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HEAT AND MASS TRANSFER ON FLOW PAST AN ACCELERATED PLATE THROUGH POROUS MEDIUM WITH VARIABLE TEMPERATURE AND MASS DIFFUSION IN PRESENCE OF HEAT SOURCE/SINK

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A study to look at how heat and mass transfer affect unsteady MHD flow across an accelerated plate with changing temperature and mass diffusion in the appearance of a heat source (or sink) through porous medium is presented. Initially the temperature and concentration of the fluid and plate are considered to be same at $t' \leq 0$. At $t' > 0$, an impulsive uniform acceleration A is applied to the plate in a vertical upward direction. The non-dimensionalised governing equations defining the flow problem are solved using Laplace transform approach. Effect of various physical quantities involved in the velocity, concentration, temperature, the rate of heat transfer and also the rate of mass transfer are investigated through graphs and tables and discussed.

Keywords: *Heat transfer; Mass transfer; Accelerated plate; Porous medium; Laplace Transform*

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1. INTRODUCTION

In nature, the action of mass and heat transfer inside a fluid occurs because of the concentration differences and temperature differences. The outcome of heat and mass transfer on MHD fluid has drawn the attraction of numerous researchers due to its diverse applications . Many reserchers have carried out numerious studies in this field under various flow situation. Heat and mass transmission play crucial role in many different fields including pump, compressor, steam-electric power generation, automobiles, power plant, gas turbine, energy utilization, food processing, etc. MHD effect on an impulsively begun perpendicular unbounded plate with uncertain temperature in the appearance of a transverse magnetic field were investigated by Soundalgekar et al [12]. Soundalgekar et al. [11] also examined how the mass transfer can effect on the flow of an incompressible, electrically conducting fluid past an impulsively begun unbounded isothermal vertical plate for a transversely applied magnetic field. Kumar et al. [8] studied the impact of an impulsive motion on the growth of two-dimensional boundary layer having applied magnetic field. Variations in mixed convection on an isothermal perpendicular plate due to radiation have been taken into account by Hossain and Takhar [5]. The stationary vertical plate was taken into account in all of the investigations above. The effects of MHD and radiation along a moving, isothermal perpendicular plate with variable mass diffusion have been explored by Muthucumaraswamy et al. [9]. The impacts of heat radiation and free convection flow through a moving perpendicular plate were investigated by Raptis and Perdikis [10]. Das et al. [4] have explored the impact of radiation on flow past an abruptly began unbounded isothermal perpendicular plate.

The thermal diffusion effect on MHD free convection and mass transfer flows have been examined by Alam and Sattar [3]. Jha and Singh [6] conducted research on the content of thermal-diffusion effects (mass diffusion caused by temperature differential). The thermal-diffusion effect on impulsively started perpendicular porous plates, changeable MHD free convection, and also mass transfer flow was examined by Alam et al. [1]. Alam et al [2] investigated coupled free convection and mass transfer flow and thermal diffusion in porous medium through a perpendicular plate. The impacts of heat radiation and diffusion on MHD flow via a perpendicular plate with varying temperature and mass diffusion were investigated by Rajesh and Varma [13]. The effects of radiation and thermal diffusion on changeable MHD flow through porous media having inconsistent mass diffusion and changing temperature were studied by Kumar and Varma [14]. Khan et al. [15] examine the combined impacts of heat and mass transport on the free convection, unstable magnetohydrodynamic flow of viscous fluid immersed in a porous media. They found that with the increasing values of Prandtl number, the fluid concentration rises. The impacts of radiation and thermal diffusion on changeable MHD flow via a vertically accelerated porous plate with changeable temperature and changeable mass diffusion while being affected by an applied transverse magnetic field, when a heat source or sink is present are investigated by Ramana Reddy et al. [16]. Thermal Stratification's impact on the flow through an infinite vertical plate was studied by Nath et al. [18]. Kalita et al. [19] examined the effect of thermal stratification on the flow passing

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an accelerated plate with changeable temperature. Kumar et al. [20] studied how mass stratification effects the unsteady flow while passing an accelerated plate with variable temperature..
Motivated from the study of the above discussions the current objective is to understand the effect of heat and mass transfer in the presence of a heat source or sink through a porous media on changeable MHD flow past an accelerating plate with varying temperature and mass diffusion. Laplace transform approach is used to derived the solution. The Sherwood and Nusselt numbers are derived. The found answer is represented in respects of complementary error functions and exponential functions.

