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# Steady MHD Flow and Heat Transfer on a Stretched Vertical Permeable Surface in Presence of Heat Generation/Absorption, Thermal Radiation and Chemical Reaction

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## Abstract

Steady MHD flow of a viscous conducting fluid past a stretched vertical permeable surface with heat generation/absorption, thermal radiation and chemical reaction has been analyzed. The boundary layer equations for velocity, temperature and concentration have been developed and solved by using fourth order Runga-Kutta method based on shooting technique. Velocity, temperature and concentration profiles have been depicted in graphs. The values of skin-friction, rate of heat transfer and mass transfer have been enlisted in the tables for various values of pertinent fluid parameters. It is observed that the magnetic field as well as porosity belittles the fluid flow due to the influence of retarding Lorentz force, reduces the rate of heat and mass transfer. It is important to note that increase in radiation parameter reduces the temperature gradient from the stretching surface.

## Keywords

MHD; Heat transfer; Mass transfer; Porous medium; Thermal radiation; Chemical reaction.

## 1. Introduction

The importance of fluid flow over a stretching surface can be perceived for its ever increasing inevitable applications in industries and technological processes. The applications of the stretching surface problems include polymer sheet extrusion from a dye, drawing, thinning and annealing of copper wires, glass fiber and paper production, the cooling of a metallic plate in a cooling bath etc. The production of these sheets requires that the melt issues from a slit and is stretched to get the desired thickness. The final product depends on rate of cooling in the manufacturing processes. Sakiadis [1] was first to study the boundary-layer behavior on a continuous solid surface moving with constant speed. Crane [2] was the first to achieve an elegant analytical solution to the boundary layer equations for the problem of steady two-dimensional flow through a stretching surface in a quiescent incompressible fluid.

MHD convection flow problems are very significant in the fields of steller and planetary magnetospheres, aeronautics, chemical engineering and electronics. Model studies of the above phenomena of MHD convection have been made by many. Nayak et al. [3-4], Dash et al. [5] are some of them.

## Nomenclature

| | | | |
|---|---|---|---|
| $(u, v)$ | fluid velocity components along $x$ and $y$ directions | $g$ | acceleration due to gravity |
| $\beta$ | volumetric coefficient of thermal expansion | $T$ | fluid temperature |
| $\beta^*$ | volumetric coefficient of mass expansion | $C$ | fluid concentration |
| $T_\infty$ | temperature of ambient fluid | $C_\infty$ | concentration of ambient fluid |
| $\sigma$ | electrical conductivity | $B_0$ | magnetic field strength |
| $\rho$ | density of the fluid | $\upsilon$ | kinematic viscosity |
| $K_p^*$ | permeability parameter | $k$ | thermal conductivity of fluid |
| $C_p$ | specific heat at constant pressure | $q_r$ | radiative heat flux |
| $\phi_0$ | volumetric rate of heat generation/absorption | $D$ | diffusion coefficient |
| $\lambda$ | rate of chemical reaction | $v_w$ | suction velocity |
| $T_w$ | uniform temperature on the wall surface | $C_w$ | uniform concentration on the wall surface |
| $\sigma_1$ | Stefan-Boltzmann constant | $k_1$ | mean absorption coefficient |
| $G_r$ | thermal Grashof number | $f_w$ | suction parameter |
| $G_c$ | mass Grashof number | $M$ | magnetic parameter |
| $K_p$ | non-dimensional permeability parameter | $P_r$ | Prandtl number |
| $R$ | thermal radiation parameter | $Q$ | heat generation/absorption parameter |
| $K_c$ | chemical reaction parameter | $S_c$ | Schimdt number |
| $C_f$ | skin friction coefficient | $Nu_x$ | local Nusselt number |
| $Sh_x$ | local Sherwood number | $\tau_w$ | surface shear stress |
| $q_w$ | surface heat flux | $q_m$ | surface mass flux |

Several researchers have analyzed the free convective and mass transfer flow of viscous fluids through porous media. The need for the fundamental studies of heat transfer in porous media is utilized in various disciplines such as geophysics, oil recovery techniques and thermal insulation engineering, etc. The most significant area of technology that depends on the properties of porous media is hydrology which relates to the movement of water in earth and sand structures. Rath et al. [6] studied MHD flow with heat and mass transfer on a porous stretching wall embedded in porous medium with chemical reaction.

Chemical reaction involves the breaking of bonds in the reactive substances and the formation of bonds to form product species. So it is evident that the rate of reaction depends upon number and nature of the bonds involved. According to the intermolecular concepts reactants are made up of molecules or ions and reactions take place due to intermolecular collision. The rate at which a reaction proceeds, depends largely upon the frequency with which the reacting molecules collide. Effects of concentration, temperature, nature of reactants, catalyst and radiation are all the factors affecting the rate of reaction. Nayak et al [7] studied the effect of chemical reaction in flow and mass transfer of a micropolar fluid in a vertical channel with heat generation/absorption. Further Nayak et al. [8] studied the same in presence of transverse magnetic field.

