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Heat source impact on MHD and radiation absorption fluid flow past an exponentially accelerated vertical plate with exponentially variable temperature and mass diffusion through a porous medium

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ABSTRACT

In this study, the magnetic hydrodynamic and scattering intake of the fluid flow movement preceding an exponentially augmented vertical plate through mass distribution with varying temperature and warmth basis via a heat porous medium. Dimensionless conditions with limitation and starting conditions is workout mathematically. The plate temperature is extended in straight line alongside period t also focus closer near the plate. The dimensionless administering conditions in the current examination are tackled utilizing the Laplace change method. The velocity outlines are graphically explained to various physical limits heat Grashof value, mass Grashof value, Schmidt value also duration. It has been found that the velocity raises through the increase of the thermal grashof number Gr also expansion time t of the plate but the velocity growths through rise in absorptivity of the permeable medium while the presence of hypnotic parameter decreases. The impacts of boundaries M, K, t, Sc, an and Gr on the velocity profiles are demonstrated graphically.

1. Introduction

Magnetohydrodynamics (MHD) for all of these phenomena, where hypnotic area, velocity area are linked, caused by the presence of electric conductive and non-magnetic fluid example in fluid metals, hot ionized gases (plasmas) or effective electrolytes. The attractive field can incite flows in such a moving liquid and this produces powers acting in the fluid and changes 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 impact of the attractive area at the boundary layers. It used for geophysics, hydrology, cooling system designs. As a result small difference moving produces electrical flows, which creates attractive field.

Goud et al. [1] 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 examination is slant point on the stream phenomenon within a heat source or sink along with a critical response. Separate of Galerkin defining element method. Muthucumaraswamy, R., and V. Valliammal [2] has investigated an optimal result of an unstable movement over an exponentially quickened unbounded isothermic vertical plate with identical mass scattering in the view of a transversal hypnotic field.

Pattnaik [3] has considered the impact of mass transfer and heat energy on MHD without conduction stream over exponentially revived perpendicular plate in a permeable moderate using focus and movable temperature. The visible liquid is gray, retaining radiation however moderate collection. If the radiation limit 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 [4] have investigated the impacts of identical magnetic area via permeable mode a viscous extreme perpendicular plate of a compact overseeing electric liquid have studied impacts of relative heat source of temperature at past convection and mass transfer flow. The heated grash of value indicates the impact of warming flows, also gets zero, up and down qualities.

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Nomenclatures

A	Constants
B_0	external magnetic field
C	dimensionless concentration
C_p	specific heat at constant pressure J k g^{-1} k
C'	species concentration in the fluid k gm^{-3}
C'_w	wall concentration in the fluid
C'_∞	concentration in the fluid far away from the plate
D	mass diffusion coefficient m^2s^{-1}
Gc	mass Grashof number
Gr	thermal Grashof number
g	acceleration due to gravity m^2s^{-1}
k	thermal conductivity W$m^{-1}k^{-1}$
Pr	Prandtl number
Sc	Schmidt number
T	temperature of the fluid near the plate
T_w	temperature of the plate
T_∞	temperature of the fluid far away from the plate
T	dimensionless time
t'	time s
u	velocity of the fluid in the x' – direction ms^{-1}
u_0	velocity of the plate ms^{-1}
U	dimensionless velocity
y	co-ordinate axis normal to the plate m
Y	dimensionless coordinate axis normal to the plate
M	magnetic field parameter

Greek symbols

β	volumetric coefficient of thermal expansion K^{-1}
β^*	volumetric coefficient of expansion with concentration K^{-1}
μ	coefficient of viscosity Ra s
v	kinematic viscosity m^2s^{-1}
σ	electrical conductivity
ρ	density of the fluid kgm^{-3}
τ	dimensionless skin- friction k gm^{-3}
θ	dimensionless temperature
μ	similarity parameter
erfc	complementary error function

Subscripts

w	conditions at the wall
∞	free stream conditions

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 [5] has advanced to inspect the impact of temperature based heat source being without transient displacement and amass exchange stream of an elasto-thick liquid over an aggressive quickened endless perpendicular plate within the sight of attractive area within permeable form. In this paper talked about speed field on both cooling and warming of the plate.

