JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, p. 1859-1866
https://publishoa.com
ISSN: 1309-3452

Effect of Unsteady Flow Past an Exponentially Accelerated Inclined Vertical Plate with Variable Temperature and Mass Diffusion Through Porous Medium

R. Sivaprakasam [a], A. Selvaraj * S. Sithsabesan[b]

[a] Research Scholar, Department of Mathematics, Vels Institute of Science, Technology and Advanced Studies, Chennai-600117, India.
*Department of Mathematics, Vels Institute of Science, Technology and Advanced Studies, Chennai- 600117, India.
Email: aselvaraj_ind@yahoo.co.in
[b] Department of Mathematics, Veltech Multitech Dr. Rangarajan Dr. Sakunthala Engineering College, Chennai- 600062.
Email: sithsabesan@veltechmultitech.org

Received 2022 April 02**; Revised** 2022 May 20**; Accepted** 2022 June 18**.**

Abstract: In this paper analyse the magnetic hydrodynamic of the fluid flow past an exponentially accelerated inclined vertical plate with mass distribution with varying temperature and heat source through a porous medium. Apply more number of possible non-dimensional necessary conditions with limitation and starting conditions is workout mathematically. The plate temperature is extended inclined vertical plate alongside at time t and the focus level close to the plate. The dimensionless administering conditions in the current examination are tackled utilizing the inverse Laplace transform technique. The velocity outlines are graphically explained to different physical parameters heat Grashof value, mass Grashof value, Schmidt value and duration. It has been observed that the velocity increases with an increase in thermal grashof number Gr and also an expansion in time t of the plate but the velocity increments with an increase in permeability of the porous medium while decrease in the absence of magnetic parameter.

Keywords: Porous medium; Exponentially, Accelerated, Vertical plate, Laplace transform.

1. Introduction

Magnetohydrodynamics (MHD) for all of these phenomena, where magnetic field and the velocity field are linked, due to the presence of electric conductive and non-magnetic fluid example in liquid metals, hot ionised gases (plasmas) or strong electrolytes.The attractive field can incite flows in such a moving liquid and this produces powers acting in the fluid and the attractive field. The case in fluid metal MHD, which are regular in mechanical procedures. In the event that we need to comprehend the idea driving MHD generators (and pumps), we need to note the influence of the magnetic field at the boundary layers. It used for geophysics, hydrology, cooling system designs. A self-consistent set of MHD equations combines plasma mass density, plasma velocity, thermodynamic pressure and magnetic field. As a result, magnetic field lines are frozen, and the matter (ions and electrons) moves along the field. A slight difference moving produces electrical flows, which creates attractive field.Soundalgekar [1] mentioned on the results of mass switch on go with the flow past a uniformly accelerated vertical plate and studied a particular investigation of the effects of mass exchange on the Stokes problem for a boundless perpendicular plate has been introduced on thinking about the loose-convection flows. It's been visible that there's an ascent in the quickness because of the nearness of an out of doors mass. Anyways, a variety in Schmidt number, prompts a fall within the velocity. The pores and skin-erosion increments due to the nearness of a far flung mass.Goud et.al [2] has examined the mass and heat transfer past an oblique plate of the unmodified MHD free flow the fixation and temperature. The principle embodiment of the examinationis slant pointon the flow phenomenon with a heat source or sink along with a destructive reaction. Separate of Galerkin defnding element method. Muthucumaraswamy. R., and V. Valliammal [3] has investigated an optimal solution of an unsteady flow past an exponentially quickened unbounded isothermal vertical plate with uniform mass dispersion within the sight of a transverse magnetic field.