The thermal radiation effects are of vital importance at high absolute temperature due to basic difference between radiation and convection and conduction energy-exchange mechanisms. For space applications, some devices are designed to operate at high temperature levels in order to obtain high thermal efficiency. Nayak et al. [9] investigated the effects of thermal radiation on MHD free convective flow and mass transfer of a viscoelastic fluid past an inclined porous plate.

Heat generation/absorption may be constant, space-dependent or temperature dependent as assumed by several previous researchers. Heat source causes heat generation leading to rise in temperature while heat sink causes heat absorption leading to fall in temperature in thermal boundary layer. Hakeem et al. [10] analyzed the effect of heat generation/absorption in a viscoelastic fluid of low order elasticity flow over a stretching sheet.

The objective of the present study is to analyze the heat and mass transfer effects on a steady MHD flow past a stretched vertical permeable surface in presence of heat generation/absorption, thermal radiation and chemical reaction.

The novelty of the present study comprises the following aspects:

1. The porous matrix is included because it acts as an insulator due to which the flow and heat transport processes which greatly prevents heat loss and accelerates the process of cooling/heating as the case may be serving as a heat exchanger. Also the permeability of a porous medium reduces the flow instability.
2. Thermal radiation is considered because the effects of radiation are of vital importance while calculating thermal effects in the processes dealing with high absolute temperatures. Also thermal radiation plays an important role effectively in controlling the thermal boundary layers.
3. Heat generation/absorption is included because it controls the heat transfer rates in the thermal boundary layer appreciably.
4. Inclusion of chemical reaction term in the mass transport equation is inevitable as the fluids may be chemically reactive.

## 2. Formulation of the problem

Consider a magnetohydrodynamic steady, laminar and two dimensional incompressible flow of an electrically conducting viscous fluid past a vertical porous surface with thermal energy transmission and mass transport under varied species concentration. The fluid flows over continuously moving vertical permeable surface with thermal radiation and heat generation/absorption. A uniform transverse magnetic field is applied normally to the direction of the flow as shown in Fig. 1.

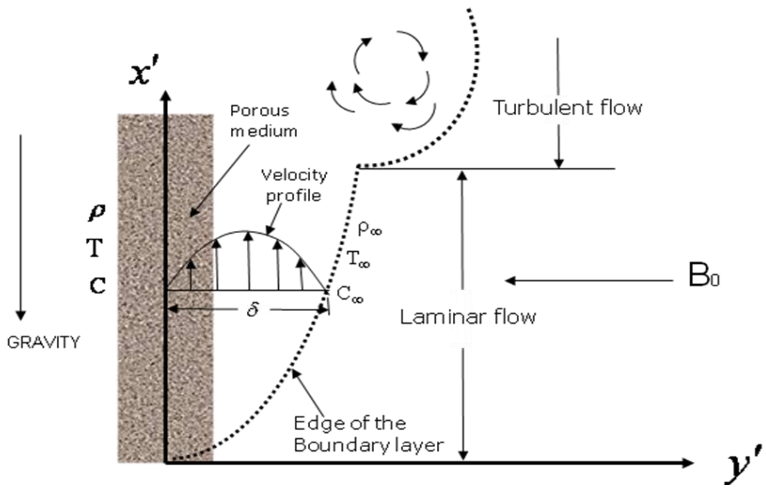



**Fig. 1 Flow geometry**

Assuming that the magnetic Reynolds number is small (less than unity) so that the induced magnetic field is neglected in comparison to applied magnetic field. The external electric field is zero and the electric field due to polarization of charges is negligible. Moreover, chemically reactive species are emitted from the moving vertical surface in the hydrodynamic flow field. It diffuses into the fluid where it undergoes a simple isothermal, homogeneous chemical reaction in the stream. Under these assumptions along with the usual Boussinesq approximation, the continuity, momentum, energy and concentration equations governing the above boundary layer flow are

$$\frac{\partial \mathrm{v}}{\partial y}=0 \tag{1}$$

$$\mathrm{v}\frac{\partial u}{\partial y}=\nu\frac{\partial^2 u}{\partial y^2}+g\beta\left(T-T_\infty\right)+g\beta^*(C-C_\infty)-\frac{\sigma B_0^2}{\rho}u-\frac{\upsilon}{K_p^*}u \tag{2}$$

$$\mathrm{v}\frac{\partial T}{\partial y}=\frac{k}{\rho C_p}\frac{\partial^2 T}{\partial y^2}+\frac{Q_0}{\rho C_p}\left(T-T_\infty\right)-\frac{1}{\rho C_p}\frac{\partial q_r}{\partial y} \tag{3}$$

$$\mathrm{v}\frac{\partial C}{\partial y}=D\frac{\partial^2 C}{\partial y^2}-\lambda(C-C_\infty) \tag{4}$$