Reddy et.al [6] have researched a thick, non-compressible flow electrically determined, moving free temperature outline flow. At nearness of a radiative and biochemical response 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 of flow use uniform speed 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 [7]

2. Mathematical formulation

The transitory movement of an infinite vertical plate past viscous and electrically conductive viscous fluid with varying temperature through a porous medium is considered. It is expected that the constant asset B_0a hypnotic area (virtual to the plate) is used inversely to the plate. The prompted hypnotic area is overlooked since the hypnotic reynolds value of movement is minuscule. The stream is taken in x' - axle taking upwards through vertical plate. y'- axle line is set aside even to the plate. Originally the liquid and also the plate are standing at the related temperature T'_∞ at all points with concentration level C'_∞. At $t' > 0$, the plate accelerates exponentially through a speed velocity $u = u_0 \exp(a't')$in its specific level and the plate temperature is linear and high among time duration t also together to plate. The focus near is high elevated to C'_w. The impact of thick scattering considered slight. By the estimate of the steady Boussinesq's, the instable movement is overseen in the below equations.

$$\frac{\partial u'}{\partial t'} = g\beta(T' - T'_\infty) + g\beta^*(C' - C'_\infty) + v\frac{\partial^2 u'}{\partial y'^2} - \frac{\sigma B_0^2}{\rho}u' - \frac{vu'}{K} \quad (1)$$

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

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

Along with the basic and limit constrains:

$$\begin{aligned} &t' \le 0 \quad u' = 0, \quad T' = T'_\infty, \quad C' = C'_\infty \quad \text{for all} \quad y' \le 0 \\ &t' > 0 \quad u' = u_0 \exp(a't'), \quad T' = T'_\infty + \left(T'_w - T'_\infty\right)At', \\ &C' = C'_w \quad \text{at} \quad y' = 0 \\ &u' \to 0, \quad T' \to T'_\infty, \quad C' \to C'_\infty \quad \text{as} \quad y' \to \infty \end{aligned} \quad (4)$$

where $A = \frac{u_0^2}{v}$

On presenting the resulting dimensionless magnitudes:

$$u = \frac{u'}{u_0}, \quad t = \frac{t'u_0'}{v}, \quad y = \frac{y'u_0}{v}, \quad \theta = \frac{T' - T'_\infty}{T'_w - T'_\infty}, \quad G_r = \frac{g\beta v(T'_w - T'_\infty)}{u_0^3}, \quad C = \frac{C' - C'_\infty}{C'_w - C'_\infty},$$
$$G_c = \frac{g\beta v\left(C'_w - C'_\infty\right)}{u_0^3}, \quad M = \frac{\sigma B_0^2 v}{\rho u_0^2}, \quad P_r = \frac{\mu C_p}{k}, \quad S_c = \frac{v}{D}, \quad a = \frac{a'v}{u_0^2}, \quad K = \frac{u_0^2 K'}{v^2} \quad (5)$$