2. MATHEMATICAL FORMULATION

We consider the unstable laminar free convection flow of an incompressible viscous fluid past a plate that is propelled impulsively and has variable mass diffusion and temperature. Also the fluid is electrically conducting fluid. Here, the plate is taken vertically upward along the x'-axis, and the y'-axis is considered perpendicular with respect to plate. It is considered that the fluid and plate are initially at the same concentration C'_∞ and temperature T'_∞ at $t' \leq 0$. At $t' > 0$, an impulsive uniform acceleration A is applied to the plate in a vertical upward direction. Both the temperature level and concentration level are raised from T'_∞ and C'_∞ to T'_w and C'_w respectively . The viscous dissipation is regarded as insignificant. Also the induced magnetic field is considered insignificant. With the standard Boussinesq's approximation under this supposition, the governing equations are:

$$\frac{\partial u^{'}}{\partial t^{'}} = g\beta(T^{'} - T^{'}_{\infty}) - \frac{\sigma\beta_0^2 u'}{\rho} + g\beta^*(C^{'} - C^{'}_{\infty}) + \nu\frac{\partial^2 u^{'}}{\partial y'^2} - \nu\frac{u^{'}}{K'} \tag{1}$$

$$\rho C_p\frac{\partial T^{'}}{\partial t^{'}} = \kappa\frac{\partial^2 T^{'}}{\partial y'^2} - \frac{\partial q_r}{\partial y^{'}} + Q^{'}(T^{'}_{\infty} - T^{'}) \tag{2}$$

$$\frac{\partial C^{'}}{\partial t^{'}} = D\frac{\partial^2 C^{'}}{\partial y'^2} + D_1(\frac{\partial^2 T^{'}}{\partial y'^2}) \tag{3}$$

with the folowing initial and boundary conditions

$$\begin{gathered} t^{'} \leq 0 : u^{'} = 0, T^{'} = T^{'}_{\infty}, C^{'} = C^{'}_{\infty}, \quad for \quad all \quad y^{'} \\ t^{'} > 0 : u^{'} = At^{'}, T^{'} = T^{'}_{\infty} + (T^{'}_{w} - T^{'}_{\infty})Bt^{'}, C^{'} = C^{'}_{\infty} + (C^{'}_{w} - C^{'}_{\infty})Bt^{'} \quad at \quad y^{'} = 0 \\ u^{'} = 0, T^{'} \to T^{'}_{\alpha}, C^{'} \to C^{'}_{\infty} \quad as \quad y^{'} \to \infty \end{gathered} \tag{4}$$

where $B = \frac{u_0^2}{v}$ and A $\rightarrow$ uniform acceleration of the plate.

Using the Roseland approximation, the radioactive heat flux term of an optically very thin fluid is made simpler.

$$q_r = -\frac{4\sigma^*}{3k'}\frac{\partial T'^4}{\partial y'} \tag{5}$$

It is assumed that T'^4 may be represented as a linear function of temperature and that the temperature differences inside the flow are suitably modest. This is achieved by disregarding the higher order terms and expanding T'^4 in a Taylor series up to T'_∞, thus we get

$$T'^4 \cong 4T'^3_{\infty}T^{'} - 3T'^4_{\infty} \tag{6}$$

With the help equations (5) and (6), from equation (2) we have

$$\frac{\rho C_p}{\kappa}\frac{\partial T'}{\partial t'} = \frac{\partial^2 T'}{\partial y'^2}(1 + \frac{16\sigma^* T'^3_{\infty}}{3\kappa k'}) + \frac{Q'}{\kappa}(T'_{\infty} - T') \tag{7}$$

On defining the following dimensionless variables:

$$u = \frac{u'}{(A\nu)^{\frac{1}{3}}}, \quad t = t'(\frac{A^2}{\nu})^{\frac{1}{3}}, \quad y = y'(\frac{A}{\nu^2})^{\frac{1}{3}}, \quad C = \frac{C^{'} - C^{'}_{\infty}}{C^{'}_{w} - C^{'}_{\infty}}, \quad \theta = \frac{T^{'} - T^{'}_{\infty}}{T^{'}_{w} - T^{'}_{\infty}},$$

$$Pr = \mu\frac{C_p}{\kappa}, \quad Gr = \frac{g\beta(T'_w - T'_{\infty})}{A}, \quad M^2 = \frac{\sigma\beta_0^2\nu^{\frac{1}{3}}}{\rho A^{\frac{2}{3}}}, \quad Gm = \frac{g\beta^*(C'_w - C'_{\infty})}{A},$$

$$Sc = \frac{\nu}{D}, \quad K = \frac{K' A^{\frac{2}{3}}}{\nu^{\frac{4}{3}}}, \quad R = \frac{16\sigma^* T_{\infty}^{'3}}{3\kappa k'}, \quad S_0 = \frac{D_1(T_w^{'} - T_{\infty}^{'})}{\nu(C_w^{'} - C_{\infty}^{'})}, \quad H = \frac{Q'}{\kappa}\left(\frac{\nu^2}{A}\right)^{\frac{2}{3}} \tag{8}$$

we get the follwoing dimensionless governing equation:

