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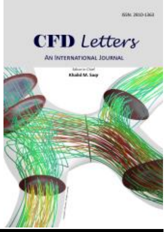

Heat and Mass Transfer Significance on MHD Flow over a Vertical Porous Plate in the Presence of Chemical Reaction and Heat Generation

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ABSTRACT

Numerical solutions to the problems of heat generation and chemical reaction as well as heat and mass transfer in a 2-D viscous, electrically conducting fluid oscillating through an infinite vertical permeable moving plate in a saturated porous material subject to a transverse magnetic field are considered. The flow equations explain how things work by the Finite Difference Method (FDM). The impacts of different flow factors on flow fields are talked about. It has been found that the velocity of the fluid goes up as both the chemical reaction and the permeability factors increase. Although it keeps rising as the magnetic field factor declines. Also, the concentration keeps enhancing as the chemical reaction factors increase.

1. Introduction

The investigation of MHD problems in conjunction with chemical reactions taking place in the incidence of a magnetic field while passing through a permeable medium is significant for a great number of practical implementations in the scientific disciplines. This process plays a significant part in a variety of scientific and technological fields, including the oil refineries, the cooling of nuclear reactors, heat exchangers, and the hydro power sector. Because of the vast number of possible applications, several researchers have offered techniques for dealing with this kind of flow when there is a magnetic field extant. Unsteady MHD convective heat transmission was investigated by Kim [7] by passing a semi-infinite vertical permeable affecting plate with changing suction. Mass and heat transfer impacts on flow via an abruptly started vertical plate were explored by Muthucumaraswamy *et al.,*[10] in their work. Heat transfer study was performed by Hayat and Abbas [6] on the MHD flow of a second-grade liquid in a channel with porous media to evaluate its effects. Chamkha [3] described the unstable MHD convection heat transfer that occurred as a result of the motion of a semi-infinite and permeable plate, which included heat absorption and conduction as well. The authors Das *et al.,* [4] spoke about the impacts of mass transfer on MHD flow and heat

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transmission as it goes through a vertical porous plate and via a porous medium when there is oscillatory suction and a heat source. Hady *et al.,* [5] investigated the MHD free convection flow over a vertically wavy surface while considering the influence of heat production or absorption. The MHD free convection and mass transfer flow across an infinite vertical porous plate with viscous dissipation was investigated by Poonia and Chaudhary [12]. In a vertical permeable plate, mass and heat are transferred via convection in an unstable MHD boundary layer due to thermal radiation and chemical reactions were reported by Malapati and Polarapu [9]. The MHD heat & mass propagation of an oscillating movement that takes place via a vertical porous plate in a porous material as a result of a chemical reaction was investigated by Zubi [15]. Raju *et al.,* [21] studied the Heat and mass transfer in MHD mixed convection flow on a moving inclined porous plate

As a result of its effectiveness in fields as diverse as astrophysics, geophysics, metallurgy, aeronautics, meteorology, electronics, and petroleum, in recent years, many researchers have been interested in studying hydromagnetic natural convection flow in absorbent and non-porous media. Ahmed *et al.,* [2] used the perturbation approach to investigate the influence of viscous dissipation, chemical reaction, mass and heat transport, and on an MHD flow through a vertical porous wall. Unsteady MHD flow via an infinitely varying vertical porous surface was investigated by Veera Krishna *et al.,* [8]. The Darcian model for magnetohydrodynamic unsteady flow via a vertical plate utilizing the finite difference approach in porous media transfer modeling was studied by Ahmed *et al.,* [1]. Using heat and mass transfer, Muthucumaraswamy and Ganesean [11] inspected unsteady flow across a vertical plate that is impulsively begun. For their study, RamanaAziz *et al.,* [13] took into convection to analyze MHD flow over a vertically moving porous plate with heat flux. Tripathy *et al.,* [14] have reported that chemical reactions have been found to affect the MHD free convection surface over a moving vertical plate via porous media.