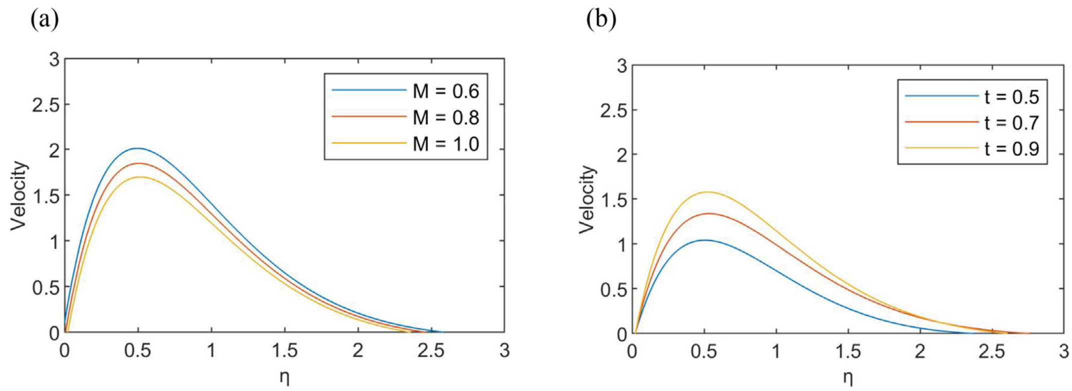

Fig. 1. (a) Velocity profiles when $G_r = 10, G_c = 5, P_r = 0.71, S_c = 0.22$, K = 2, a = 1, t = 1. (b) Velocity profiles when$G_r = 10, G_c = 5, P_r = 0.71, S_c = 0.22$, K = 2, a = 1, M = 1.

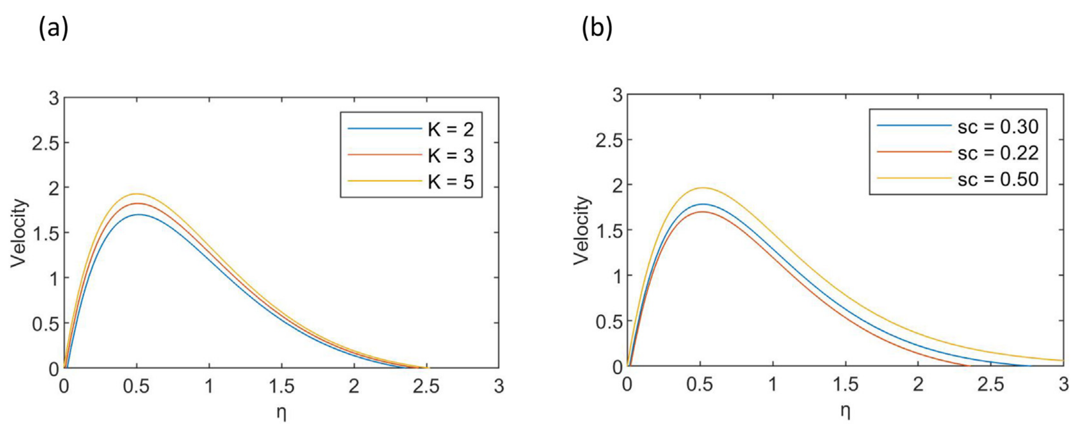

Fig. 2. (a) Velocity profiles while $G_r = 10, G_c = 5, P_r = 0.71, S_c = 0.22$ M = 1, a = 1, t = 1. (b) Velocity profiles while $G_r = 10, G_c = 5, P_r = 0.71$, M = 1, K = 2, a = 1, t = 1.

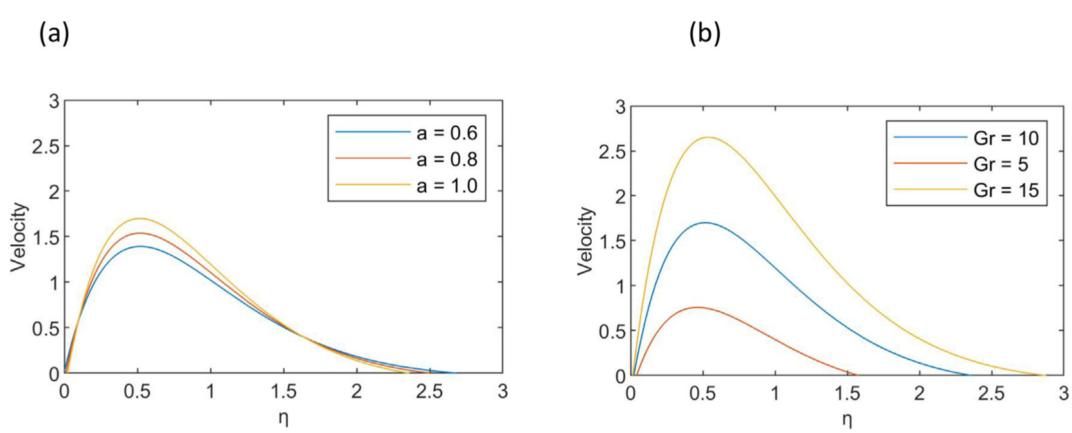

Fig. 3. (a) Velocity profiles when $G_r = 10, G_c = 5, P_r = 0.71, S_c = 0.22$, K = 2, M = 1, t = 1. (b) Velocity outlines while $G_c = 5, P_r = 0.71, S_c = 0.22$, K = 2, M = 1, a = 1, t = 1.