where $x$ axis is taken along the motion of the surface in upward direction, $y$ axis is normal to it, $u$ and $\mathrm{v}$ are the velocities along the directions of $x$ and $y$ respectively, $\nu$ is the kinematic viscosity, $g$ is the acceleration due to gravity, $\beta$ is the volumetric coefficient of thermal expansion, $\beta^*$ is the volumetric co-efficient of mass expansion, $T$ is the temperature of the fluid, $T_\infty$ is the temperature of the fluid far away from the wall, $C$ is the concentration of the fluid, $C_\infty$ is the concentration of the fluid far away from the wall, $\sigma$ is the electrical conductivity of the fluid, $B_0$ is the uniform magnetic field strength $K_p^*$ is the permeability of the medium, $k$ is the thermal conductivity of the fluid, $C_p$ is the specific heat at constant pressure, $Q_0$ is the volumetric rate of heat generation/absorption, D is the diffusion co-efficient and $\lambda$ is the rate of chemical reaction.

The initial and boundary conditions for the problem are

$$\left.\begin{array}{ll} u=-u_w, \mathrm{v}=\mathrm{v}_w, T=T_w, C=C_w & \text{at } y=0 \\ u\to 0,\ T\to T_w, C\to C_w & \text{as } y\to\infty \end{array}\right\} \tag{5}$$

where $u_w$ (a constant), $v_w, T_w$ and $C_w$ are the velocities of the fluid at the vertical permeable surface, suction velocity, temperature and concentration at the wall respectively.

By using Rosseland approximation for thermal radiation [11, 12] the radiative heat flux is modeled as

$$q_r = -\frac{4\sigma_1}{3k_1}\frac{\partial(T^4)}{\partial y}$$

where $\sigma_1$ is the Stefan-Boltzmann constant and $k_1$ is the mean absorption coefficient.

We assume that the differences in temperature within the flow are such that the non-linear term $T^4$ can be expressed as a linear combination of the temperature. This is obtained by expanding $T^4$ in a Taylor series about $T_\infty$ and neglecting higher order terms [13], we obtain

$$T^4 \cong 4T_\infty^3 T - 3T_\infty^4$$

and thus the gradient of heat radiation term can be expressed as

$$\frac{\partial q_r}{\partial y} = -\frac{16\sigma_1 T_\infty^3}{3k_1}\frac{\partial^2 T}{\partial y^2}$$

Using the above expression eqn. (3) takes the form

$$v\frac{\partial T}{\partial y} = \frac{k}{\rho C_p}\frac{\partial^2 T}{\partial y^2} + \frac{Q_0}{\rho C_p}(T - T_\infty) + \frac{16\sigma_1 T_\infty^3}{3k_1\rho C_p}\frac{\partial^2 T}{\partial y^2} \tag{6}$$

Let us introduce the following similarity transformation [14]

$$\left.\begin{aligned} &\eta = y\sqrt{\frac{u_w}{\nu x}},\ u = -u_w f'(\eta),\ v = -\sqrt{\frac{u_w \nu}{x}}\, f(\eta) \\ &\theta(\eta) = \frac{T - T_\infty}{T_w - T_\infty},\ \phi(\eta) = \frac{C - C_\infty}{C_w - C_\infty} \end{aligned}\right\} \tag{7}$$

Applying eqn. (7), eqns. (2)-(6) take the form

$$f''' + ff'' - G_r\theta - G_c\phi - \left(M^2 + \frac{1}{K_p}\right) f' = 0 \tag{8}$$

$$(1+R)\theta'' + P_r f\theta' + P_r Q\theta = 0 \tag{9}$$

$$\phi'' + S_c f\phi' - K_c S_c \phi = 0 \tag{10}$$

$$\left.\begin{aligned} &f' = 1,\ f(0) = f_w, \theta = 1, \phi = 1 \quad \text{at}\ \ \eta = 0 \\ &f' \to 0, \theta \to 0, \phi \to 0\ \text{as}\ \eta \to \infty \end{aligned}\right\} \tag{11}$$

where $f_w = \frac{-v_w}{\sqrt{(\nu u_w/x)}}$ is the suction parameter, $G_r = \frac{g\beta(T_w - T_\infty)x}{u_w^2}$ is the thermal Grashof number, $G_c = \frac{g\beta^*(C_w - C_\infty)x}{u_w^2}$ is the mass Grashof number, $M = \sqrt{\frac{\sigma B_0^2 x}{\rho u_w}}$ is the magnetic parameter, $K_p = \frac{u_w K_p^*}{\nu x}$ is the permeability parameter, $P_r = \frac{\upsilon\rho C_p}{k}$ is the Prandtl number, $R = \frac{16\sigma_1 T_\infty^3}{3k\,k_1}$ is the thermal radiation parameter, $Q = \dfrac{Q_0 x}{\rho C_p u_w}$ is the heat generation/absorption parameter, $K_c = \dfrac{\lambda x}{u_w}$ is the chemical reaction parameter and $S_c = \dfrac{\upsilon}{D}$ is the Schmidt number.

## 3. Numerical Solution

The governing equations are solved numerically by employing fourth order Runge-Kutta method based on shooting technique. This method has been proven to be adequate and gives accurate results for boundary layer equations.