The heat source and the consequences of the chemical reaction are both essential components in the process of managing the heat and mass transfer. The purpose of this work is to make an effort to explore the impact that chemical reactions and the combined effects of internal heat production and the convective boundary condition have on the MHD heat and mass transfer flow. To the best of the authors' knowledge, no one has ever studied the influence of a chemical reaction and a heat source along with a convective surface boundary condition on MHD flow, as well as the heat and mass transfer across a moving vertical plate. This is despite the fact that this is something that should have been considered in the past. Because of this, we were compelled to suggest doing research just like it. Makinde [16] researched the effects of a convective surface boundary condition on heat and mass transport in a moving vertical plate in magnetohydrodynamics. While considering the influence of chemical reaction on free convective flow of a polar fluid through a porous material with internal heat generation, Patil and Kulkarni [17] conducted an investigation. The effects of mass suction on MHD boundary layer flow and heat transmission were investigated by Goud*et al.,*[18] using a porous shrinking sheet equipped with a heat source and a heat sink. heat mass transfer impact on flat plate with variable viscosity researched by kumar and shivaraj [19], Padmaja and Kumar [20] examined the Higher order chemical reaction effects with nanofluid flow concept, Sowmiya and Rushi [22] studied Dufour effects on MHD mixed convection flow in a permeable vertical plate, Padmaja and Rushi [23] studied the effects of buoyancy and ohmic heating on the motion of a magnetically driven nanofluid along a vertical plate embedded in a porous medium.

This research aims to propose a numerical solution for the heat and mass transfer MHD oscillatory flow across a vertical porous permeable plate with chemical reaction and heat generation. In this situation in the flow field is described by partial differential equations. When these flow-describing partial differential equations come up, they are changed into regular differential equations. A computational algorithm is used to find a number solution which is known as finite difference method. With the help of diagrams, the outcomes of the physical factors on the profiles of velocity, temperature, and concentration are shown. Also, physical quantities are calculated and shown in tables.

2. Formulation

We consider a saturated porous media on an infinite vertical plate and a 2-D unsteady laminar non-Darcian mixed convective moment of viscous, incompressible fluid (see Figure 1). To avoid considering the stimulus of the induced magnetic field, a magnetic field of intensity (B_0) is produced perpendicularly to the surface. The x^* axis is vertical with respect to the flat surface, whereas the y^* axis is normal to it. Because of this, the flow variables are only dependent on y′ and time t′ as it is supposed that the flat surface is infinite. We start with the hypothesis that both the fluid and the plate are at rest, and then, once$t^* > 0$, we allow the whole thing to begin moving at a constant speed. At time $t^* = 0$, the plate temperature is rapidly increased to T_w and then held at that value. The governing equations are:

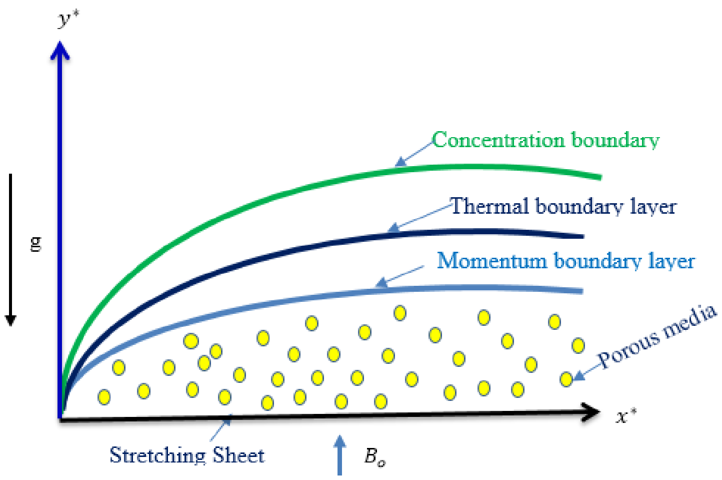

Fig. 1. Flow geometry

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

$$\frac{\partial u^*}{\partial t^*} + v^*\frac{\partial u^*}{\partial y^*} = \upsilon\frac{\partial^2 u^*}{\partial y^{*2}} + \upsilon_r\frac{\partial^2 u^*}{\partial y^{*2}} + g\beta_T(T - T_\infty) + g\beta_C(C - C_\infty) - \frac{\sigma B_0^2}{\rho}u^* - \frac{\upsilon}{K^*}u^* - \frac{\upsilon_r}{K^*}u^* \tag{2}$$