Pattnaik [4] have analyzed the impact of mass transfer and thermal radiation on MHD without convection stream past an exponentially revived vertical plate in a permeable medium with variable temperature and concentration. The visible liquid is gray, retaining radiation however not a non-scattering medium. If the radiation boundary should be the solution of the growth, the speed is reduces the incidence of cooled plate. The opposite impact is seen if there should arise an occurrence of plate heat. This is clearly conditions, as the loss of vitality because of radiation in the thick condition is irreversible. Rajesh. V and S. V. K. Varma [5] under the action of uniform magnetic field through porous medium a viscous infinite vertical plate of a incompressible electrically conducting fluid have studied impacts of relative heat source of temperature at past convection and mass transfer flow. The thermal grashof number here indicates the impact of free warming flows, and gets positive, zero or negative qualities.In any case in these papers don't consider the impacts of temperature based warmth sources. Such a circumstance exists in numerous mechanical or innovative applications, sun oriented vitality issues, or the issue of space sciences. Rajesh Varma [6] has advanced to inspect the impact of temperature based heat source being without transient convection and mass exchange flow of an elasto-thick liquid past an exponentially quickened endless vertical plate within the sight of attractive field through porous medium. In this paper talked about speed field on both cooling and warming of the plate. Reddy et.al [7] have researched a thick, non-compressible flow electrically determined, moving free temperature boundary layer flow. The nearness of a radiative and chemical reaction medium within the sight of a vertical plate. The transverse magnetic field. Notice some key in the fundamental and three sorts as the plate moves, various types motion of the plate use uniform speed when the plate is a is single quickened and when the plate is moving with impermanent increasing speed.Mhd characteristic convection is broadly known the impacts of warm radiation on hydromagnetic normal convection stream with heat move assumes a significant role in the assembling ventures for glass fabricating, heater configuration, throwing and levitation, steel rolling. Moreover, many building techniques, at incredibly high temperatures are inevitable in the structure of radiation heat move hardware, atomic force stations, gas turbines, rocket re-emergence aerothermodynamics and numerous drive gadgets forairetes, rockets. Instances of such designing regions, for example, satellites and space vehicles. Numerical estimations of essential and optional liquid speeds in the limit layer region,in terms of expanding the plate increasing speed boundary, Hall current, warm lightness power, radiation, heat retention and stream field time processed by Seth et.al [8].Selvaraj et al [9],[10] have studied MHD regular convective flow past on exponentially with mass and thermal reaction and a particular case unsteady rotational effect of flow past an electrically conducting liquid a uniform mass diffusion in vertical plate

2. **Mathematical Formulation**

The transient flow of an inclined vertical plate past viscous and electrically conductive viscous fluid with varying temperature through a porous medium is considered. It is expected that constant asset B_0 ahypnoticarea (virtual to the plate) is used inversely to the plate. The prompted attractive field is overlooked since the magnetic Reynolds value of the movement is minuscule. The stream is assumed to be in thex' - direction, taking upwards through the vertical plate.y'-axis line is set aside even to the plate. Originally the plate and the liquid are standing at the similar temperature T'_∞ at all points with concentration level C'_∞. At t'>0, the plate accelerates exponentially with a speed velocity u = u_0 exp$(a't')$in its specific level and the plate temperature is higher linearly with time t and together to the plate. The focus near is high elevated to C'_w. The effect of viscous scattering considered negligible. By the estimate of the steady Boussinesq's, the instable movement is overseen by the following equations.

$$\frac{\partial u'}{\partial t'} = g\beta cos\phi(T' - T'_\infty)+g\beta^* cos\phi(C'-C'_\infty)+v\,\frac{\partial^2 u'}{\partial y'^2} -\frac{vu'}{K} \quad (1)$$

$$\rho C_p \frac{\partial T'}{\partial t'} = k\frac{\partial^2 T'}{\partial y'^2} \quad (2)$$

$$\frac{\partial C'}{\partial t'} = D\frac{\partial^2 C'}{\partial y'^2} \quad (3)$$

with the following suitable initial and boundary conditions:

$t' \leq 0 \quad u' = 0 \;, T' = T'_\infty C' = C'_\infty$ for all $y' \leq 0$

$t' > 0 \quad u' = u_0 cos\omega(a't') \;, T' = T'_\infty + (T'_w - T'_\infty)At', \;\; C' = C'_w$ at $y' = 0$ (4)

$u' \to 0, T' \to T'_\infty, \; C' \to C'_\infty$ as $y' \to \infty$ where A = $\frac{u_0^2}{v}$