in Eqs. (1)–(4), leads to

$$\frac{\partial q}{\partial t} = G_r\theta + G_cC + \frac{\partial^2 q}{\partial z^2} - \text{mq} - \frac{q}{K} \tag{6}$$

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

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

With the initial and limit constrains

$$\begin{aligned} &t \leqslant 0: \quad q = 0, \quad \theta = 0, \quad C = 0 \quad \text{for all} \quad z \\ &t > 0: \quad q = e^{at}, \quad \theta = e^{at}, \quad C = e^{at} \quad \text{at} \quad z = 0 \\ &q \to 0, \quad \theta \to 0, \quad C \to 0 \quad \text{as} \quad z \to \infty \end{aligned} \tag{9}$$

The non-dimensional quantities are stated in the classification.

3. Method of solution

The dimensionless overseeing Eqs. (6)–(8), sub to consistent starting limit constrains [5], also handled utilizing Laplace transforms strategy also result determined in this way:

$$\theta = \frac{e^{at}}{2}\left[\exp(-\sqrt{Pra})\mathrm{zerfc}(\eta\sqrt{Pr}-\sqrt{at}) + exp\sqrt{Pra}\mathrm{zerfc}(\eta\sqrt{Pr}+\sqrt{at})\right] \quad (10)$$

$$C = \frac{e^{at}}{2}\left[\exp(-\sqrt{Sca})\mathrm{zerfc}(\eta\sqrt{Sc}-\sqrt{at}) + exp\sqrt{Sca}\mathrm{zerfc}(\eta\sqrt{Sc}+\sqrt{at})\right] \quad (11)$$