Let $y_1 = f, y_2 = f', y_3 = f'', y_4 = \theta, y_5 = \theta', y_6 = \phi, y_7 = \phi'$

Then
$$y_3' = \left(M^2 + \frac{1}{K_p}\right) y_2 - y_3 + G_r y_4 + G_c y_6$$
$$y_5' = -\frac{1}{1+R}\left[P_r y_1 y_5 + P_r Q y_4\right]$$
$$y_7' = -S_c y_1 y_7 + K_c S_c y_6$$
$$y_1(0) = 1, y_4(0) = 1, y_6(0) = 1, y_2(\infty) = s^{(2)}, y_4(\infty) = s^{(4)}, y_6(\infty) = s^{(6)}.$$

where the shooting technique is applied to guess $s^{(2)}, s^{(4)}$ and $s^{(6)}$ until the boundary conditions $y_2(\infty) = 0, y_4(\infty) = 0$ and $y_6(\infty) = 0$ are satisfied.

The physical quantities of interest such as the skin friction coefficient, the local Nusselt number and the local Sherwood number are defined as

$$C_f = \frac{\tau_w}{\rho u_w v_w}, Nu_x = \frac{x q_w}{k(T_w - T_\infty)}, Sh_x = \frac{x q_m}{D(C_w - C_\infty)}$$

where the surface shear stress $\tau_w$, surface heat flux $q_w$ and surface mass flux $q_m$ are given by

$$\tau_w = \mu\left(\frac{\partial u}{\partial y}\right)_{y=0}, q_w = -k\left(\frac{\partial T}{\partial y}\right)_{y=0}, q_m = -D\left(\frac{\partial C}{\partial y}\right)_{y=0}$$

with $\mu$ and *k* being the dynamic viscosity and the thermal conductivity respectively.

Using similarity variables (7), we obtain the skin friction coefficient, Nusselt number and Sherwood number as

$$\frac{1}{2} C_f R_{e_x}^{1/2} = f''(0), Nu_x R_{e_x}^{-1/2} = -\theta'(0), Sh_x R_{e_x}^{-1/2} = -\phi'(0)$$

## 4. Results and Discussion

The discussion on numerical solution of equations characterizing the flow across a continuously moving isothermal vertical surface in a porous medium has been presented.

Fig. 2 depicts the effects of *M*, and *Q* on the velocity profiles when other fluid parameters are fixed. It is observed that the velocity $f'$ becomes negative for lower value of $\eta$. Beyond $\eta = 0.5$, transition takes place. Thereafter, as $\eta$ increases, the velocity first increases and then falls gradually tending to be zero. In the absence of magnetic field, the velocity is more than in the presence of magnetic field. This indicates that the magnetic field contributes to die down the velocity due to its resistive force offered by Lorentz force as observed in [15]. The velocity further decreases in the presence of sink/source. However, the decrease in velocity is more pronounced in case of source than in case of sink when suction is initiated.

The effects of permeability parameter ($K_p$), Grashof number ($G_r$) and modified Grashof number ($G_c$) on the velocity field have been exhibited by the curves of Fig. 3. The nature of the velocity profiles show that the velocity becomes negative for smaller values of $\eta$. With the rise of both $G_r$ and $G_c$, the velocity gets enhanced. The velocity of flow also gets reduced due to the resistive force offered by porous matrix as is seen by [16].

Fig. 4 represents the effects of chemical reaction parameter $(K_c)$, the Schmidt number ($S_c$) and the Prandtl number ($P_r$) on the velocity profiles under the action of external transverse magnetic field. The curves I to V of Fig. 4 show that the velocity is negative for smaller values of $\eta$. As $P_r$ rises the velocity falls. Comparing the nature of the curves II and V it is noticed that the rise of the Schmidt number also reduces the flow velocity.