Equation (1) is exits and applicable only when the magnetic lines of force are fixed relative to the plate. On presenting the resulting dimensionless magnitudes:

$$u = \frac{u'}{u_0}, \quad t = \frac{t'u'_0}{v}, \quad y = \frac{y'u_0}{v}, \quad \theta = \frac{T' - T'_\infty}{T'_w - T'_\infty}, G_r = \frac{g\beta v(T'_w - T'_\infty)}{u_0^3}, C = \frac{C' - C'_\infty}{C'_w - C'_\infty}, \tag{5}$$

$$G_c = \frac{g\beta v(C'_w - C'_\infty)}{u_0^3}, \; P_r = \frac{\mu C_p}{k}, \quad S_c = \frac{v}{D}, \quad a = \frac{a'v}{u_0^2}, \quad K = \frac{u_0^2 K'}{v^2}$$

From equation (1) to (4), leads to the non dimensional equations

$$\frac{\partial q}{\partial t} = G_r \theta cos\phi + G_c C cos\phi + \frac{\partial^2 q}{\partial z^2} - \frac{q}{K} \tag{6}$$

$$\frac{\partial \theta}{\partial t} = \frac{1}{P_r}\frac{\partial^2 \theta}{\partial z^2} \tag{7}$$

$$\frac{\partial C}{\partial t} = \frac{1}{S_c}\frac{\partial^2 C}{\partial z^2} \tag{8}$$

With the initial and boundary conditions

t ≤ 0: q = 0, $\theta = 0$, C = 0 for all z

t > 0 : q = $\cos(\omega t), \theta = e^{at}$, C = e^{at} at z = 0 (9)

q → 0 , $\theta \to 0$, C→ 0as z→ ∞

The non-dimensional quantities are defined in the classification.

3. Method of Solution

The non-dimensional governing Equations from (6) to (8) apply and get to consistent starting limit constrains [9], also handled utilizing Laplace transforms method also result determined in this way of structure

$$q = \frac{e^{at}}{2}\left[\begin{array}{c} \exp(-2\eta\sqrt{\left(a+\frac{1}{k}\right)t})\,\mathrm{erf}\,c\,(\eta - \sqrt{\left(a+\frac{1}{k}\right)t}) + \\ \exp(2\eta\sqrt{\left(a+\frac{1}{k}\right)t})\,\mathrm{erf}\,c\,(\eta + \sqrt{\left(a+\frac{1}{k}\right)t}) \end{array}\right]$$

$$-\frac{G_r cos\phi}{(a-(b+d))(1-P_r)}\frac{e^{at}}{2}\left[\begin{array}{c} \exp(-2\eta\sqrt{\left(a+\frac{1}{k}\right)t})\,\mathrm{erf}\,c\,(\eta - \sqrt{\left(a+\frac{1}{k}\right)t}) + \\ \exp(2\eta\sqrt{\left(a+\frac{1}{k}\right)t})\,\mathrm{erf}\,c\,(\eta + \sqrt{\left(a+\frac{1}{k}\right)t}) \end{array}\right]$$

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, p. 1859-1866
https://publishoa.com
ISSN: 1309-3452

$$-\frac{G_r\,cos\phi}{((b+d)-a)(1-P_r)}\frac{e^{(b+d)t}}{2}\left[\begin{array}{c}\exp(-2\eta\sqrt{\left(b+d+\frac{1}{k}\right)t}\,)\,\mathrm{erf}\,c\,(\eta-\sqrt{\left(b+d+\frac{1}{k}\right)t}\,)+\\ \exp(2\eta\sqrt{\left(b+d+\frac{1}{k}\right)t})\,\mathrm{erf}\,c\,(\eta\ +\sqrt{\left(b+d+\frac{1}{k}\right)t}\,)\end{array}\right]$$

$$-\frac{G_c\,cos\phi}{(a-(c+f))(1-Sc)}\frac{e^{at}}{2}\left[\begin{array}{c}\exp(-2\eta\sqrt{\left(a+\frac{1}{k}\right)t}\,)\,\mathrm{erf}\,c\,(\eta-\sqrt{\left(a+\frac{1}{k}\right)t}\,)+\\ \exp(2\eta\sqrt{\left(a+\frac{1}{k}\right)t})\,\mathrm{erf}\,c\,(\eta\ +\sqrt{\left(a+\frac{1}{k}\right)t}\,)\end{array}\right]$$

