

(16)

Equations (15) and (16) are to be inverted in order to determine the velocity solution in time domain. Since these equations are difficult to invert in closed form. We use a numerical procedure used in Jha and Apere [20] which is based on the Riemann-sum approximation. In this method, any function in the Laplace domain can be inverted to the time domain as follows.

$$U(R,t) = \frac{e^{\varepsilon t}}{t}\left[\frac{1}{2}\overline{U}(R,\varepsilon) + Re\sum_{n=1}^{M}\overline{U}\left(R,\varepsilon+\frac{in\pi}{t}\right)(-1)^n\right], 1 \le R \le \lambda \qquad (17)$$

Where Re refers to the real part of $i = \sqrt{-1}$ the imaginary number. M is the number of terms used in the Riemann-sum approximation and ε is the real part of the Bromwich contour that is used in inverting Laplace transforms. The Riemann-sum approximation for the Laplace inversion involves a single summation for the numerical process its accuracy depends on the value of ε and the truncation error dictated by M. According to Tzou [21], the value of εt that best satisfied the result is 4.7. The same numerical procedure (17) is applied on equations (18) and (19) to obtain their solutions in time domain.

2.1 NUSSELT NUMBER AND SKIN FRICTION

The expression for skin friction and Nusselt number, which are the shear stress at the plate and measures of heat transfer rate respectively, are presented in the following form.

$$\tau = \left.\frac{\partial \bar{u}}{\partial y}\right|_{y=0}$$

$$= \left(\frac{(1-e^{-p})}{P^2}\right)\frac{q}{2} - \left(\frac{\sqrt{q^2+4(P+M^2)}}{2}\right)$$

$$+ \frac{\dfrac{Prq-\sqrt{Pr^2q^2+4(PrP+S)}}{2}}{\left(\dfrac{Prq-\sqrt{Pr^2q^2+4(PrP+S)}}{2}\right)^2-(q)\left(\dfrac{(Prq-\sqrt{Pr^2q^2+4(PrP+S)}}{2}\right)-(P+M^2)}$$

(18)

$$\mathrm{Nu}_0 = -\frac{\partial \bar{T}}{\partial y}\bigg|_{y=0} = \left(\frac{(1-e^{-P})}{P^2}\right)\frac{Prq}{2} - \left(\sqrt{\frac{Pr^2 q^2 + 4(PrP+S)}{2}}\right) \tag{19}$$

3.0 RESULTS AND DISCUSSION

To investigate the effects of the various flow parameters such as the Hartman number (M), the Prandtl number (Pr), heat sink (S) and suction/injection parameter (q) on the velocity field $U(y,t)$ and temperature $T(y,t)$, suitable values of M, λ were chosen to depict the flow behavior graphically. The values of Pr were choosen to be $Pr = 0.71$ and $Pr = 7.0$ corresponding to the values for air and H_2O

Temperature profile for different values of time is presented in $\boldsymbol{Fig}$ **2** It shows that the temperature increase as time increases. **Fig 3** shows the temperature profile for different values of Pr. It shows that temperature decreases as Pr increase. For fluid with large Pr, the temperature decays faster with distance which makes thermal boundary layer to decrease. This is expected since fluid with large Pr has low thermal diffusivity and hence heat penetration is less when Pr is large. $\boldsymbol{Fig}$ 4 Shows temperature profile for different values of heat sink (S). As (S) increases, the temperature decreases. This is expected since the heating of the fluid takes place gradually and the vertical plate is porous**.** $\boldsymbol{Fig}$ **5** Shows temperature profile for different values of suction/injection parameter. As the porosity of the vertical plate increases, the temperature increases.

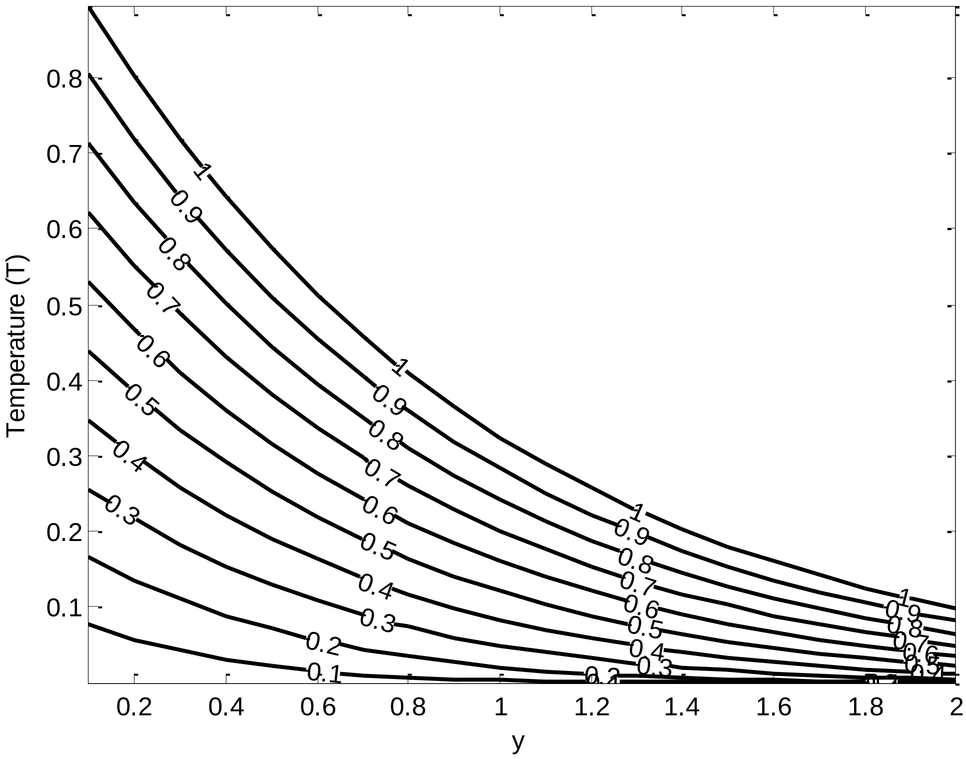


Fig 2.Temperature profile for different values of t ($Pr = 0.71, S = 2, q = 2$)