$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial y^2} + Gr\theta + GmC - Zu \tag{9}$$

$$\frac{\partial \theta}{\partial t} = \frac{(1+R)}{Pr}\frac{\partial^2 \theta}{\partial y^2} - \frac{H\theta}{Pr} \tag{10}$$

$$\frac{\partial C}{\partial t} = \frac{1}{Sc}\frac{\partial^2 C}{\partial y^2} + S_0\frac{\partial^2 \theta}{\partial y^2} \tag{11}$$

and the relevant corresponding initial and boundary conditions are:

$$\begin{gathered} t \leq 0: \quad u = 0, \quad \theta = 0, \quad C = 0 \quad for \quad all \quad y \\ t > 0; \quad u = t, \quad \theta = t, \quad C = t \quad at \quad y = 0 \\ u \to 0, \quad \theta \to 0, \quad C \to 0 \quad as \quad y \to \infty \end{gathered} \tag{12}$$

Here the non-dimensional velocity, concentration, temperature and time are denoted by u, C, θ and t respectively. $C_p \to$ specific heat at constant pressure, $\beta^{'}$ and $\beta \to$ concentration and thermal expansion coefficients respectively, D is chemical mass diffusivity, $D_1 \to$ coefficient of thermal diffusivity, $\rho \to$ fluid density, $\beta_0 \to$ magnetic induction, $\mu \to$ coefficient of viscosity, ν is the kinematic viscosity, R $\to$ Radiation parameter, Gr $\to$ Thermal Grashof number, Gm $\to$ Mass Grashof number, M $\to$ magnetic field parameter, Pr $\to$ Prandtl number, Sc $\to$ Schmidt number, $S_0 \to$ Soret number, K $\to$ permeability parameter, H $\to$ Heat source parameter.

3. ANALYTICAL SOLUTION

Solutions of the non-dimensional governing equations (9), (10) and (11) with regard to the boundary condition (12) are solved using Laplace transform approach. We attained solutions as :

$$\begin{aligned} \theta(y,t) = {} & (\frac{t}{2} + \frac{yX}{4\sqrt{Y}})exp(y\sqrt{Y})erfc(\frac{y\sqrt{X}}{2\sqrt{t}} + \sqrt{\frac{Yt}{X}}) + (\frac{t}{2} - \frac{yX}{4\sqrt{Y}})exp(-y\sqrt{Y}) \\ & erfc(\frac{y\sqrt{X}}{2\sqrt{t}} - \sqrt{\frac{Yt}{X}}) \end{aligned} \tag{13}$$

$$\begin{aligned} C(y,t) = {} & (1+e)\left[(t + \frac{y^2 Sc}{2})erfc(\frac{y\sqrt{Sc}}{2\sqrt{t}}) - y\sqrt{\frac{tSc}{\pi}}exp(-\frac{y^2 Sc}{4t})\right] + (d - \frac{e}{j})erfc(\frac{y\sqrt{Sc}}{2\sqrt{t}}) \\ & -\frac{1}{2}(d - \frac{e}{j})exp(-jt)\left[exp(y\sqrt{-jSc})erfc(\frac{y\sqrt{Sc}}{2\sqrt{t}} + \sqrt{-jt}) + exp(-y\sqrt{-jSc})\right. \\ & \left. erfc(\frac{y\sqrt{Sc}}{2\sqrt{t}} - \sqrt{-jt})\right] - \frac{1}{2}(d - \frac{e}{j})\left[exp(y\sqrt{Y})erfc(\frac{y\sqrt{X}}{2\sqrt{t}} + \sqrt{\frac{Yt}{X}}) + exp(-y\sqrt{Y})\right. \\ & \left. erfc(\frac{y\sqrt{X}}{2\sqrt{t}} - \sqrt{\frac{Yt}{X}})\right] - e\left[(\frac{t}{2} + \frac{yX}{4\sqrt{Y}})exp(y\sqrt{Y})erfc(\frac{y\sqrt{X}}{2\sqrt{t}} + \sqrt{\frac{Yt}{X}})\right. \\ & \left. +(\frac{t}{2} - \frac{yX}{4\sqrt{Y}})exp(-y\sqrt{Y})erfc(\frac{y\sqrt{X}}{2\sqrt{t}} - \sqrt{\frac{Yt}{X}})\right] + \frac{1}{2}(d - \frac{e}{j})exp(-jt)\left[exp(y\sqrt{(Y - jX)})\right. \\ & \left. erfc(\frac{y\sqrt{X}}{2\sqrt{t}} + \sqrt{(\frac{Y}{X} - j)t}) + exp(-y\sqrt{(Y - jX)})erfc(\frac{y\sqrt{X}}{2\sqrt{t}} - \sqrt{(\frac{Y}{X} - j)t})\right] \end{aligned} \tag{14}$$