$$\frac{\partial T}{\partial t^*} + v^*\frac{\partial T}{\partial y^*} = \alpha\frac{\partial^2 u^*}{\partial y^{*2}} - \frac{1}{\rho C_p}\frac{\partial q_r}{\partial y^*} + \frac{Q_0}{\rho C_p}(T - T_\infty) \tag{3}$$

$$\frac{\partial C}{\partial t^*} + v^*\frac{\partial C}{\partial y^*} = D\frac{\partial^2 C}{\partial y^{*2}} + \gamma_1^*(C - C_\infty) \tag{4}$$

The appropriate boundary constraints are

$$\left.\begin{array}{c} u^* = u_p^*,\ \ T = T_\infty + \varepsilon(T_w - T_\infty)e^{n^*t^*}, C = C_\infty + \varepsilon(C_w - C_\infty)e^{n^*t^*}, at\ \ y^* = 0 \\ u^* \to 0, T \to T_\infty, C \to C_\infty\ \ at\ \ y^* \to \infty \end{array}\right\} \tag{5}$$

Integrating Eq.(1),

We get $v^* = -V_0$ (6)

$$\left.\begin{array}{c} u=\frac{u^*}{U_0}, t=\frac{V_0^2}{v}t^*, v=\frac{v^*}{V_0}, Gr=\frac{vg\beta_T(T_w-T_\infty)}{U_0V_0^2}, Gm=\frac{vg\beta_C(C_w-C_\infty)}{U_0V_0^2}, \\ y=\frac{V_0}{v}y^*,\ M=\frac{\sigma B_0^2 v}{\rho V_0^2}, \beta=\frac{v_r}{v}\ , Kp=\frac{K^*V_0^2}{v^2}, n^*=\frac{V_0^2}{v}n, Pr=\frac{v}{\alpha}, Sc=\frac{v}{D}, \\ Kr=\frac{v}{V_0^2}\gamma_1^*, u_p^*=U_0U,\ Q=\frac{Q_0 v}{\rho C_p V_o^2},\ R=\frac{k_e k}{4\sigma_s T_\infty^3} \end{array}\right\} \tag{7}$$

Eq. (1) – Eq. (6) are reduced to the following, when Eq. (5) is used.

$$\frac{\partial u}{\partial t}-\frac{\partial u}{\partial y}=(1+\beta)\frac{\partial^2 u}{\partial y^2}+Gr\theta+Gm\phi-Mu-\left(\frac{1+\beta}{K}\right)u \tag{8}$$

$$\frac{\partial \theta}{\partial t}-\frac{\partial \theta}{\partial y}=\frac{1}{Pr}\frac{\partial^2 \theta}{\partial y^2}+Q\theta \tag{9}$$

$$\frac{\partial \phi}{\partial t}-\frac{\partial \phi}{\partial y}=\frac{1}{Sc}\frac{\partial^2 \phi}{\partial y}+Kr\phi \tag{10}$$

Taking into consideration the relevant non - dimensional boundary circumstances:

$$\left.\begin{array}{l} u=U,\ \ \theta=\varepsilon e^{nt}, \phi=\varepsilon e^{nt}, at\ \ y=0 \\ \quad u\to 0, \theta\to 0, \phi\to 0\ \ \ as\ \ y\to\infty \end{array}\right\} \tag{11}$$

3. Solution

It's not easy to get an accurate answer to the partial differential equations. The implicit finite difference technique is used to answer the flow equations provided in Eq. (8) – Eq. (10) under the suitable starting and boundary circumstances Eq. (11). By applying Taylor's expansion, the transport Eq. (8) - Eq. (10) are rewritten to be represented in difference form at the grid point (i, j).