$$-\frac{G_c cos\phi}{\big((c+f)-a\big)(1-Sc)}\frac{e^{(c+f)t}}{2}\left[\begin{array}{c}\exp(-2\eta\sqrt{\left(c+f+\frac{1}{k}\right)t}\,)\,\mathrm{erf}\,c\,(\eta-\sqrt{\left(c+f+\frac{1}{k}\right)t}\,)+\\ \exp(2\eta\sqrt{\left(c+f+\frac{1}{k}\right)t})\,\mathrm{erf}\,c\,(\eta\ +\sqrt{\left(c+f+\frac{1}{k}\right)t}\,)\end{array}\right]$$

$$+\frac{G_r\,cos\phi}{\big(a-(b+d)\big)(1-P_r)}\frac{e^{at}}{2}\left[\begin{array}{l}\exp\big(-2\eta\sqrt{Prat}\big)\,erfc\big(\eta\sqrt{Pr}-\sqrt{at}\big)\\ +\\ \exp\big(2\eta\sqrt{Prat}\big)\,erfc\big(\eta\sqrt{Pr}+\sqrt{at}\big)\end{array}\right]$$

$$+\frac{G_r cos\phi}{((b+d)-a)(1-Pr)}\frac{e^{(b+d)t}}{2}\left[\begin{array}{c}\exp(-2\eta\sqrt{\mathrm{Pr}(b+d)t}\,)\,\mathrm{erf}\,c\,(\eta\sqrt{Pr}-\sqrt{(b+d)t}\,)+\\ \exp(2\eta\sqrt{\mathrm{Pr}(b+d)t})\ \mathrm{erf}\,c\,(\eta\sqrt{Pr}+\sqrt{(b+d)t}\,)\end{array}\right]$$

$$+\frac{G_c cos\phi}{(a-(c+f))(1-Sc)}\frac{e^{at}}{2}\left[\begin{array}{c}\exp(-2\eta\sqrt{Scat}\,)\,\mathrm{erf}\,c\,(\eta\sqrt{Sc}-\sqrt{at}\,)+\\ \exp(2\eta\sqrt{Scat})\ \mathrm{erf}\,c\,(\eta\sqrt{Sc}+\sqrt{at}\,)\end{array}\right]$$

$$+\frac{G_c cos\phi}{((c+f)-a)(1-Sc)}\frac{e^{(c+f)t}}{2}\left[\begin{array}{c}\exp(-2\eta\sqrt{Sc(c+f)t}\,)\,\mathrm{erf}\,c\,(\eta\sqrt{Sc}-\sqrt{(c+f)t}\,)+\\ \exp(2\eta\sqrt{Sc(c+f)t})\ \mathrm{erf}\,c\,(\eta\sqrt{Sc}+\sqrt{(c+f)t}\,)\end{array}\right] \qquad (10)$$

$$\theta\ =\ \frac{e^{at}}{2}\left[\exp(-\sqrt{Pra})\,z\,\mathrm{erf}\,c\,(\eta\sqrt{Pr}-\ \sqrt{at}\,)+\ exp\sqrt{Pra}\,z\,\mathrm{erf}\,c\,(\eta\sqrt{Pr}+\ \sqrt{at}\,)\,\right] \qquad (11)$$

$$\mathrm{C}=\ \frac{e^{at}}{2}\left[\exp(-\sqrt{Sca})\,z\,\mathrm{erf}\,c\,(\eta\sqrt{Sc}-\ \sqrt{at}\,)+\ exp\sqrt{Sca}\,z\,\mathrm{erf}\,c\,(\eta\sqrt{Sc}+\ \sqrt{at}\,)\,\right] \qquad (12)$$

4. Result and discussions

To study the effects of the heat sources the plate accelerates in its own plane with velocity$u$ = $u_0\exp(a't')$ numerical calculations are made for different values of G_r(Thermal grashof number), G_c(Mass grashof number), S_C(Schmidt number), K (Permeability parameter), a (Accelerating parameter), when the prandtl number $P_r$is equal to 0.71 corresponding to the air. This is in order to reveal the different outcomes parameters in the dimensionless velocity field, temperature field, concentration field.