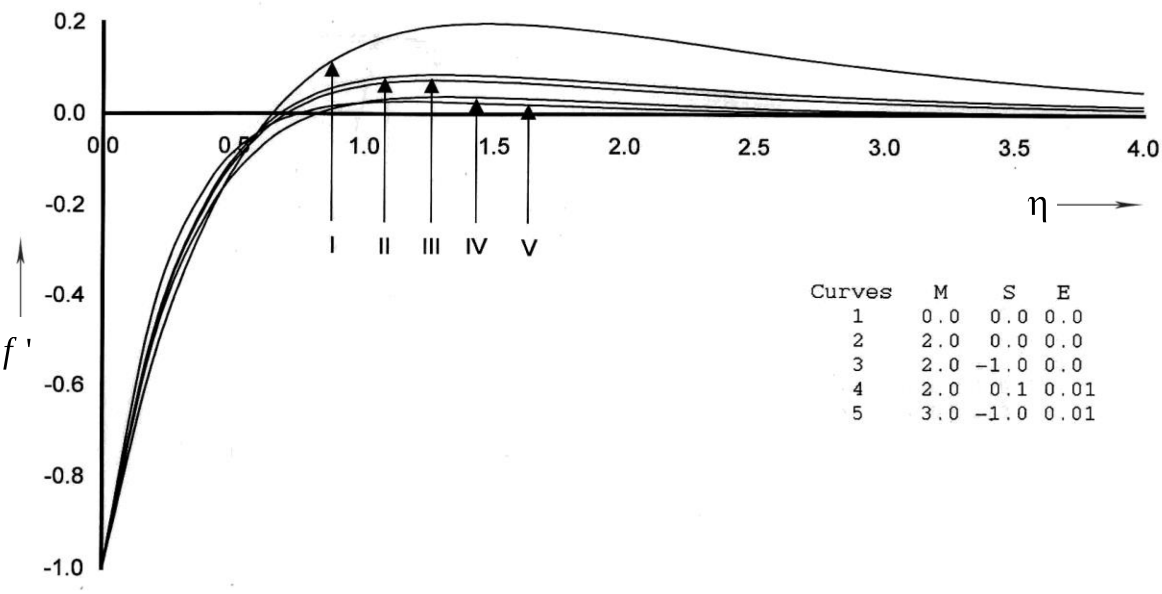
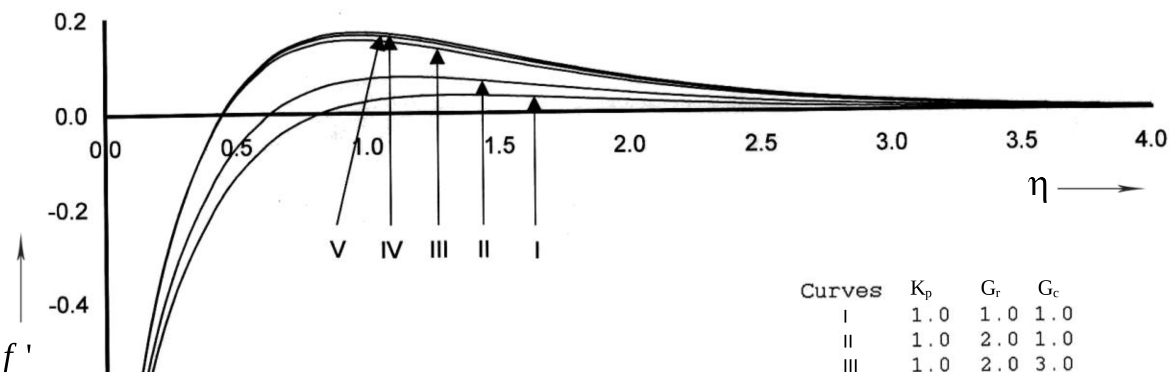



**Fig. 2 Effects of $M$ and $Q$, on the velocity profiles with $K_p$ =1, $G_r$ =1, $G_c$ = 1, $K_c$ = 2, $P_r$ = 0.71, $R$ = 2, $S_c$ = 0.6.**



| Curves | Kp | Gr | Gc |
|---|---|---|---|
| I | 1.0 | 1.0 | 1.0 |
| II | 1.0 | 2.0 | 1.0 |
| III | 1.0 | 2.0 | 3.0 |
| IV | 2.0 | 2.0 | 3.0 |
| V | 4.0 | 2.0 | 3.0 |

**Fig. 3 Effects of $K_p$, $G_r$, $G_c$ on the velocity profiles with $M$ = 2, $Q$ = -1, $K_c$ = 2, $P_r$ = 0.71, $R$ = 2, $S_c$ = 0.6.**