The finite difference method involves a four-stage process for solving a partial differential equation, such as Eq. (1) – Eq. (4).

i. One possible approach in mathematical modeling is to discretize the domain.
ii. The process of determining the solution to an equation at specific, separate points in time.
iii. The application of finite differences as a substitute for derivatives.
iv. The process of creating a recursive algorithm.

The process of replacing finite difference formulae is a common technique in numerical analysis,

$\frac{\partial \xi}{\partial t}=\frac{\xi_i^{j+1}-\xi_i^j}{\Delta t},\ \frac{\partial \xi}{\partial y}=\frac{\xi_i^{j+1}-\xi_i^j}{\Delta y},\ \frac{\partial^2 \xi}{\partial y^2}=\frac{1}{2}\left(\frac{\xi_{i-1}^{j+1}-2\xi_i^j+\xi_{i+1}^{j+1}+\xi_{i-1}^j-2\xi_i^j+\xi_{i+1}^j}{(\Delta y)^2}\right)$ in to Eq. (8) to Eq. (10) and upon applying the Crank-Nicholson technique for implicit simplification, the resulting equations yield the following outcome: Eq. (8) are transformed.

$$\left(u_i^{j+1}-u_i^j\right)-\frac{\mathrm{k}}{\mathrm{h}}\left(u_{i+1}^j-u_i^j\right)=\frac{\mathrm{k}(1+\beta)}{2\mathrm{h}^2}\left(u_{i-1}^{j+1}-2u_i^{j+1}+u_{i+1}^{j+1}+u_{i-1}^j-2u_i^j+u_{i+1}^j\right)$$

$$+\mathrm{k}Gr\ \theta_i^j+\mathrm{k}Gr\ \phi_i^j-\mathrm{k}\left(M+\frac{(1+\beta)}{2}\right)u_i^j$$

On simplification

$$-\frac{\mathrm{r}(1+\beta)}{2}u_{i-1}^{j+1}+\left(1+r(1+\beta)\right)u_{i}^{j+1}-\frac{\mathrm{r}(1+\beta)}{2}u_{i+1}^{j+1}=\frac{\mathrm{r}(1+\beta)}{2}u_{i-1}^{j}+$$
$$\left(1-rh-\left(M+\frac{(1+\beta)}{2}\right)k-(1+\beta)\mathrm{r}\right)u_{i}^{j}+\left(1+rh+(1+\beta)\frac{\mathrm{r}}{2}\right)u_{i+1}^{j}+Gr\,\mathrm{k}\theta_{i}^{j}+\mathrm{k}Gr\,\phi_{i}^{j}$$
$$-A_1\left(u(i-1)+u(i+1)\right)+A_2u(i)=A(i)$$
$$A_1=\frac{\mathrm{r}(1+\beta)}{2},A_2=\left(1+r(1+\beta)\right),\;\; A_3=\left(1-rh-\left(M+\frac{(1+\beta)}{2}\right)k-(1+\beta)\mathrm{r}\right),$$
$$A(i)=A_1u_{i-1}^{j}+A_3u_{i}^{j}+(1+rh+\mathrm{A}_1)u_{i+1}^{j}+Gr\,\mathrm{k}\theta_{i}^{j}+\mathrm{k}Gr\,\phi_{i}^{j}$$

$$-A_1\left(u(i-1)+u(i+1)\right)+A_2u(i)=A(i) \tag{12}$$

Likewise the Eq. (9) and Eq. (10) variations to

$$-\frac{\mathrm{r}}{2Pr}\theta_{i-1}^{j+1}+\left(1+\frac{r}{Pr}\right)\theta_{i}^{j+1}-\frac{r}{2Pr}\theta_{i+1}^{j+1}=\frac{r}{2Pr}\theta_{i-1}^{j}+\left(1-rh-\frac{r}{Pr}+kQ\right)\theta_{i}^{j}+\left(rh+\frac{r}{2Pr}\right)\theta_{i+1}^{j}$$