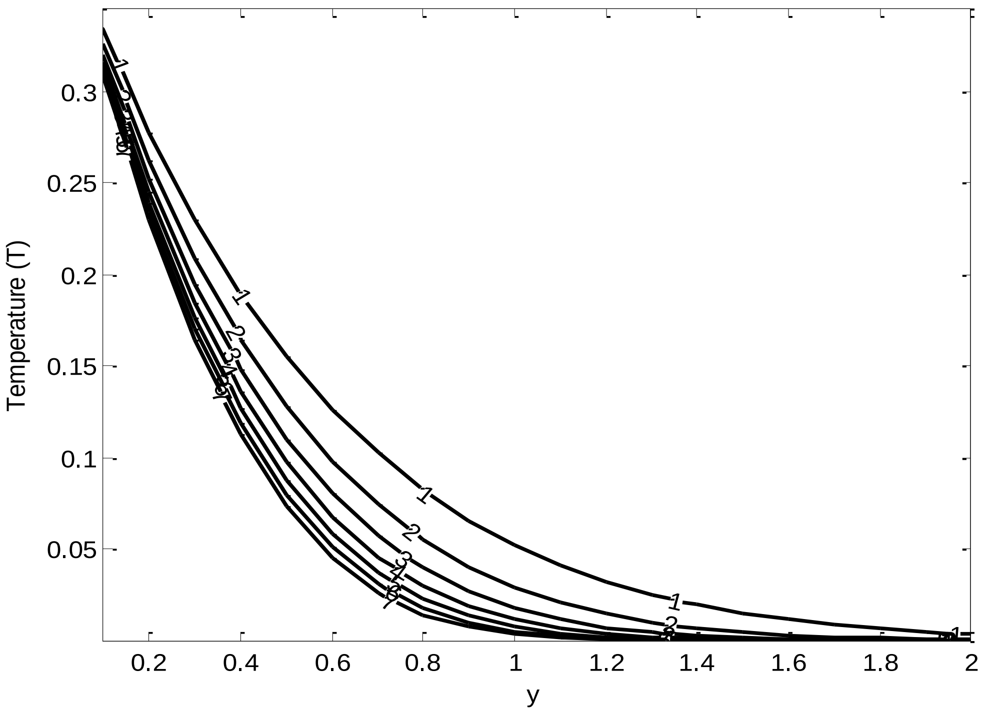


Fig3.Temperature profile for different values of Pr $(t = 0.4, S = 2, q = 1)$

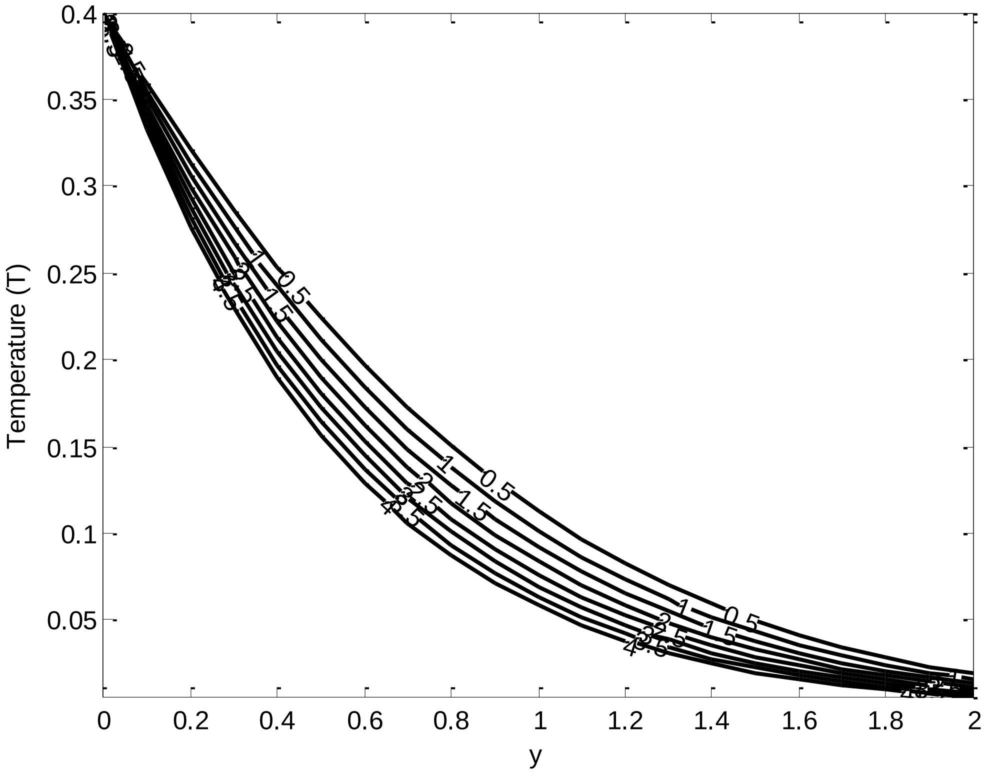


Fig 4. Temperature profile for different values of S $(t = 0.5, Pr = 0.71, q = 1)$

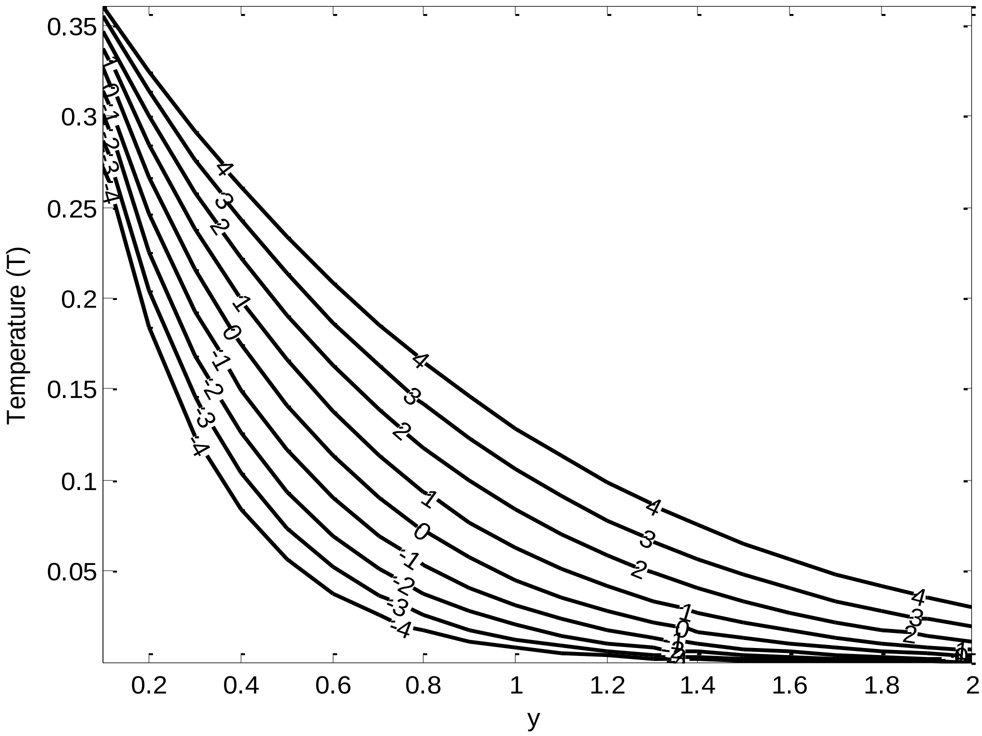


Fig 5. Temperature profile for different values of q $(t = 0.4, Pr = 0.71, S = 2.0)$

***Fig* 6 *and* 7** Shows the variation of velocity for different values of time (t) with the magnetic field fixed relative to the plate and fluid respectively, it shows that, as time increases the velocity increases. ***Fig* 8** Shows the variation of velocity for different values of (Pr) it shows that the velocity decreases as Pr increase. ***Fig* 9** Shows the variation of velocity profile for different values of the heat sink (S) from $\boldsymbol{Fig\ 9}$, it is clear that velocity decreases with increase of heat sink parameter (S). $\boldsymbol{Fig\ 10\ and\ 11}$ Shows the variation of velocity profile for different values of magnetic field (M), with the magnetic field fixed relative to the plate and fluid respectively. It shows that velocity decreases on increasing magnetic parameter (M) fixed relative to the plate. This implies that the magnetic field decelerates fluid velocity this is due to the fact that the application of magnetic field to an electrically conducting fluid gives rise to resistivity force which is known as Lorentz force. This force has tendency to decelerate fluid flow in the boundary layer region. While the velocity increases on increasing magnetic parameter (M) fixed relative to the fluid. This is physically true because, when the magnetic lines of force are fixed with the fluid, the resulting Lorentz force is a retarding force. This retarding effect is manifested by the reduction of the velocity profile. It is also clear from $equation\ (7)$. For $K = 0.0$, $equation\ (7)$ contains $-M^2U$ which reduces the velocity as magnetic field increases. On the other hand, for $K = 1.0$, $equation\ (7)$ contains $-M^2U + Kf(t)$, which supports the velocity as magnetic field increases $\boldsymbol{Fig\ 12}$ shows the variation of velocity profile for different values of suction/injection (q). It shows that the velocity of the fluid increases as the suction/injection increases. A comparative study reflects that the effect of injection is to increases the velocity while the suction decreases it. The physical interpretation of velocity increase due to injection is borne out of the fact that injection increase thickens the momentum boundary layer which eventually increases the fluid velocity while suction causes a thinning of the boundary layer which leads to it decrease in the fluid velocity.