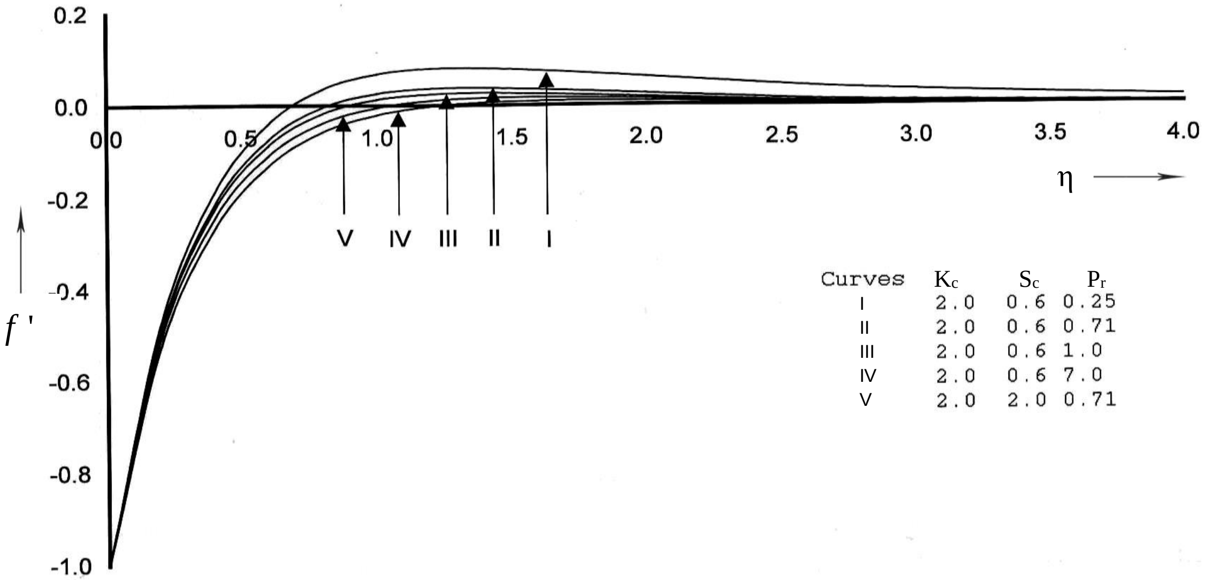



**Fig. 4 Effects of $K_c$, $S_c$, $P_r$ on the velocity profiles with $M$ = 2, $K_p$ = 1, $G_r$ =1, $G_c$ = 1, $Q$ = -1, $R$ = 2.**

The effects of Prandtl number (Pr) and generation/absorption parameter (Q) on the temperature field have been shown in the Fig. 5. It is marked from the profiles that the increase in the values of the Prandtl number decreases the temperature gradually from the surface (Curves II, III) as is noticed in [17]. There is a sharp fall of the temperature in case of high Prandtl number (Curves III and IV) irrespective of source/sink which leads to thinning of thermal boundary layer. It is observed that the temperature of the fluid falls with the increase of distance ($\eta$) from the permeable surface in the absence of heat generating source or heat absorbing sink (curve I). In the presence of sink (Q = –1.0), the temperature of the fluid decreases further. It is quite interesting to note that the temperature gets reduced in the presence of heat generating source with small $P_r$.

From Fig. 6, it is observed that an increase in thermal radiation parameter ($R$) increases the temperature of the fluid layer and processes get accelerated due to the influence of porous matrix. The increase in temperature with an increase in radiation parameter causes a reduction in temperature gradient of the stretched surface concerned [18].

Fig. 7 delineates the effects of the chemical reaction parameter $(K_c)$ and Schmidt number ($S_c$) on the concentration of the fluid. It is noticed that the concentration falls gradually with the increase of distance from the surface. It is also noticed that the concentration falls with increase of $S_c$ in presence of chemical reaction [17]. The fall of concentration becomes more pronounced for heavier species in presence of chemical reaction and this leads to thinning of concentration boundary layer.

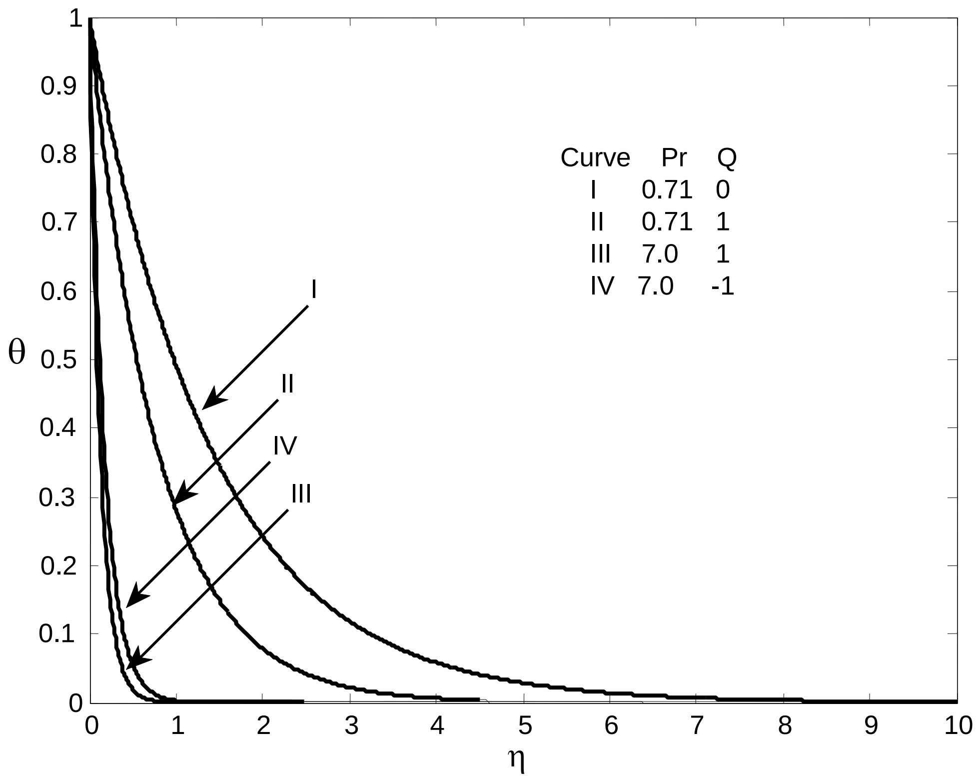



**Fig. 5 Effects of $P_r$, $Q$ on temperature profiles with $M$ = 2, $K_p$ = 1, $G_r$ =1, $G_c$ = 1, $K_c$ = 2, $R$ = 2, $S_c$ = 0.6.**