$$-B_1\left(\theta(i-1)+\theta(i+1)\right)+B_2\theta(i)=B(i) \tag{13}$$

$$B_1=\frac{r}{2Pr},B_2=\left(1+\frac{r}{2Pr}\right),B_3=\left(1-rh-\frac{r}{Pr}+kQ\right),B(i)=B_1\theta_{i-1}^{j}+B_3\theta_{i}^{j}+(rh+B_1)\theta_{i+1}^{j}$$

$$-\frac{\mathrm{r}}{2Sc}\phi_{i-1}^{j+1}+\left(1+\frac{r}{Sc}\right)\phi_{i}^{j+1}-\frac{\mathrm{r}}{2Sc}\phi_{i+1}^{j+1}$$
$$=\frac{\mathrm{r}}{2Sc}\phi_{i-1}^{j}+\left(1-rh-\frac{\mathrm{r}}{Sc}+kKr\right)\phi_{i}^{j}+\left(rh+\frac{\mathrm{r}}{2Sc}\right)\phi_{i+1}^{j}$$

$$-C_1\left(\phi(i-1)+\phi(i+1)\right)+C_2\phi(i)=C(i) \tag{14}$$

$$C_1=\frac{\mathrm{r}}{2Sc},C_2=1+\frac{r}{Sc},C_3=\left(1-rh-\frac{\mathrm{r}}{Sc}+kKr\right),C(i)=C_1\phi_{i-1}^{j}+C_3\phi_{i}^{j}+(rh+C_1)\phi_{i+1}^{j}$$

Eq. (12) –Eq. (14) may be written as;

$$A_2u(i)-A_1\left(u(i-1)+u(i+1)\right)=A(i)$$
$$B_2\theta(i)-B_1\left(\theta(i-1)+\theta(i+1)\right)=B(i)$$
$$C_2\phi(i)-C_1\left(\phi(i-1)+\phi(i+1)\right)=C(i)$$

Where ξ stands $u\ \theta\ and\ \phi$

$$A_1=\frac{\mathrm{r}(1+\beta)}{2},A_2=\left(1+r(1+\beta)\right),\;\; A_3=\left(1-rh-\left(M+\frac{(1+\beta)}{2}\right)k-(1+\beta)\mathrm{r}\right),B_1$$
$$=\frac{r}{2Pr},B_2=\left(1+\frac{r}{2Pr}\right),B_3=\left(1-rh-\frac{r}{Pr}+kQ\right),C_1=\frac{\mathrm{r}}{2Sc},C_2=1+\frac{C_1}{2},C_3$$
$$=\left(1-rh-\frac{\mathrm{r}}{Sc}+kKr\right),r=\frac{k}{h^2}$$
$$A(i)=A_1\left(u(i-1)+u(i+1)\right)+A_3u(i)+Gr\,\mathrm{k}\theta_{i}^{j}+\mathrm{k}Gr\,\phi_{i}^{j} \tag{15}$$
$$B(i)=B_1\left(\theta(i-1)+\theta(i+1)\right)+B_3\theta(i) \tag{16}$$
$$C(i)=C_1\left(\phi(i-1)+\phi(i+1)\right)+C_3\phi(i) \tag{17}$$

Initial and boundary constraints expressed in finite difference format as

$$\left.\begin{array}{c} u(i,0) = U, \theta(i,0) = \varepsilon e^{\xi t}, \phi(i,0) = \varepsilon e^{\xi t} \quad for\ all\ i \\ u(i_{max},\infty) \to 0,\ \theta(i_{max},\infty) \to 0,\ \phi(i_{max},\infty) \to 0, for\ all\ i \end{array}\right\} \tag{18}$$

The variables y and t are denoted by the numbers i and j, correspondingly.

When the velocity field is known, the skin-friction at the plate can be calculated, and the result, in a form that is not dimensioned, is provided by$C_f = -\left(\frac{\partial u}{\partial y}\right)_{y=0}$.