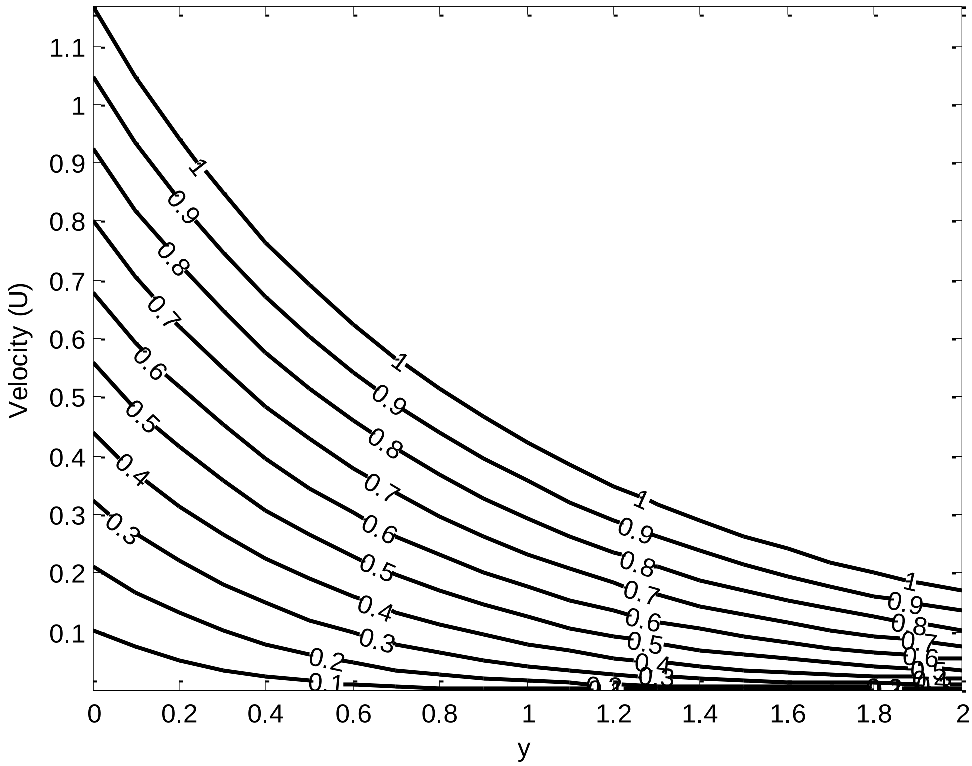


Figure 6: Velocity profile for different values of t $(Pr = 0.71, S = 1.0, q = 1, M = 0.5\ and\ k = 1.0)$

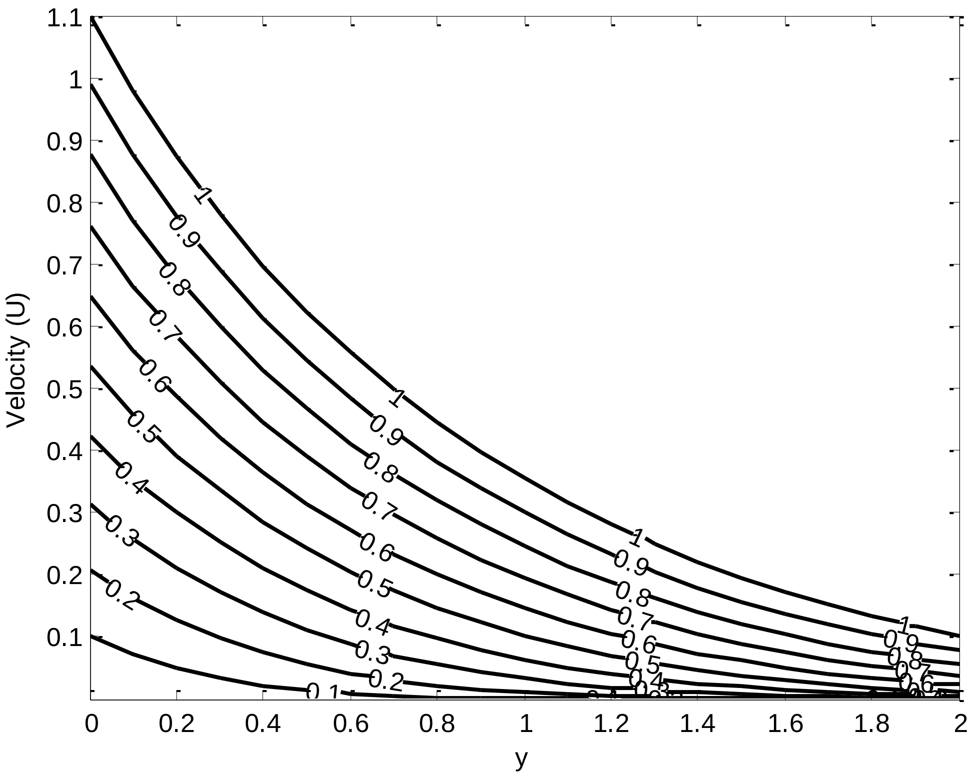
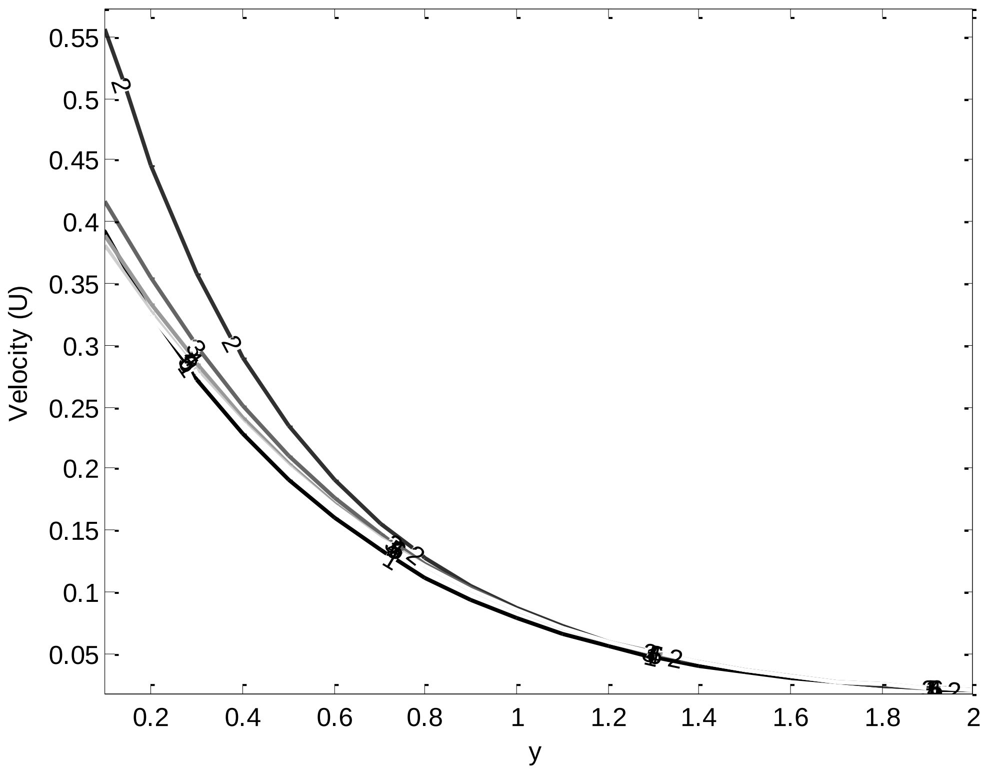