$$\begin{aligned} u(y,t) = {} & (\frac{t}{2} + \frac{y}{4\sqrt{Z}})exp(y\sqrt{Z})erfc(\frac{y}{2\sqrt{t}} + \sqrt{Zt}) + (\frac{t}{2} - \frac{y}{4\sqrt{Z}})exp(-y\sqrt{Z}) \\ & erfc(\frac{y}{2\sqrt{t}} - \sqrt{Zt}) + A_1\left[(\frac{t}{2} + \frac{yX}{4\sqrt{Y}})exp(y\sqrt{Y})erfc(\frac{y\sqrt{X}}{2\sqrt{t}} + \sqrt{\frac{Yt}{X}})\right. \\ & \left. +(\frac{t}{2} - \frac{yX}{4\sqrt{Y}})exp(-y\sqrt{Y})erfc(\frac{y\sqrt{X}}{2\sqrt{t}} - \sqrt{\frac{Yt}{X}})\right] + A_2\left[(t + \frac{y^2 Sc}{2})erfc(\frac{y\sqrt{Sc}}{2\sqrt{t}})\right. \end{aligned}$$

$$-y\sqrt{\frac{tSc}{\pi}}exp(-\frac{y^2Sc}{4t})\Big] - (A_1 + A_2)\Big[(\frac{t}{2} + \frac{y}{4\sqrt{Z}})exp(y\sqrt{Z})erfc(\frac{y}{2\sqrt{t}} + \sqrt{Zt})$$
$$+(\frac{t}{2} - \frac{y}{4\sqrt{Z}})exp(-y\sqrt{Z})erfc(\frac{y}{2\sqrt{t}} - \sqrt{Zt})\Big] + \frac{A_3}{2}exp(-jt)\Big[exp(-y\sqrt{(Y - jX)})$$
$$erfc(\frac{y\sqrt{X}}{2\sqrt{t}} - \sqrt{(\frac{Y}{X} - j)t}) + exp(y\sqrt{(Y - jX)})erfc(\frac{y\sqrt{X}}{2\sqrt{t}} + \sqrt{(\frac{Y}{X} - j)t})\Big]$$
$$-\frac{A_4}{2}exp(-jt)\Big[exp(y\sqrt{-jSc})erfc(\frac{y\sqrt{Sc}}{2\sqrt{t}} + \sqrt{-jt}) + exp(-y\sqrt{-jSc})erfc(\frac{y\sqrt{Sc}}{2\sqrt{t}} - \sqrt{-jt})\Big]$$
$$+\frac{A_5}{2}exp(-lt)\Big[exp(y\sqrt{Z - l})erfc(\frac{y}{2\sqrt{t}} + \sqrt{(Z - l)t}) + exp(-y\sqrt{Z - l})$$
$$erfc(\frac{y}{2\sqrt{t}} - \sqrt{(Z - l)t})\Big] - \frac{A_5}{2}exp(-lt)\Big[exp(y\sqrt{Y - lX})erfc(\frac{y\sqrt{X}}{2\sqrt{t}} + \sqrt{(\frac{Y}{X} - l)t})$$
$$+exp(-y\sqrt{Y - lX})erfc(\frac{y\sqrt{X}}{2\sqrt{t}} - \sqrt{(\frac{Y}{X} - l)t})\Big] + \frac{A_6}{2}exp(ft)\Big[exp(y\sqrt{Z + f})$$
$$erfc(\frac{y}{2\sqrt{t}} + \sqrt{(Z + f)t}) + exp(-y\sqrt{Z + f})erfc(\frac{y}{2\sqrt{t}} - \sqrt{(Z - f)t})\Big]$$
$$-\frac{A_6}{2}exp(ft)\Big[exp(y\sqrt{fSc})erfc(\frac{y\sqrt{Sc}}{2\sqrt{t}} + \sqrt{ft}) + exp(-y\sqrt{fSc})erfc(\frac{y\sqrt{Sc}}{2\sqrt{t}} - \sqrt{ft})\Big]$$
$$+\frac{A_7}{2}\Big[exp(y\sqrt{Y})erfc(\frac{y\sqrt{X}}{2\sqrt{t}} + \sqrt{\frac{Yt}{X}}) + exp(-y\sqrt{Y})erfc(\frac{y\sqrt{X}}{2\sqrt{t}} - \sqrt{\frac{Yt}{X}})\Big] + A_8 erfc(\frac{y\sqrt{Sc}}{2\sqrt{t}})$$
$$-\frac{(A_7 + A_8)}{2}\Big[exp(y\sqrt{Z})erfc(\frac{y}{2\sqrt{t}} + \sqrt{Zt}) + exp(-y\sqrt{Z})erfc(\frac{y}{2\sqrt{t}} - \sqrt{Zt})\Big] \tag{15}$$

where

$$Z = M^2 + \frac{1}{K}, \quad X = \frac{Pr}{1 + R}, \quad Y = \frac{H}{1 + R}, \quad b = \frac{S_0 Sc}{1 + R}$$

$$j = \frac{Y}{X - Sc}, \quad d = \frac{bPr}{Y}, \quad e = \frac{b}{1 + R}, \quad f = \frac{Z}{Sc - 1}$$