When the temperature field is known, the Nusselt number at the plate can be calculated, and the result, in a form that is not dimensioned, is provided by$Nu = -\left(\frac{\partial \theta}{\partial y}\right)_{y=0}$.

When the concentration field is known, the Sherwood number at the plate can be calculated, and the result, in a form that is not dimensioned, is provided by$Sh = -\left(\frac{\partial \phi}{\partial y}\right)_{y=0}$.

4. Results and Discussion

Through the use of the finite difference method, set of PDEs with constraints may be solved numerically. As can be seen from the findings, different non-dimensional regulating factors have different impacts on the flow patterns. Additionally, the skin friction, the Nusselt number, and the Sherwood number are shown in the tabular format.

The velocity field is shown for a variety of numerous values of the magnetic field factor(M) in Figure 2. It is clear that when one enhances M, the velocity distribution drops. This is due to the fact that the introduction of a magnetic field consequences in the generation of a flow resistive force.

The impact of the permeability parameter on the velocity is seen in Figure 3. It was perceived that there was a correlation between the change in the permeability parameter and the rise in the fluid velocity. This occurs as a direct result of the existence of a porous media in the movement, which creates opposition to flow. Therefore, as a consequence of the ensuing resistive force, the velocity of the fluid over the plate surface tends to slow down.

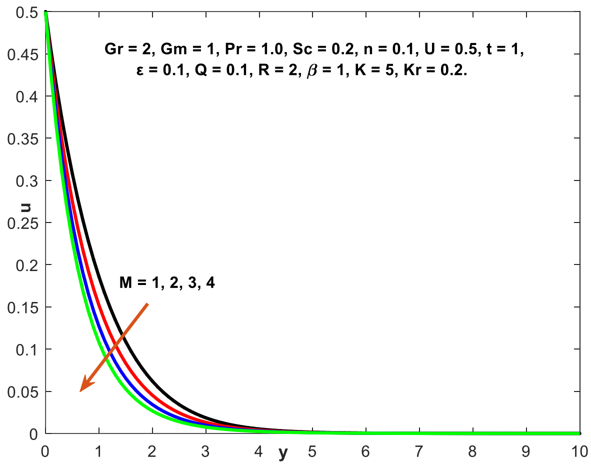

Fig. 2. Velocity against M

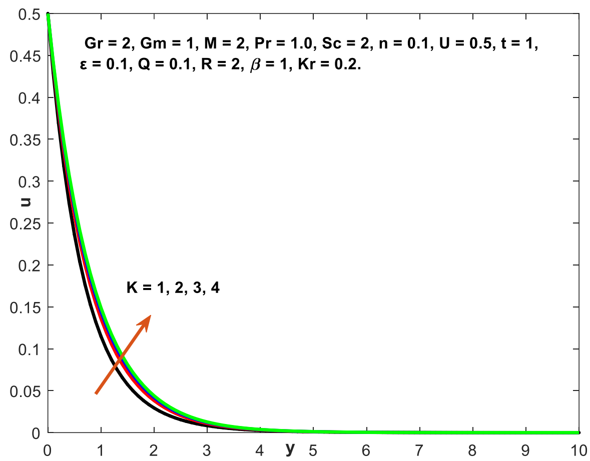

Fig. 3. Velocity against K

According to Figure 4, various values of the thermal Grashof number Gr produce a different velocity field. Since the buoyant force is increased with a higher Gr values,it is seen that the velocity upsurges.

In Figure 5, the velocity field is shown for a variety of various solutal Grashof number (Gm) values. After reaching its highest point in the area, the flow velocity begins to drop and eventually approaches the value of the free stream. This is made clear by the fact that the value of velocity rises as the Gm, becomes higher.