Fig7. Velocity profile for different values of t $(Pr = 0.71, S = 1.0, q = 1, M = 0.5 \ and \ k = 0.0)$



$Fig. 8: Velocity\ profile\ for\ different\ values\ of\ \mathrm{Pr}$

$(k = 1.0, M = 0.5, q = 1, S = 1.0\ and\ t = 0.4)$

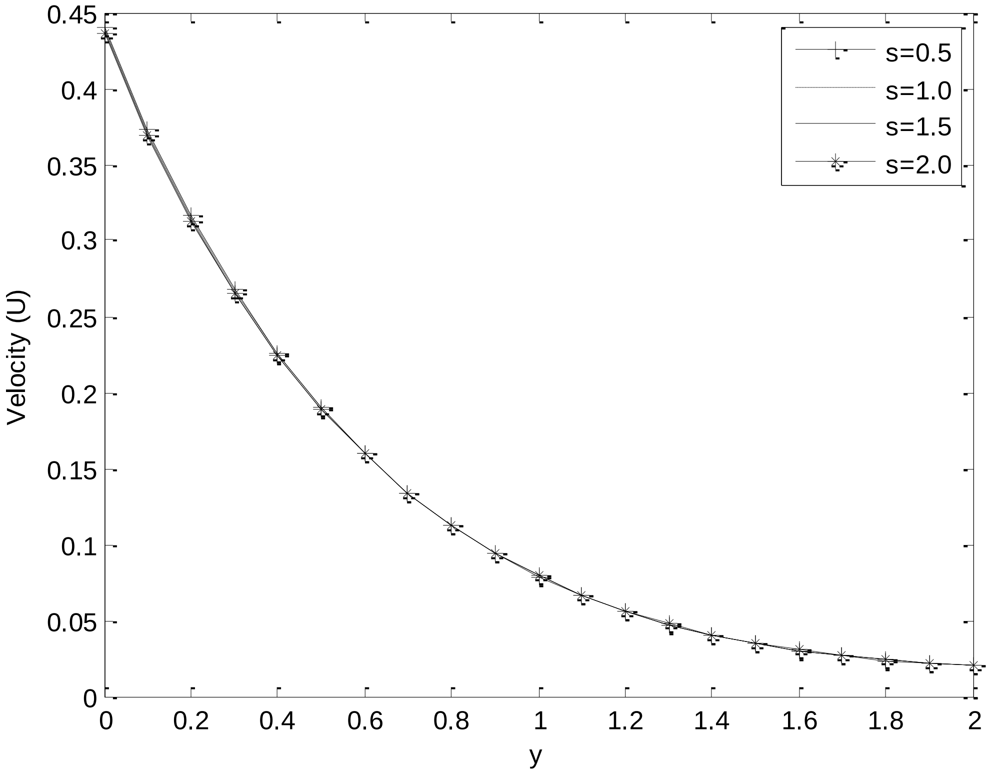


Fig. 9 Velocity profile for different values of S

$(k = 1.0, M = 0.5, q = 1, Pr = 0.71 \ and \ t = 0.4)$

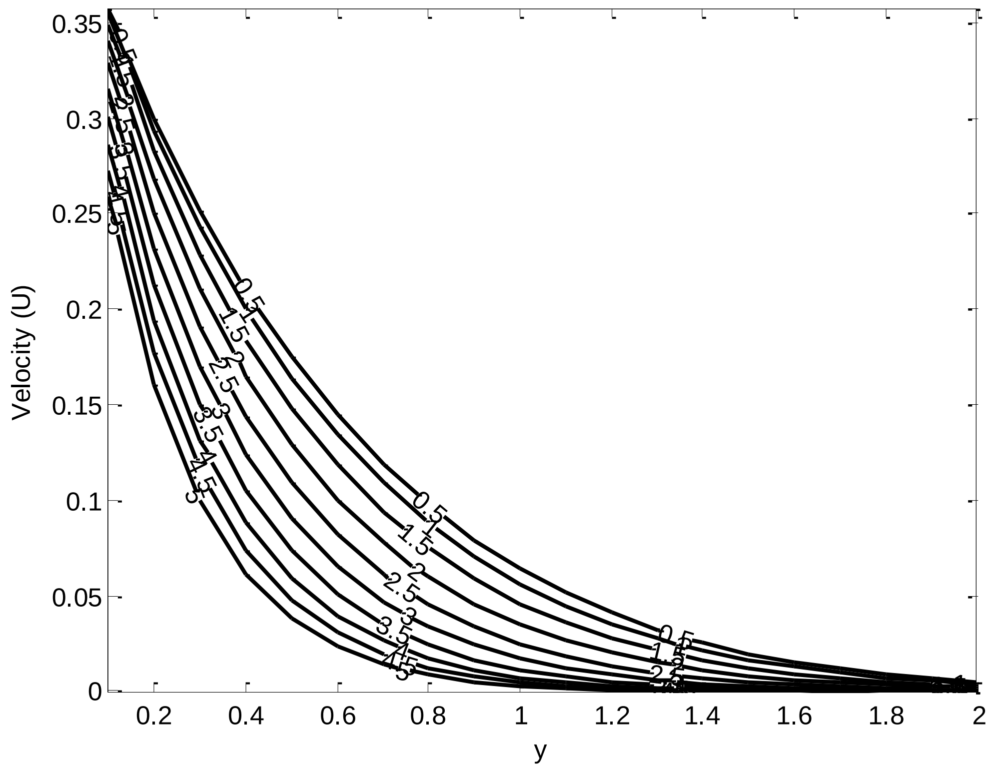


Fig10. Velocity profile for different values of $M\ (k = 0.0, Pr\ = 0.71, S = 1.0, q\ = 1\ and\ t = 0.4)$