$$A_1 = \frac{eGm - Gr}{Y - Z}, \quad A_2 = \frac{(1 + e)Gm}{Z}$$

$$A_3 = \frac{bGm(Y - jPr(1 + R))}{jY(1 + R)(Y - Z + j - jX)}$$

$$A_4 = \frac{bGm(Y - jPr(1 + R))}{jY(1 + R)(Y - Z + j - jX)}$$

$$A_5 = \frac{(X - 1)[YGr(Y - Z + j - jX) + bjGm(Pr(Z - Y) - \frac{Y(1-X)}{1+R})]}{Y(Y - Z)^2(Y - Z + j - jX)}$$

$$A_6 = \frac{(Sc - 1)Gm[Y(1 + R)(Z - j + jSc) + bjY(Sc - 1) + bjZPr(1 + R)]}{YZ^2(1 + R)(Z - j + jSc)}$$

$$A_7 = \frac{jY(X - 1)[Gr(1 + R) - bGm] + bGm[jPr(1 + R) - Y]}{jY(1 + R)(Y - Z)^2}$$

$$A_8 = \frac{Gm[(1+R)j(Y(Sc-1)+bPrZ)+bY(j(Sc-1)-Z)]}{jYZ^2(1+R)}$$

NUSSELT NUMBER

From temperature profile (13), the change rate of heat transfer is obtained as

$$\begin{aligned} Nu &= -\left[\frac{\partial\theta}{\partial y}\right]_{y=0} \\ Nu &= t\sqrt{Y}erf(\sqrt{\frac{Yt}{X}})+\sqrt{\frac{tX}{\pi}}\exp(-\frac{Yt}{X})+\frac{X}{2\sqrt{Y}}erf(\sqrt{\frac{Yt}{X}}) \end{aligned} \tag{16}$$

SHERWOOD NUMBER

From concentration profile (14), the change rate of mass transfer is obtained as

$$\begin{aligned} Sh &= -\frac{\partial C}{\partial y}\Big]_{y=0} \\ Sh &= 2(1+e)\sqrt{\frac{tSc}{\pi}}+(d-\frac{e}{j})\sqrt{\frac{Sc}{\pi t}}-(d-\frac{e}{j})\exp(-jt)\left[\sqrt{(-jSc)}erf(\sqrt{-jt})\right. \\ &\left.+\sqrt{\frac{Sc}{\pi t}}\exp(jt)\right]-(d-\frac{e}{j})\left[\sqrt{Y}erf(\sqrt{\frac{Yt}{X}})+\sqrt{\frac{X}{\pi t}}\exp(-\frac{Yt}{X})\right] \\ &-e\left[\frac{X}{2\sqrt{Y}}erf(\sqrt{\frac{Yt}{X}})+t\sqrt{Y}erf(\sqrt{\frac{Yt}{X}})+\sqrt{\frac{Xt}{\pi}}\exp(-\frac{Yt}{X})\right] \\ &+(d-\frac{e}{j})\exp(-jt)\left[\sqrt{Y-jX}erf\left(\sqrt{(\frac{Y}{X}-j)t}\right)+\sqrt{\frac{X}{\pi t}}\exp\left(-(\frac{Y}{X}-j)t\right)\right] \end{aligned} \tag{17}$$

4. RESULTS AND DISCUSSION

To examine the physical behaviour related to the problems, figures and tables are presented for velocity (u), temperature (θ) , concentration (C), Nusselt number (Nu), and Sherwood number (Sh), illustrating the results of numerous parameters involved in the problems. Figure (1) demonstrate how a magnetic field parameter affects fluid velocity. We have seen that when the magnetic parameter M increases, the velocity drops. It is due to the result of application of transverse magnetic fileds, a drag-like resistive force is created that tends to impede the flow of the fluid, reducing its velocity. Figure (2) and (3) are used to illustrate graphically how temperature and mass Grashof numbers (Gr and Gm) affect the velocity field. The fluid velocity increases as the thermal Grashof number or mass Grashof number increases when all other parameters remain constant. Figure (4) shows how the velocity field is affected by the thermal-diffusion parameter (S_0). As the Soret number rises, the velocity rises as well. To investigate the impact of permeability parameter K, Figure (5) is sketched. It is discovered that the velocity grows as K is raised. From Figure (6), it can be found that when the radiation parameter (R) increases, the velocity rises up to a specific y value (distance from the plate), after which it falls off in the event that the plate cools. Figure (7) reveals how the velocity decreases as the heat source parameter (H) is increased. The radiation parameter (R) and heat source parameter (H) have a significant impact on the flow field's temperature. Figure (8) illustrates how these characteristics affect the flow field's temperature. The temperature of the boundary layer rises as radiation parameter increases and temperature falls with the increase of heat source parameter.