$$\begin{aligned} q = {} & \frac{e^{at}}{2}\begin{bmatrix} exp(-2\eta\sqrt{(a+m+\frac{1}{k})t})\mathrm{erfc}(\eta-\sqrt{(a+m+\frac{1}{k})t})+ \\ exp(2\eta\sqrt{(a+m+\frac{1}{k})t})\mathrm{erfc}(\eta+\sqrt{(a+m+\frac{1}{k})t}) \end{bmatrix} \\ & -\frac{G_r}{(a-(b+d))(1-P_r)}\frac{e^{at}}{2} \\ & \times\begin{bmatrix} exp(-2\eta\sqrt{(a+m+\frac{1}{k})t})\mathrm{erfc}(\eta-\sqrt{(a+m+\frac{1}{k})t})+ \\ exp(2\eta\sqrt{(a+m+\frac{1}{k})t})\mathrm{erfc}(\eta+\sqrt{(a+m+\frac{1}{k})t}) \end{bmatrix} \\ & -\frac{G_r}{((b+d)-a)(1-P_r)}\frac{e^{(b+d)t}}{2} \\ & \times\begin{bmatrix} exp(-2\eta\sqrt{(b+d+m+\frac{1}{k})t})\mathrm{erfc}(\eta-\sqrt{(b+d+m+\frac{1}{k})t})+ \\ exp(2\eta\sqrt{(b+d+m+\frac{1}{k})t})\mathrm{erfc}(\eta+\sqrt{(b+d+m+\frac{1}{k})t}) \end{bmatrix} \\ & -\frac{G_c}{(a-(c+f))(1-Sc)}\frac{e^{at}}{2} \\ & \times\begin{bmatrix} exp(-2\eta\sqrt{(a+m+\frac{1}{k})t})\mathrm{erfc}(\eta-\sqrt{(a+m+\frac{1}{k})t})+ \\ exp(2\eta\sqrt{(a+m+\frac{1}{k})t})\mathrm{erfc}(\eta+\sqrt{(a+m+\frac{1}{k})t}) \end{bmatrix} \\ & -\frac{G_c}{((c+f)-a)(1-Sc)}\frac{e^{(c+f)t}}{2} \\ & \times\begin{bmatrix} exp(-2\eta\sqrt{(c+f+m+\frac{1}{k})t})\mathrm{erfc}(\eta-\sqrt{(c+f+m+\frac{1}{k})t})+ \\ exp(2\eta\sqrt{(c+f+m+\frac{1}{k})t})\mathrm{erfc}(\eta+\sqrt{(c+f+m+\frac{1}{k})t}) \end{bmatrix} \\ & +\frac{G_r}{(a-(b+d))(1-P_r)}\frac{e^{at}}{2}\begin{bmatrix} \exp\left(-2\eta\sqrt{Prat}\right)erfc\left(\eta\sqrt{Pr}-\sqrt{at}\right)+ \\ \exp\left(2\eta\sqrt{Prat}\right)erfc\left(\eta\sqrt{Pr}+\sqrt{at}\right) \end{bmatrix} \\ & ++\frac{G_r}{((b+d)-a)(1-Pr)}\frac{e^{(b+d)t}}{2} \\ & \times\begin{bmatrix} exp(-2\eta\sqrt{\mathrm{Pr}(b+d)t})\mathrm{erfc}(\eta\sqrt{Pr}-\sqrt{(b+d)t})+ \\ exp(2\eta\sqrt{\mathrm{Pr}(b+d)t})\mathrm{erfc}(\eta\sqrt{Pr}+\sqrt{(b+d)t}) \end{bmatrix} \\ & +\frac{G_c}{(a-(c+f))(1-Sc)}\frac{e^{at}}{2}\begin{bmatrix} exp(-2\eta\sqrt{Scat})\mathrm{erfc}(\eta\sqrt{Sc}-\sqrt{at})+ \\ exp(2\eta\sqrt{Scat})\mathrm{erfc}(\eta\sqrt{Sc}+\sqrt{at}) \end{bmatrix} \\ & +\frac{G_c}{((c+f)-a)(1-Sc)}\frac{e^{(c+f)t}}{2} \\ & \begin{bmatrix} exp(-2\eta\sqrt{Sc(c+f)t})\mathrm{erfc}(\eta\sqrt{Sc}-\sqrt{(c+f)t})+ \\ exp(2\eta\sqrt{Sc(c+f)t})\mathrm{erfc}(\eta\sqrt{Sc}+\sqrt{(c+f)t}) \end{bmatrix} \end{aligned} \quad (12)$$

where $b = \frac{m}{P_r-1}, c = \frac{m}{S_c-1}, d = \frac{1}{k(P_r-1)}, f = \frac{1}{k(S_c-1)} and \eta = \frac{z}{2\sqrt{t}}$

4. Results and discussion

Analysis the decision of the warmth resources the plate step up on its retain level with velocity $u = u_0\exp(a't')$ numerical calculations are made for distinct ideals of G_r (heat grashof value), G_c (Mass grashof value), S_C (Schmidt value), M (Magnetic field parameter), K (Permeability parameter), a (Accelerating parameter), After prandtl value P_r like 0.71 corresponding to the air. This is disclose the distinct outcomes limits in the dimensionless velocity outline, temperature outline, concentration outline.

Fig. 1(a) represents the velocity outlines for distinct ideals of magnetic parameter (M = 0.6, 0.8, 1.0), $G_r = 10$, G_c=5, P_r = 0.71, S_c = 0.22, K = 2, a = 1 of the plate at t = 1. As of the diagram it is establish that the velocity growths through the decrease in M. Fig. 1.(b) represents the velocity outlines for distinct ideals of time (t = 0.5, 0.7, 0.9), $G_r = 10$, G_c= 5, P_r = 0.71, S_c = 0.22 , K = 2, M = 1 and a = 1. From this figure the velocity is discovered to growth with raise in time duration t of the plate.