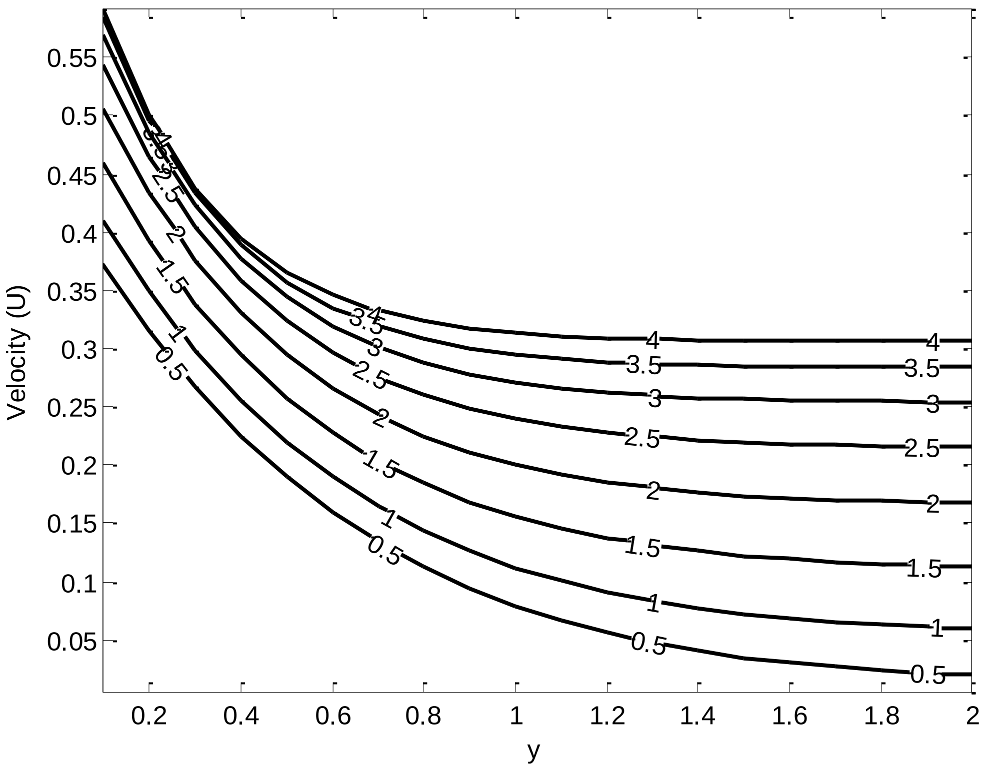


Fig 11. Velocity profile for different value of M $(k = 1.0, Pr = 0.71, S = 1.0, q = 1 \ and \ t = 0.4)$

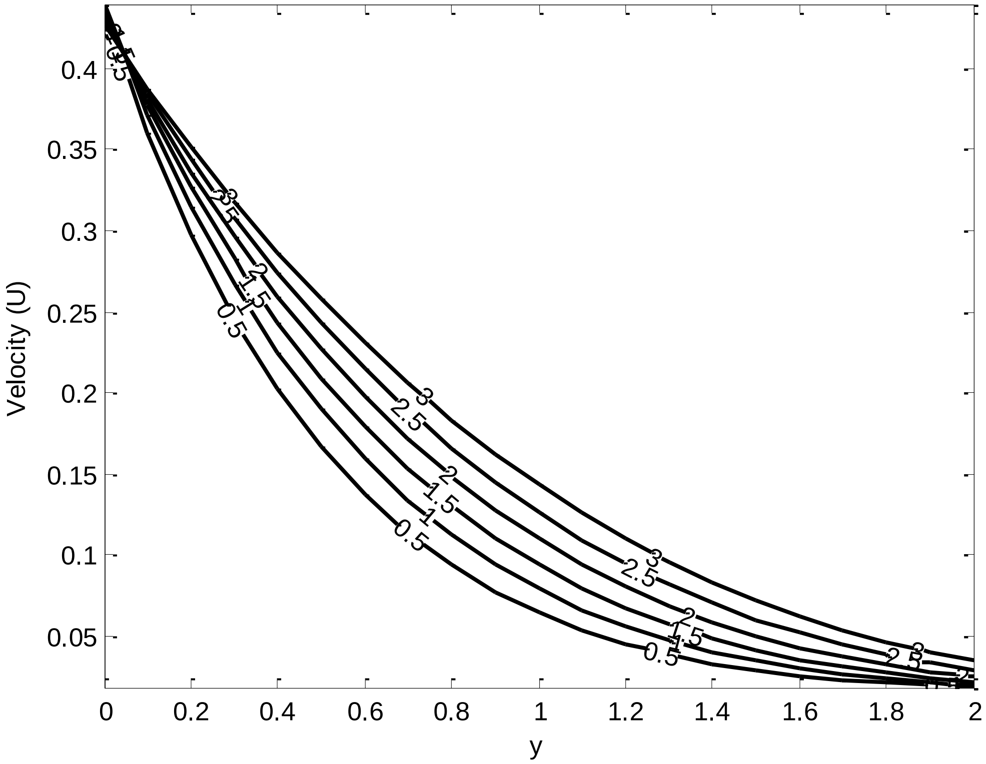


Fig 12: Velocity profile for different values of q

$(t = 0.4, Pr = 0.71, S = 1.0, M = 0.5\ and\ k = 1.0)$

***Fig* 13** Shows the variation of Nusselt number for different values of Pr, it shows that the Nusselt number increases as Pr increases. This implies that there is an enhancement in the rate of heat transfer at $t \leq 1$. ***Fig* 14** Shows the variation of Nusselt number for different values of Pr, it shows that the rate of heat transfer increases as the suction/injection increases. $Fig\ 15$ Shows the variation of Nusselt Number for different values of Pr, it shows that the Nusselt number increase as heat sink increases. $Fig\ 16$ Shows the variation of skin friction versus time for different values of Pr, it shows that the skin friction increases on increasing Pr over time. $Fig\ 17$ Shows the variation of skin friction versus heat sink for different Pr, it shows that as the heat sink increases there is an increase in skin friction with increase in Pr, This implies that heat sink enhances the shear stress of the fluid $Fig\ 18$ Shows the variation of skin friction versus time for different M, it shows that the shear stress increase as magnetic field increases. $Fig\ 19$ Shows the variation of skin friction for different value of Pr, it shows that the shear stress increases as suction/injection increases.