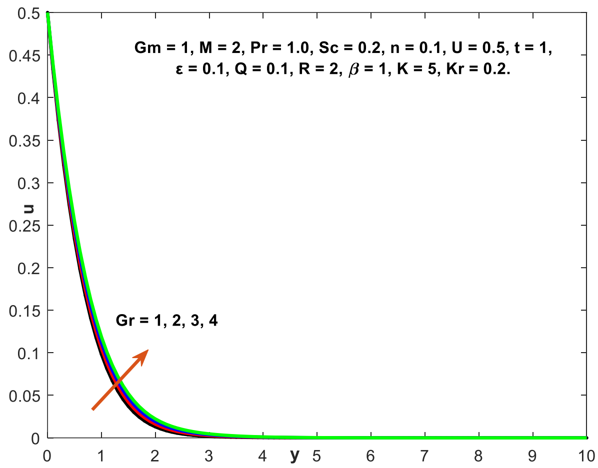

Fig. 4. Velocity against Gr

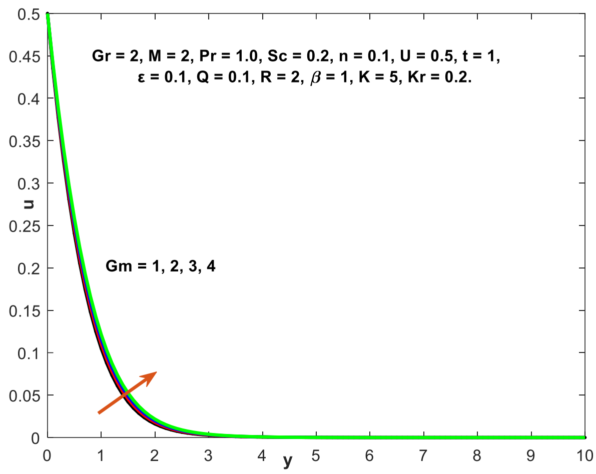

Fig. 5. Velocity against Gm

Figure 6 shows an illustration of the velocity distribution for a variety of various values of the dimensionless viscosity factor(β). When β is increased, it is clear to observe that there is a corresponding rise in the velocity filed.

A visualization of the velocity curves against many values of the Prandtl number P is shown in Figure 7. As the Pr grows, this can be perceived that the flow field's velocity is decreasing.

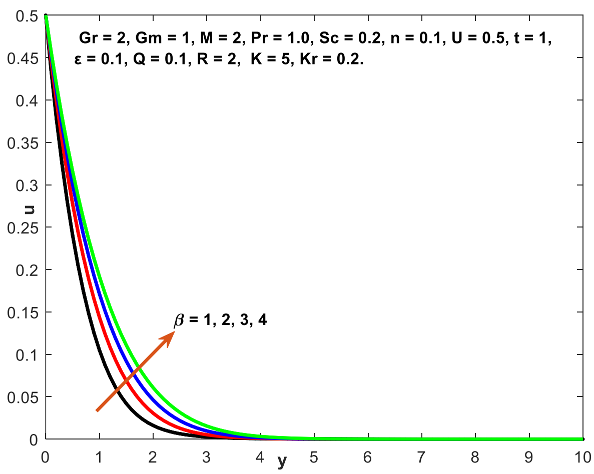

Fig. 6. Velocity against β

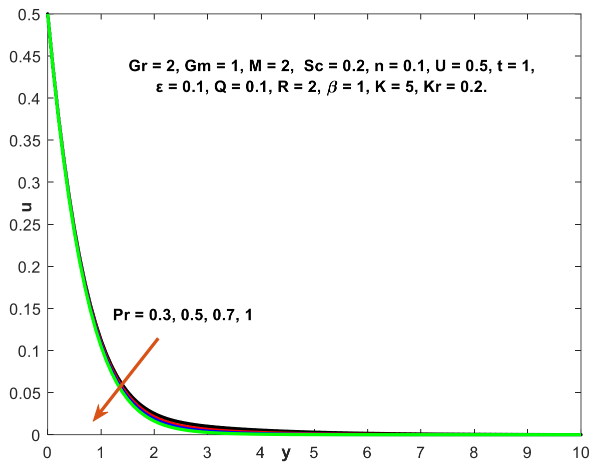

Fig. 7. Velocity against Pr

The impact that the Schmidt number Sc has on the velocity is seen in Figure 8. When the Schmidt number is increased, the fluid velocity reduces. Concurrently, the momentum boundary layer width also lowers as a result of the decline in velocity field.