Figure (9) reveals that as the Soret number S_0 is increased, the concentration profiles rise. It can be seen from Figure (10) that as the Schmidt number rises, the concentration field decreases. From figure (11) it is revealed that the greater the values of radiation parameter the concentration decreases. From Figure (12), we can see that the greater the values of the Prandtl number Pr, the fluid concentration rises.

It is cleared from Table (1) that Nusselt number rises with rising Prandtl number Pr values, but falls with rising radiation parameter values. It is evident from Table (2) that Sherwood number rises as Sc rises, while the pattern is the opposite for high values of Pr and S_0.

5. CONCLUSION

We looked at how heat and mass transfer affected an accelerating plate with changing temperature and mass diffusion when there was a heat source or sink present through a porous medium. Based on the results

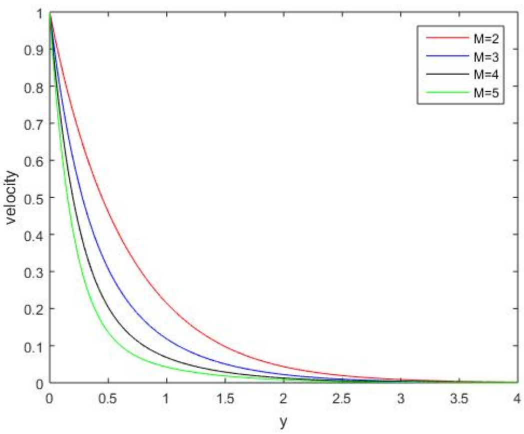

Figure 1. Effect of various M on Velocity profile with $S_0 = 5$, $Sc = 2.01$, $Gm = 1$, $Pr = 0.71$, $Gr = 1$, $K = 0.5$, $R = 2$, $H = 8$, $t = 1$ and $Sc = 2.01$.

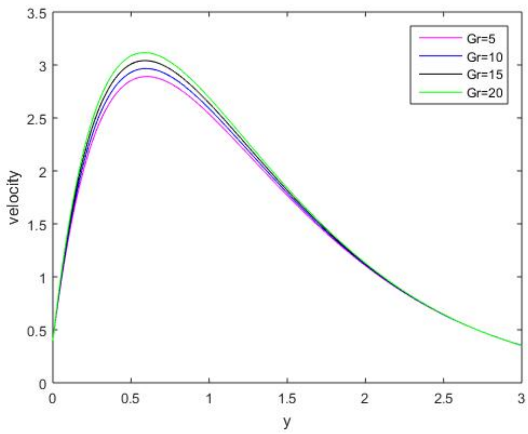

Figure 2. Effect of various Gr on velocity profile with $Sc = 2.01$, $S_0 = 5$, $Pr = 0.71$, $K = 0.5$, $Gm = 5$, $H = 2$, $t = 0.4$, $Sc = 2.01$, $R = 2$ and $M = 2$.

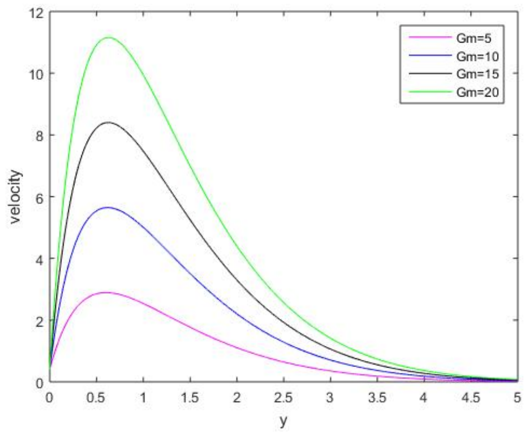

Figure 3. Effect of various Gm on velocity profile with $S_0 = 5$, $Pr = 0.71$, $H = 2$, $K = 0.5$, $t = 0.4$, $Sc = 2.01$, $M = 2$, $R = 2$ and $Gr = 5$.

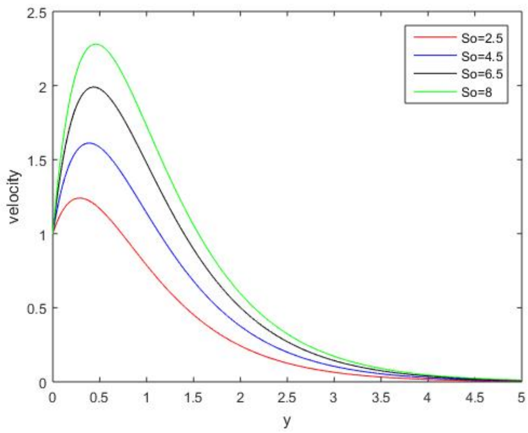

Figure 4. Effect of various S_0 on velocity profile with $Pr = 0.71$, $Gm = 5$, $Gr = 5$, $K = 0.5$, $Sc = 2.01$, $H = 5$, $t = 1$, $R = 2$ and $M = 2$.