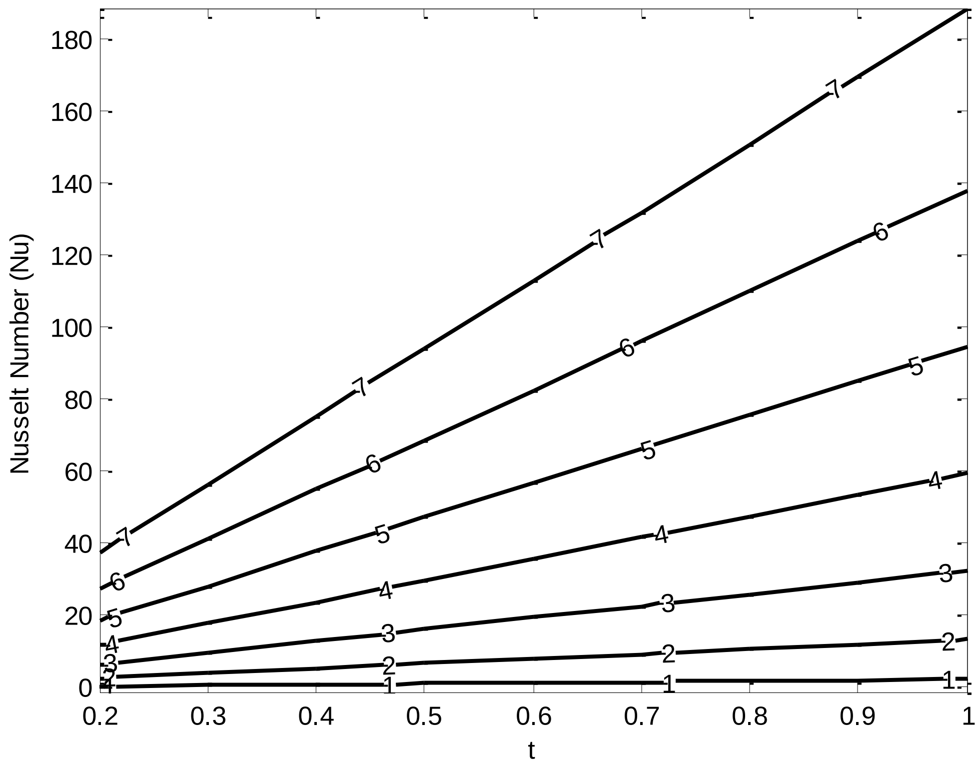


Fig13. Variation of Nusselt Number for different Pr $(S = 2.0\ and\ q = 2.0)$

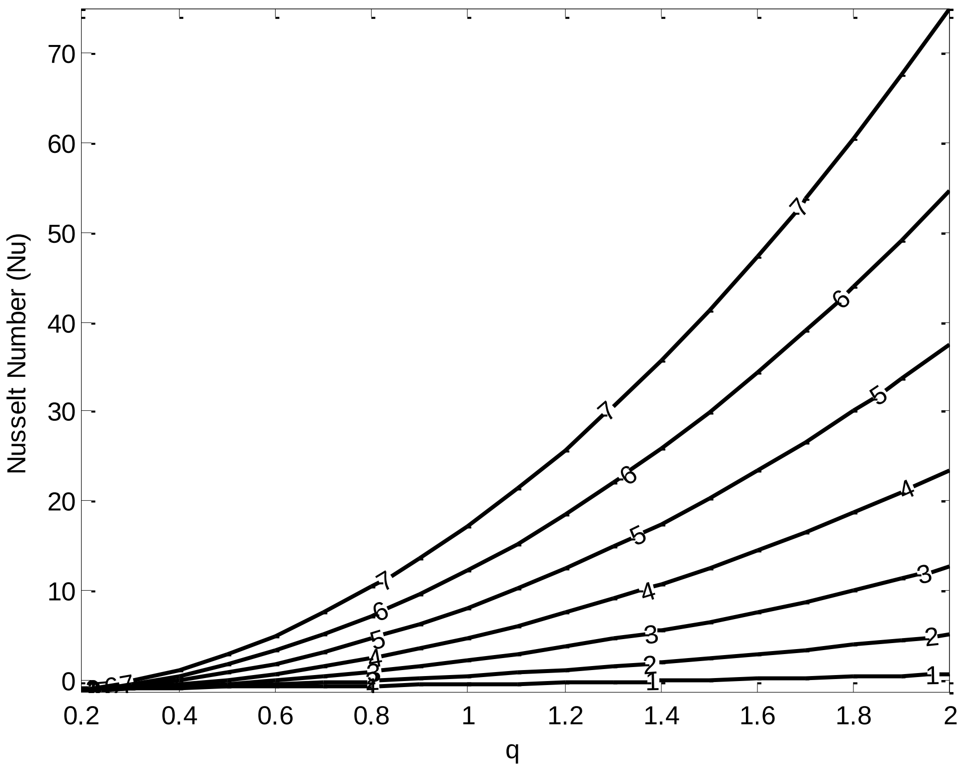


Fig 14: Variation of Nusselt Number for Different Value of Pr $(S = 2.0, t = 0.4)$

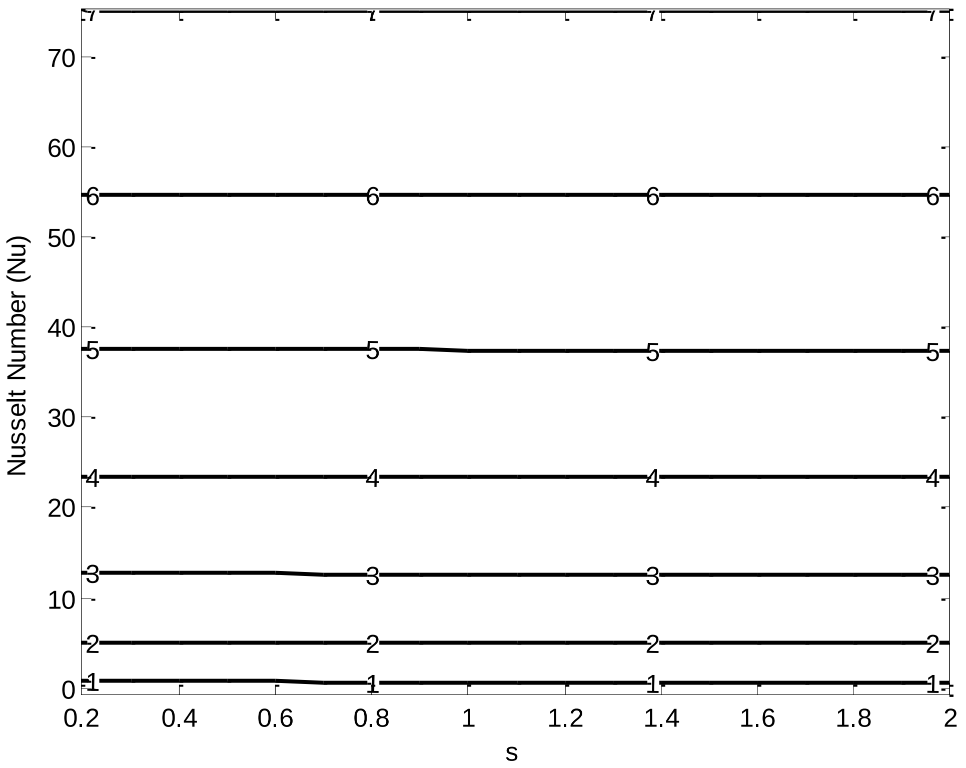


Fig 15. Variation of Nusselt Number for different value of Pr $(t = 0.4, q = 2.0)$