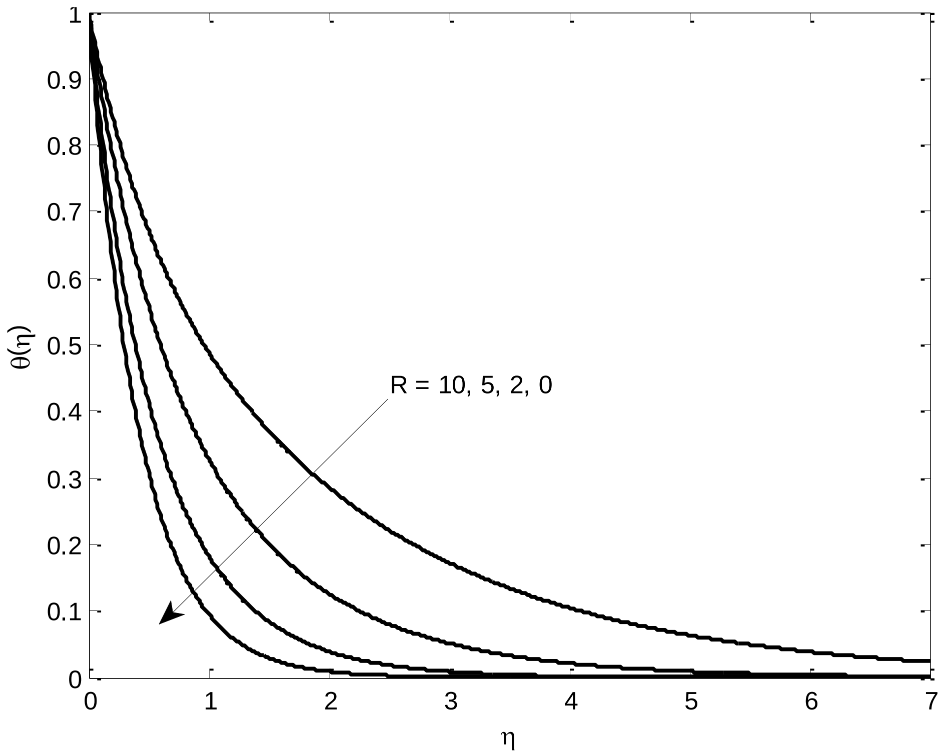



**Fig. 6 Effects of *R* on temperature profiles with $M$ = 2, $K_p$ = 1, $G_r$ =1, $G_c$ = 1, $P_r$ = 0.71, $Q$ = 1.**

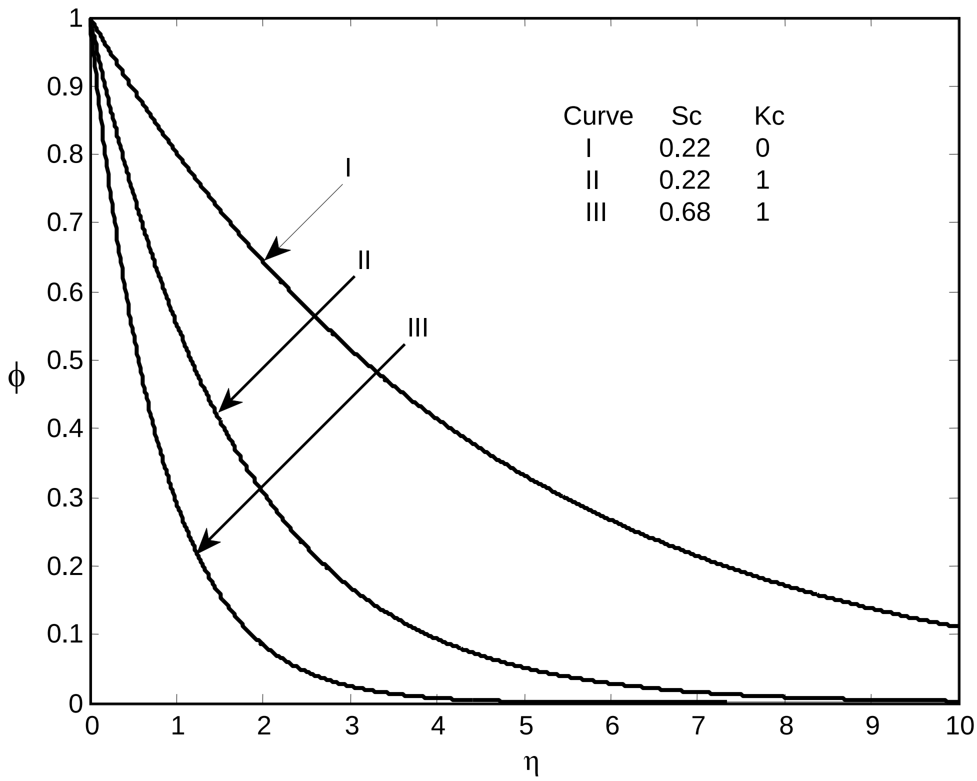



**Fig. 7 Effects of $S_c$ and $K_c$ on the concentration profiles with $M$ = 2, $K_p$ = 1, $G_r$ =1, $G_c$ = 1, $P_r$ = 0.71, $R$ = 2, $Q$ = 1.**

Table 1 enlists the values of the skin friction $C_f$ for different values of $M, K_p, G_r$ and $G_c$. It is observed that the values of skin friction increases with the increase of magnetic field strength whereas its value gets reduced with rise of $K_p$.