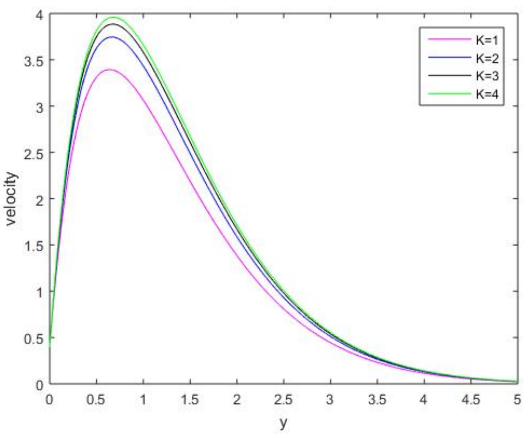

Figure 5. Effect of various K on velocity profile with S_0=5, $Sc = 2.01$, $Gm = 5$, $H = 2$, $Pr = 0.71$, $t = 0.4$, $M = 2$, $R = 2$ and $Gr = 5$.

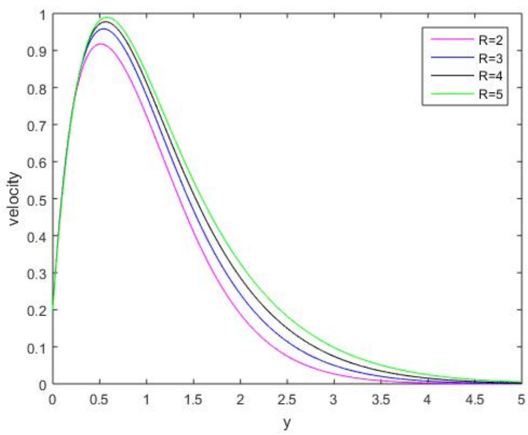

Figure 6. Effect of various R on velocity profile with $S_0 = 5$, $Pr = 0.71$, $Gm = 5$, $Gr = 5$, $K = 0.5$, $Sc = 2.01$, $H = 5$, $t = 0.2$ and $M = 2$.

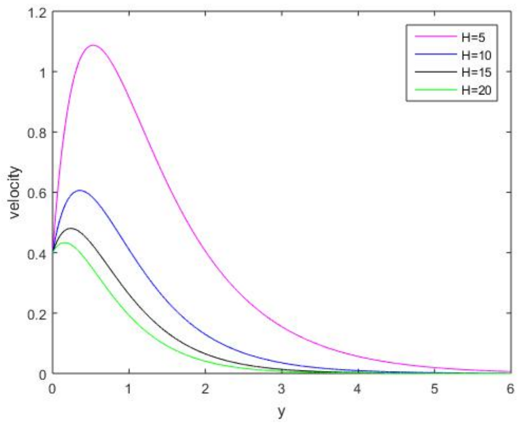

Figure 7. Effect of various H on velocity profile with S_0=5, $Sc = 2.01$, $Gm = 5$, $K = 0.5$, $Pr = 0.71$, $t = 0.4$, $M = 2$, $R = 5$ and $Gr = 5$.

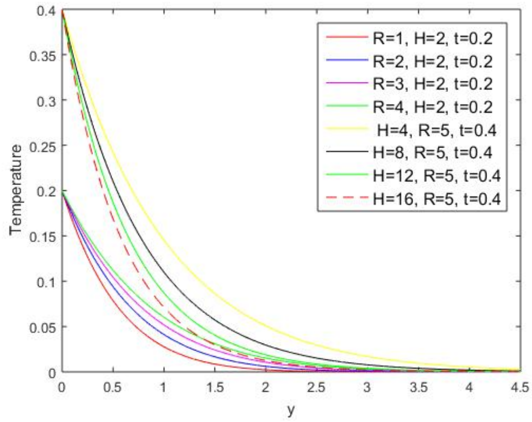

Figure 8. Effects of R and H on temperature

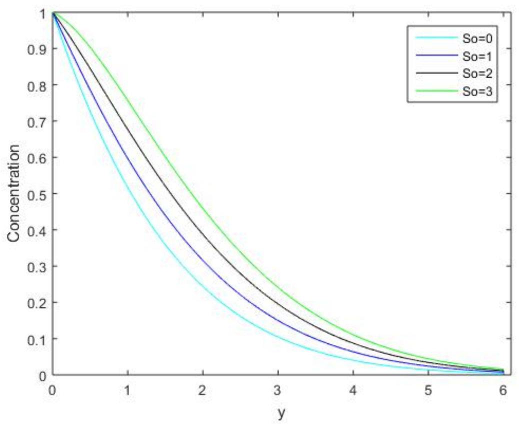

Figure 9. Effect of S_0 on concentration with $Pr = 0.71$, $t = 1$, $R = 0.4$, $H = 1$ and $Sc = 0.3$.