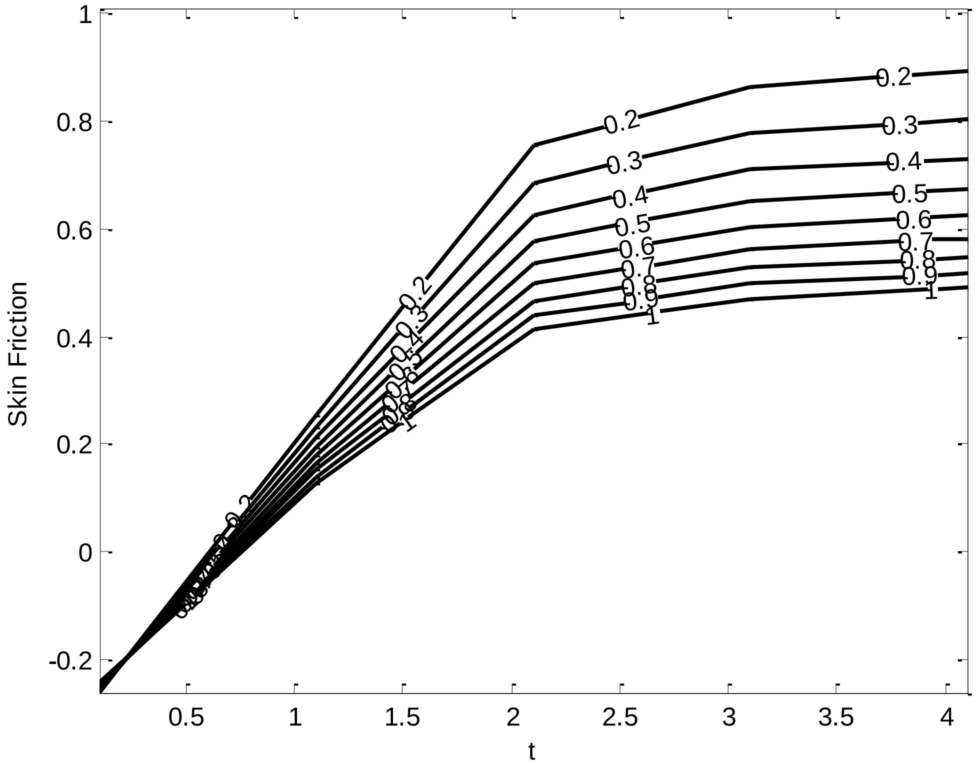


Fig. 16 Variation of Skin friction for different value of Pr

$(S = 2.0, q = 2.0 \; and \; M = 0.5)$

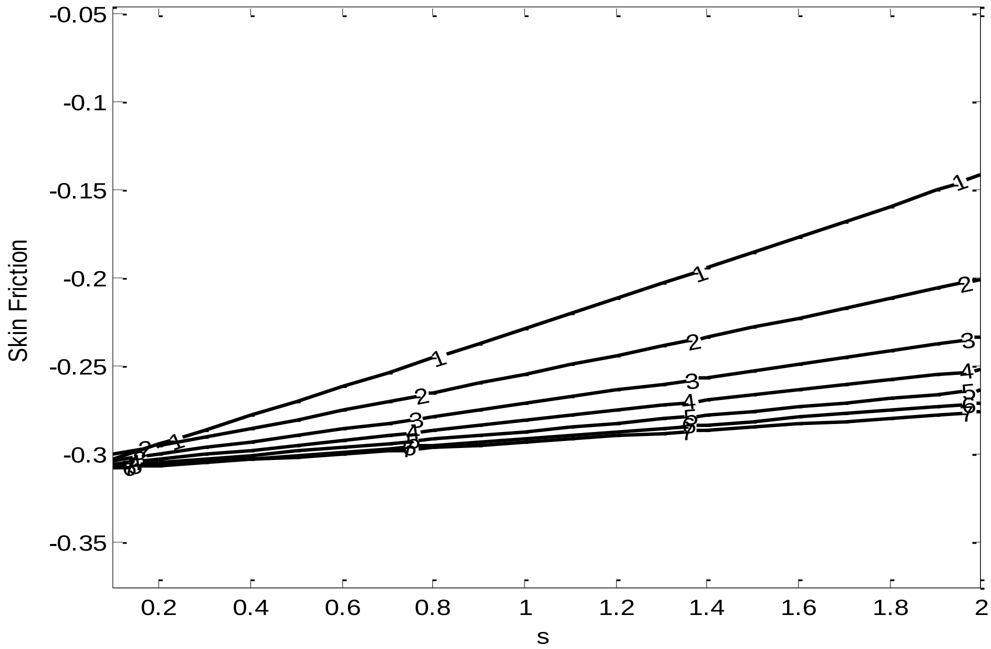


Fig. 17. Variation of Skin friction for different value of Pr

$(q\ 2.0, M = 1.0\ and\ t = 1.0)$

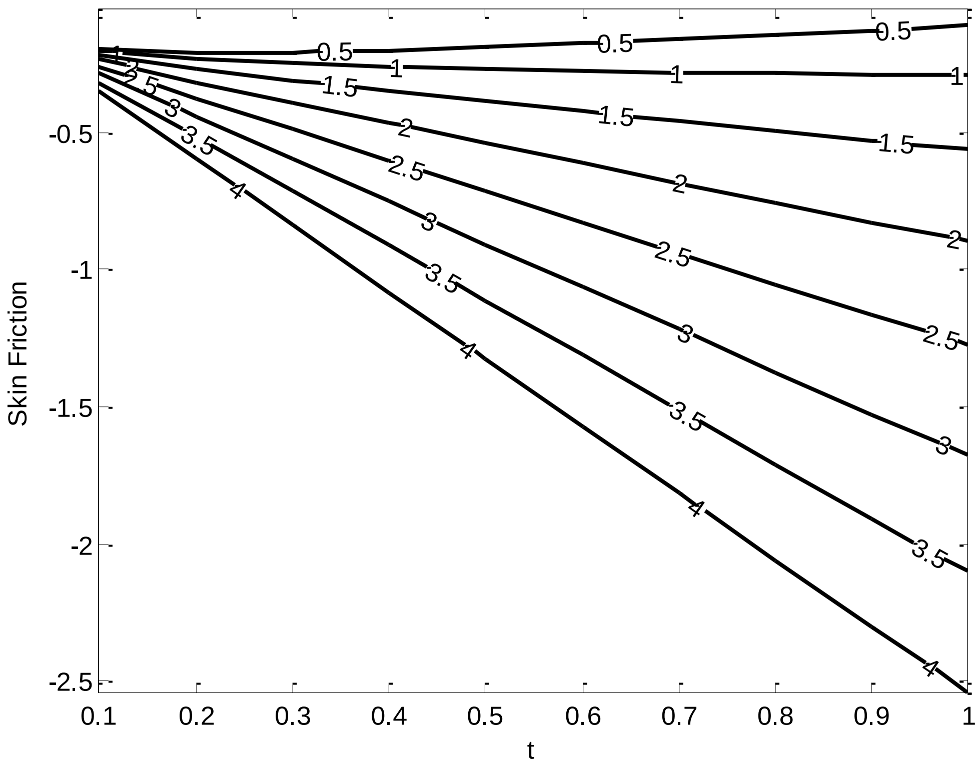


Fig. 18: Variation of Skin friction for different value of M

$(S = 2.0, q = 4.0 \; and \; t = 1.0)$

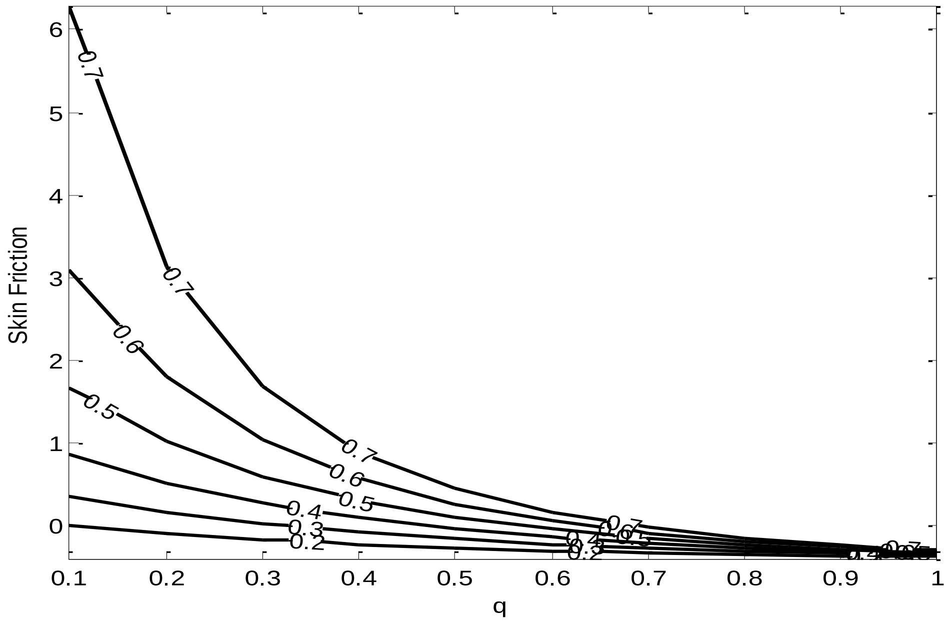


Fig. 19. Variation of Skin friction for different value of Pr

$(S = 2.0, M = 1.0 \text{ and } t = 1.0)$

CONCLUSION

This study presents a theoretical investigation of unsteady MHD natural convection flow through a vertical porous plate with ramped wall temperature and ramped motion. The Laplace transform technique and the Riemann-sum approximation method have been used to obtain the solution of the governing equation. The influence of some carefully selected flow parameter; Hartmann number (M), Prandtl (Pr), suction/injection (q), heat sink (S) and time (t) on the fluid velocity, skin-friction and rate of heat transfer has been extensively discussed. The significant findings are summarized below;

1. The temperature of the fluid increases as the suction/injection of the plate increases.
2. Magnetic field fixed relative to the porous plate decrease the velocity of the fluid while magnetic field fixed relative to the fluid increase the velocity of the fluid.
3. Suction/injection increases the velocity of the fluid. This is because injection increase thickens the boundary layer which eventually increases the fluid velocity while suction causes a thinning of the boundary layer which leads to the decreases in the fluid velocity.
4. suction/injection and heat sink increase the rate of heat transfer
5. Magnetic field, heat sink and suction/injection increase the shear stress of the fluid.

REFERENCES

Ahmed, N., Sarmah, H.K. and Kalita D. (2011) Thermal diffusion effect on a three dimensional MHD free convection with mass transfer flow from a porous vertical plate lat. Am. Appl. Res. 41, 165-176.

Aldos, T.K., Al-Nimr, M.A., Jarrah, M.A. and Al-Shaer, B.J. (1995) Magneto hydro dynamic mixed convection from a vertical plate embedded in a porous medium. Numer. Heat Trans. 28, 635-645.

Chamkha A.J. (2000) Unsteady laminar hydro dynamic fluid particles flow and heat transfer in channels and circular pipes. Int. J. heat fluid flow 21, 740-746.

Chamkha A.J. (1997) Solar radiation assisted natural convection in a uniform porous medium supported by a vertical flat plate. ASME J. heat transf. 119: 89-96.

Chandran .P. Sacheti N.C. and Singh A.K. (1998)Unsteady hydro magnetic free convection flow with heat flux and accelerated boundary motion. J. Phys Jpn 67: 124-129.

Georgantopolus G.A. (1979) Effect of free convection on the hydro magnetic accelerated flow past a vertical porous limiting surface. Astro. Phys. Sci. 65:433-442.

Jha et al. (2012) Natural convection flow of heat generating or absorbing fluid near a vertical plate with ramped temperature. JEAS, 2: 61-68.