Fig. 2.(a) represents the velocity outlines as a result of the variations in permeability limitation (K = 2, 3, 5), $G_r = 10$, G_c = 5, P_r = 0.71, S_c = 0.22 , M = 1, a = 1 of the plate at t = 1. As of the diagram the velocity is viewed to growth rise with increase in permeability parameter K of the plate. This is caused by the information that the transposition growths the resistivity of a porous medium Fig. 2.(b) represents the velocity outlines for distinct ideals of schmidt value (S_c = 0.22, 0.3, 0.5), $G_r = 10$, G_c= 5, P_r = 0.71, M = 1, K = 2, a = 1of the plate at t = 1. From the diagram it is found that the velocity raises with an increase in S_c

Fig. 3(a) denotes the velocity outlines for distinct ideals of accelerating limitation (a = 0.6, 0.8, 1.0), $G_r = 10$, G_c= 5, P_r = 0.71, S_c = 0.22 , M = 1, K = 2 of the plate at t = 1. The velocity from the figures raises with an increase in a (accelerating parameter) of the plate. It is also found that the liquid velocity caused by the involuntary beginning of the plate (a is equal to zero) is less than due to the exponentially accelerated start (a is not equal to zero) of the plate. Fig. 3(b) denotes the velocity differences with thermal grashof number (G_r = 15, 10, 5),G_c = 5, P_r = 0.71, S_c = 0.22 , M = 1, K = 2, a = 1 of the plate at t = 1. From the figures it is viewed that the velocity raises through an expansion in heated grashof value G_r of the plate. It is as a outcome of the information growth in the assessments of thermal Grashof value is partiality to raise the mass elasticity outcomes. This assigns elevation to an expansion in the prompted Stream.

Fig. 4(a) represents the concentration outlines for distinct values of accelerating limitation (a = 1, a = 2, a = 3), S_c = 0.22 of the plate at t = 0.5. The concentration from the figures increases along with raise in a (accelerating parameter) of the plate. Fig. 4(b) represent the temperature outlines for distinct values of accelerating limitation (a = 1, a = 2, a = 3), P_r = 0.71 of the plate at t = 0.5. The temperature from the figures increases along with grows a (accelerating parameter) of the plate.

5. Conclusion

In this study we investigate the heat source impact of mhd and scattering intake of the liquid flow movement preceding an exponentially augmented vertical plate with permeable medium. Clarifications to the ideal comprehended via Laplace transformation method. The effects of distinct parameters on the velocity, temperature and concentration fields are studied graphically. The results of this examination are (i) The Velocity profiles increments with an decrease in magnetic parameter M. (ii) The velocity growth through an expansion in time t of the plate. (iii) The velocity is seen to raises through an expansion in permeability parameter K of the plate. (iv) the velocity growths through an raise in Schmidt number

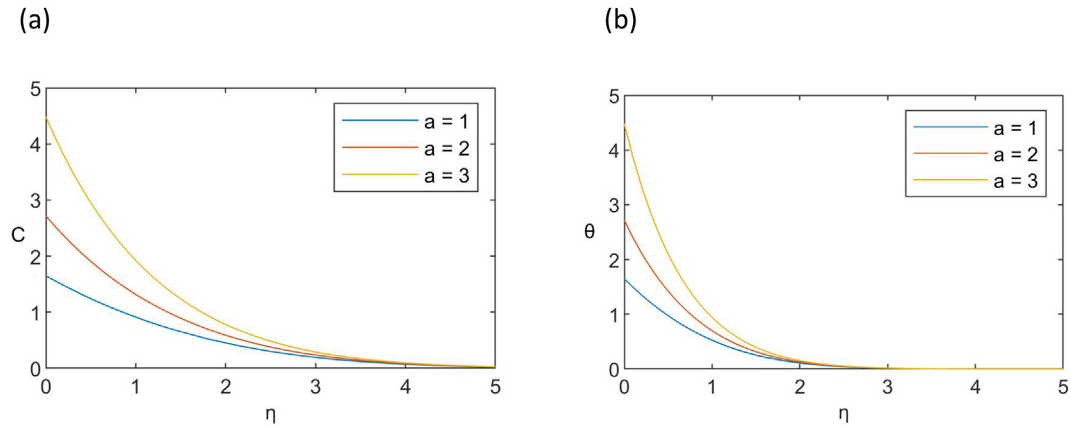

Fig. 4. (a) Concentration profiles when S_c = 0.22, t = 0.5. (b) Temperature profiles when P_r = 0.71, t = 0.5.