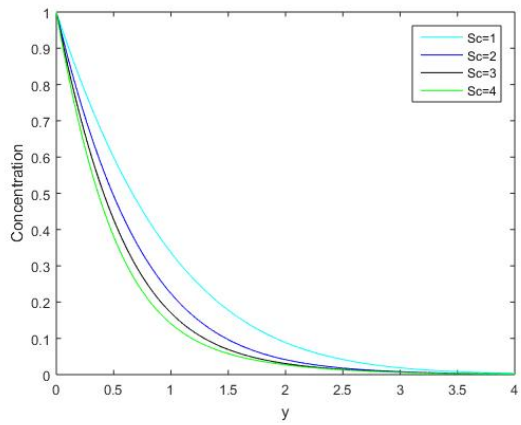

Figure 10. Effect of Sc on concentration with $S_0 = 0.4$, $Pr = 0.71$, $R = 0.4$, $H = 1$ and $t = 1$.

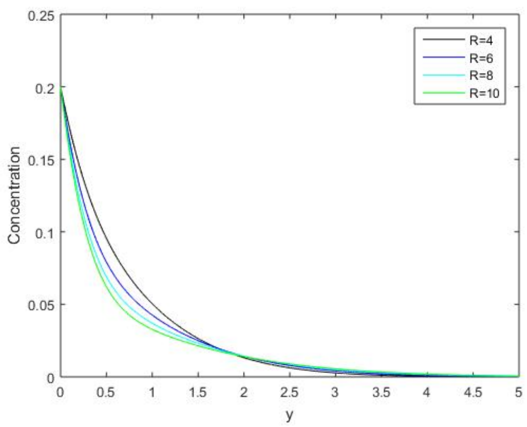

Figure 11. Effect of R on concentration with $S_0 = 5$, $H = 1$, $t = 0.2$, $Pr = 0.71$ and $Sc = 2.01$.

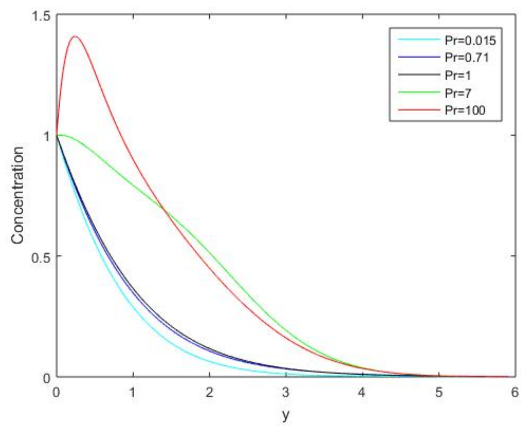

Figure 12. Concentration profiles for various Pr with $S_0 = 0.9$, $R = 2$, $H = 1$, $t = 1$ and $Sc = 1$.

of our current investigation and graphical analysis, as the values of K and Gr grows, the velocity rises but it decreases as M increases. The temperature inside the boundary layer increases with rising value of radiation parameter. The concentration grows with rising value of S_0 and Pr, whereas it falls when Sc is increased.

Table 1. The impact of different parameters on Nusselt number with $H = 1, t = 1$.

Pr	R	Nu
0.71	0.2	1.2277
1	0.2	1.4018
0.71	0.4	1.0545

Table 2. The impact of different parameters on Sherwood number with $R = 0.1, H = 2$ and $t = 1$.

Pr	Sc	So	Sh
0.71	0.6	1	0.3371
1	0.6	1	0.2745
0.71	1	1	0.594
0.71	1	2	0.0596

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ТЕПЛО- ТА МАСОПЕРЕНОС ПРИ РУХУ ПОТОКУ ПОВЗ ПРИСКОРЕНУ ПЛАСТИНУ ЧЕРЕЗ ПОРИСТЕ СЕРЕДОВИЩЕ ЗІ ЗМІННОЮ ТЕМПЕРАТУРОЮ ТА МАСОДИФУЗІЄЮ ЗА НАЯВНОСТІ ДЖЕРЕЛА/ПОГЛИНАЧА ТЕПЛА

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Представлено дослідження впливу як тепло- та масообміну на нестаціонарний МГД-потік через прискорену пластину зі зміною температури та дифузії маси у вигляді джерела (або поглинача) тепла через пористе середовище. Спочатку температура та концентрація рідини та пластини вважаються однаковими при $t' \leq 0$. При $t' > 0$ до пластини прикладається імпульсне рівномірне прискорення A у вертикальному напрямку вгору. Безрозмірні керівні рівняння, що визначають проблему потоку, вирішуються за допомогою перетворення Лапласа. Вплив різних фізичних величин, пов'язаних із швидкістю, концентрацією, температурою, швидкістю теплопередачі, а також швидкістю масопереносу, досліджується за допомогою графіків і таблиць і обговорюється.

Ключові слова: *теплопередача; масообмін; прискорена пластина; пористе середовище; перетворення Лапласа*