Jha, B.K and Jibril H.M. (2010) Hydro magnetic fluid due to ramped motion of the boundary. Int. J. of applied mechanics and engineering vol. 15, no 4, pp 1101-1109.

Jha, B.K. (1991) MHD free convection and mass transfer flow through a porous medium. Asto phys. Apace Sci. 175: 283-289.

Mibeledogu I.U and Ogulu A. (2007) Heat and mass transfer of an unsteady MHD natural convection flow of a rotating fluid past a vertical porous flat plate in the presence of radiative heat transfer. Int. J. heat mass Transf. 50: 1902-1908.

Raptis A and Singh A.K. (1983) MHD free convection flow past an accelerated vertical plate. Int. Comm. Heat mass Transf. 10: 313-321.

Sacheti N.C, Chandran P, and Singh A.K. (1994) an exact solution for unsteady magneto hydro dynamic free convection flow with constant heat flux. Int. Comm. Heat mass Transf. 21: 131-142.

Seth G.S, Ansari, M.S and Nandkeolyar,R. (2011) MHD natural convection flow with radiative heat transfer past an impulsively moving plate with ramped wall temperature. Heat mass transf. 47, 551-561.

Seth G.S, Nandkeolyar R. and Ansari, M.S. (2011) Effect of rotation on unsteady on unsteady hydro magnetic natural convection flow past an impulsively moving vertical plate with thermal diffusion and heat absorption. Int. J. Appl. Math. Mech 7(21), 52-69.

Seth G.S and Ansari M.S. (2010) MHD Natural convection flow past an impulsively moving Vertical plate with ramped wall temperature in the presence of thermal diffusion with heat absorption. Int. J Appl Mech Eng. 15: 199-215.

Sahoo P.K, Datta, N. and Biswal, S. (2003) Magneto hydro dynamics unsteady free convection flow past an infinite vertical plate with constant suction and heat sink. Indian J. Pure Appl. Math 34(1), 145-155.

Sahoo D.G and Sahoo, P.K. (1986) Hydro magnetic free convection and mass transfer through a porous medium. Ind. J. Tech 24:553-556.

Takhar H.S, Gorla RSR, and Soundalgekar V.M. (1996) Radiation effects on MHD free convection flow of a gas past a semi-infinite vertical plate. Int. J. Numer. Methods heat fluid flow 6: 77-83.

Takhar, H.S, Roy, S, and Nath, G. (2003) Unsteady free convection flow of an infinite vertical porous plate due to the combined effects of thermal and mass diffusion, Magnetic field and Hall currents. Heat mass transfer.39: 825-834.

Jha, B. K. and Apere, C. A.: (2007) Unsteady MHD Couette flow in an annuli, the Riemann-sum approximation approach. J Phys Soc Jpn 79124403 (5 pp.).

Tzou, D.Y.: (1997) Macro to microscale heat transfer: the lagging behavior. London: Taylor and Francis.

Jha B. K. and Jibril H. M: (2011) Effects of transpiration on the MHD flow near a porous plate having ramped motion. J Phys Soc Jpn 64684 (6pp.).

Cite this article:

Author(s), KHADIJAH. K. LAWAL And HARUNA. M. JIBRIL **(2019).** "Time Dependent MHD Natural Convection flow of a Heat Generating/Absorbing Fluid near a Vertical Porous Plate with Ramped Boundary Conditions", Name of the Journal: Euro Afro Studies International Journal, (EASIJ.COM), P, 81 - 122. DOI: 10.5281/zenodo.3566758, Issue: 1, Vol.: 1, Article: 5, Month: December, Year: 2019. Retrieved from https://www.easij.com/all-issues/

Published by

Published By