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, p. 1859-1866
https://publishoa.com
ISSN: 1309-3452

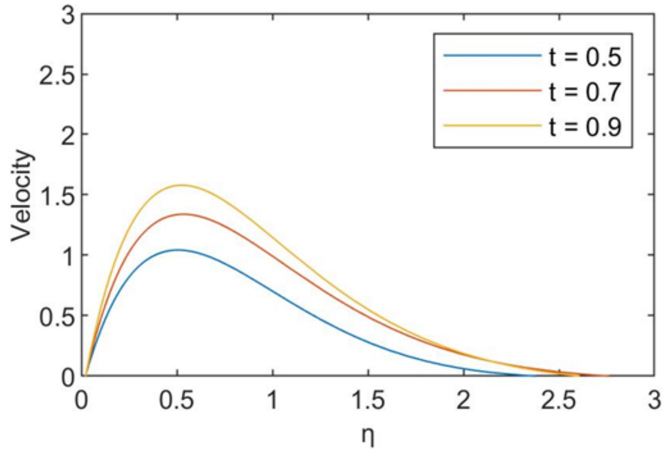
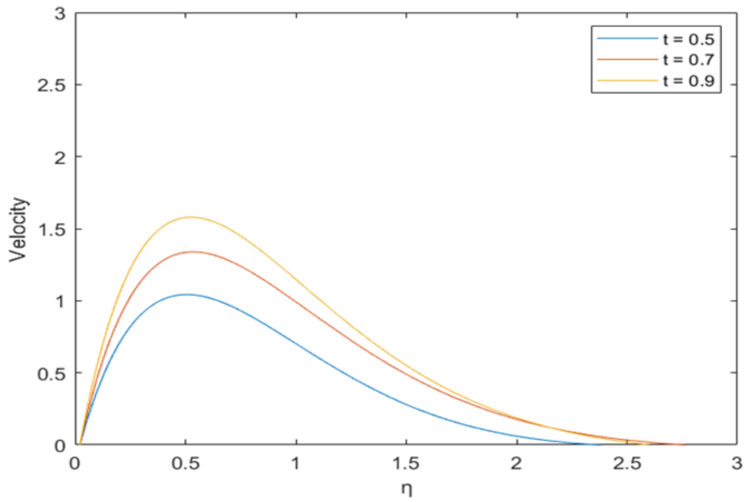


Figure 1. Velocity profile for various values of t

Figure (1) 1 Represents the velocity outlines for different time ideals (t = 0.5, 0.7, 0.9), $G_r = 10, G_c = 5, P_r = 0.71, S_c = 0.22$, K = 2, and a = 1.According to this graph, the velocity increases as the time duration t of the plate increases.



.

Figure 2. Velocity profiles when $G_r = 10, G_c = 5, P_r = 0.71, S_c = 0.22$, K = 2, a = 1

Figure (2) represents the velocity profiles for different values of time (t = 0.5, 0.7, 0.9), $G_r = 10, G_c = 5, P_r = 0.71, S_c = 0.0.22$, K = 2, and a = 1.From this figure the velocity is found to increase with an increase in time t of the plate

JOURNAL OF ALGEBRAIC STATISTICS
Volume 13, No. 3, 2022, p. 1859-1866
https://publishoa.com
ISSN: 1309-3452

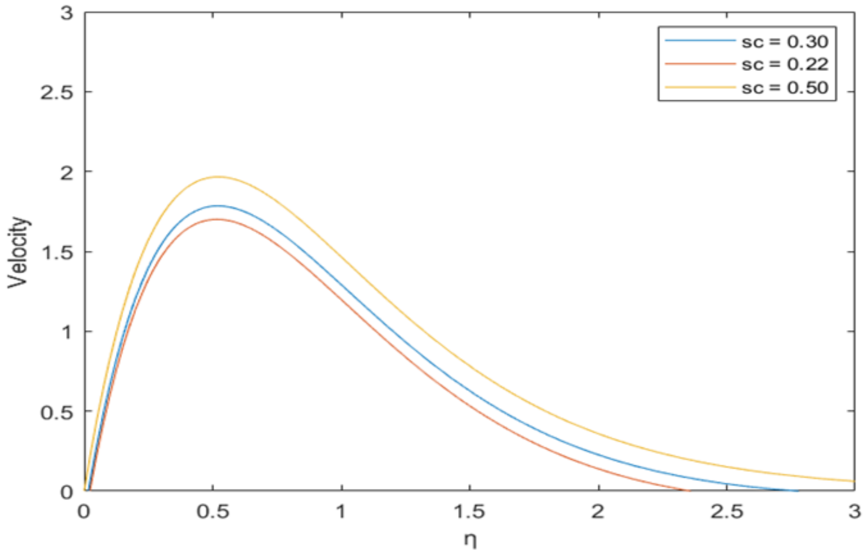


Figure 3. Velocity profiles when $G_r = 10, G_c = 5, P_r = 0.71$, K = 2, a = 1, t = 1.