**Table 1.** Values of skin friction $C_f$ for $Q$ = 1.0, $K_c$ = 2.0, $S_c$ = 2.0, $R$ = 2.0, $P_r$ = 0.71

| $M$ | $K_p$ | $G_r$ | $G_c$ | $C_f$ |
|---|---|---|---|---|
| 0 | 1 | 1 | 1 | 2.71 |
| 2 | 1 | 1 | 1 | 3.41 |
| 2 | 2 | 1 | 1 | 3.32 |
| 2 | 2 | 3 | 1 | 4.21 |
| 2 | 2 | 3 | 3 | 4.64 |

The values of the rate of heat transfer are mentioned in Table 2. It is seen that the rate of heat transfer falls with the rise of magnetic parameter. However, there is high rise in the Nusselt number with rise of Prandtl number. All the above cases are observed in the presence of sink. When source is present, the rate of heat transfer is less for $P_r = 0.71$ (air) and more for $P_r = 7$ (water). It is also seen that the presence of magnetic field with higher Prandtl value causes the Nusselt number to increase irrespective of heat generation/absorption. It is further seen that thermal radiation reduces the heat transfer rate from the surface and should be reduced to have cooling process at faster rate.

**Table 2** Values of Nusselt number $N_u$ for $K_p$ = 1.0, $G_r$ = 1.0, $G_c$ =1.0, $K_c$ = 2.0, $S_c$ = 0.6.

| $M$ | $Q$ | $P_r$ | R | $N_u$ |
|---|---|---|---|---|
| 0.0 | −1 | 0.71 | 0 | 1.26 |
| 2.0 | −1 | 0.71 | 0 | 1.25 |
| 2.0 | −1 | 0.71 | 1 | 1.21 |
| 2.0 | −1 | 7 | 1 | 7.75 |
| 2.0 | 1 | 0.71 | 0 | 0.68 |
| 2.0 | 1 | 7 | 0 | 6.83 |
| 2.0 | 1 | 7 | 1 | 6.76 |

Table 3 depicts the effects of $M$, $K_p$, $S_c$ and $K_c$ on the Sherwood number. The values of the Sherwood number decreases as the magnetic field strength increases. The permeability parameter lowers the Sherwood number further. But, the increase in the values of chemical reaction parameter as well as Schmidt number provides the same feature that raises the Sherwood number.

**Table 3** Values of Sherwood Number $S_h$ for $G_r$ = 1.0, $G_c$ = 1.0, Q =1.0, R = 2.0, $P_r$ = 0.71.

| M | $K_p$ | $K_c$ | $S_c$ | $S_h$ |
|---|---|---|---|---|
| 0.0 | 1 | 2 | 0.6 | 0.64 |
| 2.0 | 1 | 2 | 0.6 | 0.62 |
| 2.0 | 2 | 2 | 0.6 | 0.60 |
| 2.0 | 2 | 2 | 2 | 0.98 |
| 2.0 | 2 | 2 | 2 | 0.79 |
| 2.0 | 2 | 3 | 2 | 0.10 |

## 5. Conclusion

A numerical study on the radiative heat and mass transfer effects on a steady MHD flow past a stretched vertical permeable surface in presence of heat generation/absorption, chemical reaction has been investigated. The results are delineated for the major physical parameters and a systematic study on the effects of the various parameters on flow, heat and mass transfer characteristics is carried out.

From the present study it is observed that there is flow reversal very close to the vertical permeable surface. The magnetic field as well as porous matrix reduces the flow velocity due to retarding Lorentz force. The Grashof number and modified Grashof number enhance the velocity of flow. The Prandtl number and the Schmidt number both lower the velocity of flow and hence the thermal boundary layer gets narrowed. The slow rate of thermal diffusion in the presence of magnetic field and the porous matrix leads to thinning of thermal boundary layer. A sharp fall of temperature takes place in case of high Prandtl number leading to thinning of thermal boundary layer. An increase in temperature with an increase in radiation parameter causes a reduction in temperature gradient of the stretched surface considered. There is a sharp fall of concentration in case of rise in Schmidt number in the presence of chemical reaction that causes in thinning of concentration boundary layer. It is worth to mention that the skin-friction and the rate of heat transfer get enhanced with rise of magnetic field strength however the concentration gradient shows the reverse effect. The permeability parameter reduces the skin-friction as well as the concentration gradient at all points of flow domain. There is high rise in the rate of heat transfer due to the increase of Prandtl number.

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