S_c . (v) The velocity is establish to raises through an increment in a (accelerating limitations) of the plate. (vi) the velocity grows with an increase in heat thermal grashof value G_r of the plate. (vii) The presence of the hypnotic parameter diminishes as the velocity increments with the increase of absorptivity of the porous medium. (viii) The concentration and temperature increases along with grows in accelerating parameter a of the plate.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] B. Goud, B. Shankar, Suresh Babu, M.N. Raja Shekar, G. Srinivas, Mass transfer effects on MHD flow through porous medium past an exponentially accelerated inclined plate with variable temperature and thermal radiation, Int. J. Thermofluid Sci. Technol. 6 (2019) 19060402.
[2] R. Muthucumaraswamy, V. Valliammal, Hydromagnetic flow past an exponentially accelerated isothermal vertical plate with uniform mass diffusion in the presence of chemical reaction of first order, Int. J. Appl. Mech. Eng. 18 (1) (2013) 259–267.
[3] J.R. Pattnaik, G.C. Dash, S. Singh, Radiation and mass transfer effects on MHD free convection flow through porous medium past an exponentially accelerated vertical plate with variable temperature, Ann. Faculty Eng. Hunedoara 10 (3) (2012) 175.
[4] V. Rajesh, 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. Appl. Math Mech. 6 (12) (2010) 68–78.
[5] Varma Rajesh, Heat source and mass transfer effects on MHD flow of an elasto-viscous fluid through a porous medium, Ann. Faculty Eng. Hunedoara 9 (2) (2011) 205.
[6] T.S. Reddy, M. C. Raju, and S. V. K. Varma. "Unsteady MHD radiative and chemically reactive free convection flow near a moving vertical plate in porous medium." (2013): 443-451.
[7] G.S. Seth, A.K. Singha, 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.

Further Reading

[1] Perugu Mohana Kishore, Vemula Rajesh, S.V.K. Varma, Effects of heat transfer and viscous dissipation on MHD free convection flow past an exponentially accelerated vertical plate with variable temperature, J. Naval Architect. Marine Eng. 7 (2) (2010) 101–110.
[2] S. Mondal, S. Parvin, S.F. Ahmmed, Effects of radiation and chemical reaction on MHD free convection flow past a vertical plate in the porous medium, Am. J. Eng. Res. (AJER) 3 (2014) 15–22.
[3] R. Muthucumaraswamy, N. Dhanasekar, G. Easwara Prasad, MHD and rotation effects on flow past an accelerated vertical plate with variable temperature and mass diffusion in the presence of chemical reaction, Int. J. Appl. Mech. Eng. 18 (4) (2013) 1087–1097.
[4] V. Rajesh, MHD effects on free convection and mass transform flow through a porous medium with variable temperature, Int. J. Appl. Math Mech. 6 (14) (2010) 1–16.
[5] P.G. Reddy, M. Umamaheswar, M.C. Raju, S.V.K. Varma, Magneto-convective and radiation absorption fluid flow past an exponentially accelerated vertical porous plate with variable temperature and concentration, Int. J. Math. Trends Technol. (IJMTT) 31 (1) (2016).
[6] N. Sandeep, V. Sugunamma, Radiation and inclined magnetic field effects on unsteady hydromagnetic free convection flow past an impulsively moving vertical plate in a porous medium, J. Appl. Fluid Mech. 7 (2) (2014) 275–286.
[7] M. Thamizhsudar, J. Pandurangan, R. Muthucumaraswamy, Hall effects and rotation effects on MHD flow past an exponentially accelerated vertical plate with combined heat and mass transfer effects, Int. J. Appl. Mech. Eng. 20 (3) (2015) 605–616.
[8] Sami Ulhaq, Ilyas Khan, Farhad Ali, Sharidan Shafie, Radiation and magnetohydrodynamics effects on unsteady free convection flow in a porous medium, Math. Probl. Eng. 2013 (2013).