Figure (3) represent the velocity profiles for different values of Schmidt number (S_c = 0.22, 0.3, 0.5), $G_r = 10$, $G_c = 5$, $P_r = 0.71$, K = 2, a = 1of the plate at t=1. From the figure it is found that the velocity increases with an increase in S_c

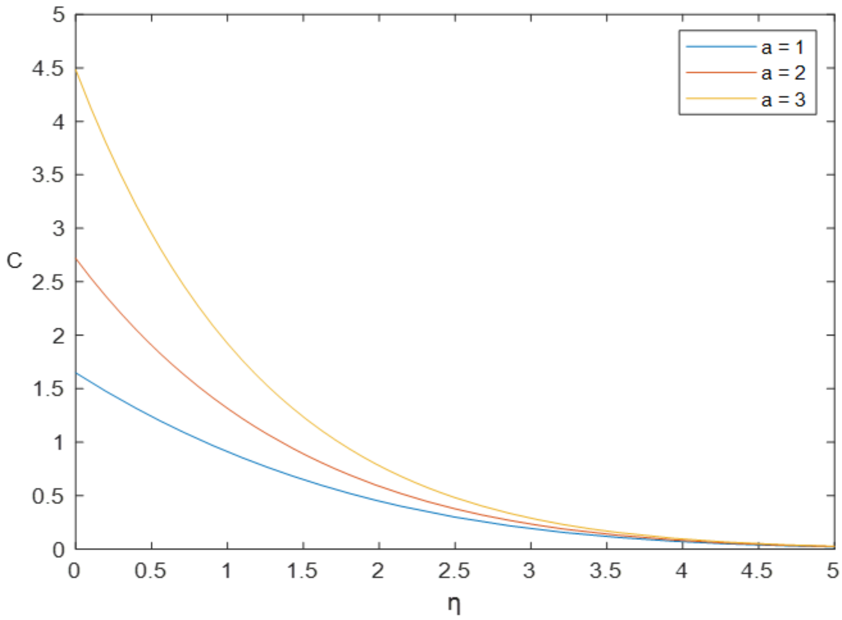


Figure 4. Concentration profiles when G_r= 5, G_c =5, S_c = 0.22, P_r = 0.71, t = 0.5,

Figure (4) represent the concentration profiles for different values of accelerating parameter (a = 1, a = 2, a = 3), $G_r = 5, G_c = 5$, $P_r = 0.71$, $S_c = 0.22$, of the plate at t= 0.5. The concentration from the figures increases with an increase in a (accelerating parameter) of the plate.

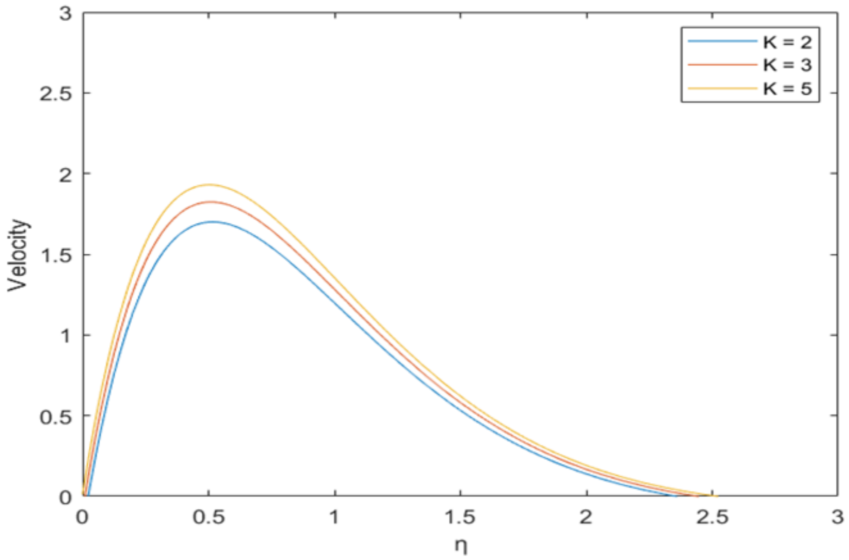


Figure 5. Velocity profiles while $G_r = 10, G_c = 5, P_r = 0.71, S_c = 0.22$, a = 1, t = 1.

Figure (5) represent the velocity profiles due to the variations in permeability limitation (K = 2, 3, 5), $G_r = 10, G_c = 5$, $P_r = 0.71$, $S_c = 0.22$, a = 1 of the plate at t= 1. As of the diagram the velocity is viewed to growth rise with an increase in permeability parameter K of the plate. This is caused by the information that the transposition growths the resistivity of a porous medium

5. Conclusions

In this paper we have considered an investigation study of the effects of unsteady and heat and mass absorption fluid flow past an exponentially accelerated vertical with porous medium. The solutions for the model have been comprehended by Laplace transformation method. The conclusions of this examination are

- The velocity growth through an expansion in time t of the plate.
- The velocity growths through an increase in Schmidt numberS_c .
- The velocity is found to increase with an increment in a (accelerating parameter) of the plate.
- Velocity increments with an increase in permeability of the porous medium while decrease in the absence of magnetic parameter.

REFERENCES

[1] Soundalgekar, V. M. "Effects of mass transfer on flow past a uniformly accelerated vertical plate." *Letters in heat and mass transfer* 9, no. 1 (1982): 65-72.

[2] Goud, B. Shankar, B. Suresh Babu, MN Raja Shekar, and G. Srinivas. "Mass Transfer Effects on MHD Flow through Porous Medium past an Exponentially Accelerated Inclined Plate with Variable Temperature and Thermal Radiation." *International Journal of Thermofluid Science and Technology* 6 (2019): 19060402.

[3] Muthucumaraswamy, R., and V. Valliammal. "Hydromagnetic flow past an exponentially accelerated isothermal vertical plate with uniform mass diffusion in the presence of chemical reaction of first order." *International Journal of Applied Mechanics and Engineering* 18, no. 1 (2013): 259-267.

[4] Pattnaik, J. R., G. C. Dash, and S. Singh. "Radiation and mass transfer effects on MHD free convection flow through porous medium past an exponentially accelerated vertical plate with variable temperature." *Annals of the Faculty of Engineering Hunedoara* 10, no. 3 (2012): 175.

[5] Rajesh, V., and S. V. K. Varma. "Heat source effects on MHD flow past an exponentially accelerated vertical plate with variable temperature through a porous medium." *Int. J. of Appl. Math and Mech* 6, no. 12 (2010): 68-78.

[6] Rajesh, Varma. "Heat source and mass transfer effects on MHD flow of an elasto-viscous fluid through a porous medium." *Annals of the Faculty of Engineering Hunedoara* 9, no. 2 (2011): 205.

[7] Reddy, P.G., Umamaheswar, M., Raju, M.C. and Varma, S.V.K., 2016. Magneto-convective and radiation absorption fluid flow past an exponentially accelerated vertical porous plate with variable temperature and concentration. *International Journal of Mathematics Trends and Technology (IJMTT)*, *31*(1).

[8] Seth, G. S., A. K. Singha, and R. Sharma. "MHD natural convection flow with Hall effects, radiation and heat absorption over an exponentially accelerated vertical plate with ramped temperature." *Ind. J. Sci. Res. Technol* 5 (2015): 10-22.

[9] Usharani, V., A. Selvaraj, R. Constance Angela, and A. Neel Armstrong. "Impact of MHD Stream Past an Exponentially Inclined Vertical Plate of First-Order Chemical Response with Variable Mass Diffusion and Thermal Radiation." In *Proceedings of First International Conference on Mathematical Modeling and Computational Science: ICMMCS 2020*, pp. 485-497. Springer Singapore, 2021.

[10] Jose, S. Dilip, A. Selvaraj, R. Muthucumaraswamy, S. Karthikeyan, and E. Jothi. "MHD-Parabolic Flow Past an Accelerated Isothermal Vertical Plate with Variable Temperature and Uniform Mass Diffusion in the Presence of Rotation." In *Proceedings of First International Conference on Mathematical Modeling and Computational Science: ICMMCS 2020*, p. 417. Springer Nature.