The influence of the various heat source parameters(Q) on the temperature distributions of the flow is shown in Figure 9. It has been observed that there is a negative correlation between the rise in Q and the temperature profiles of the flow. Which is as increase of heat source the result in the temperature decrease.

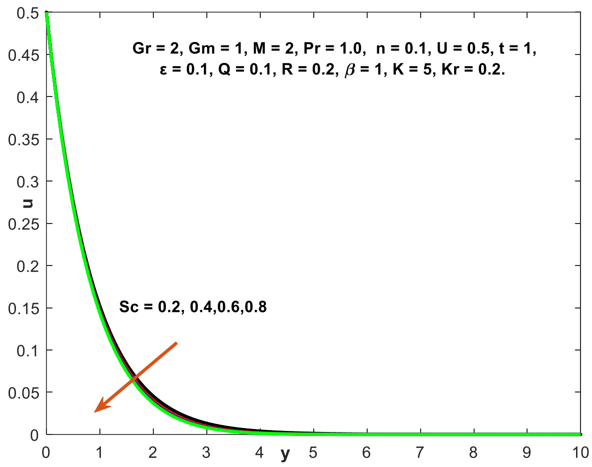

Fig. 8. Velocity against Sc

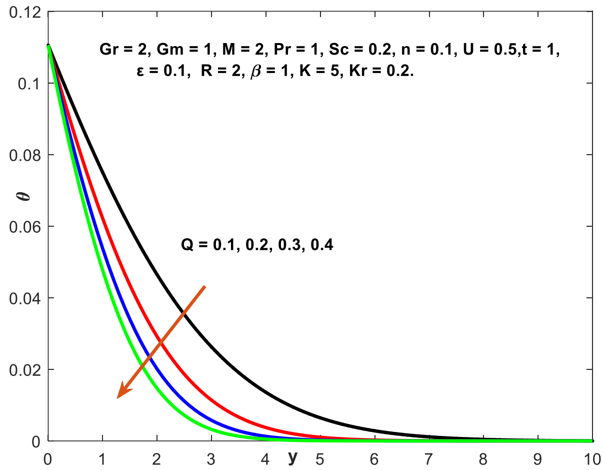

Fig. 9. Temperature against Q

The effects of time on flow fields are shown in Figures 10, 11 and 12. Over time, the fluid fields clearly expand. The maximum velocity is reached quite close to the surface, and from there the velocity profile gradually drops to an asymptotic value,same trend can be seen in the temeperature and Concentration fields .

Figure 13 depicts how the Prandtl number affects the temperature distribution. In this diagram, we can see that when Pr is increases, the fluid temperature drops. Increases in the Prandtl number cause the kinematic viscosity to become larger than the density, which results in the formation of a force that acts as a barrier to the forward movement of the fluid.

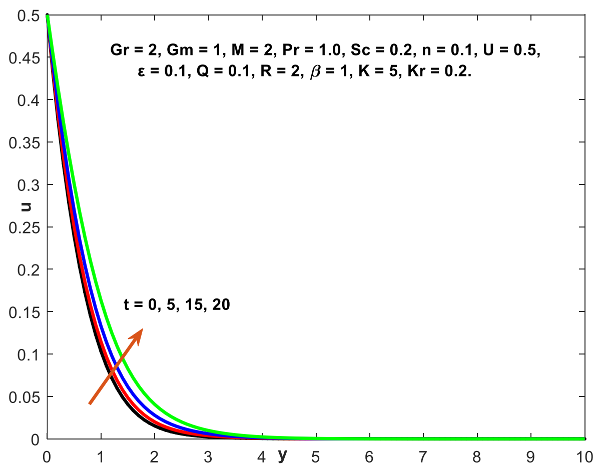

Fig. 10. Velocity against t

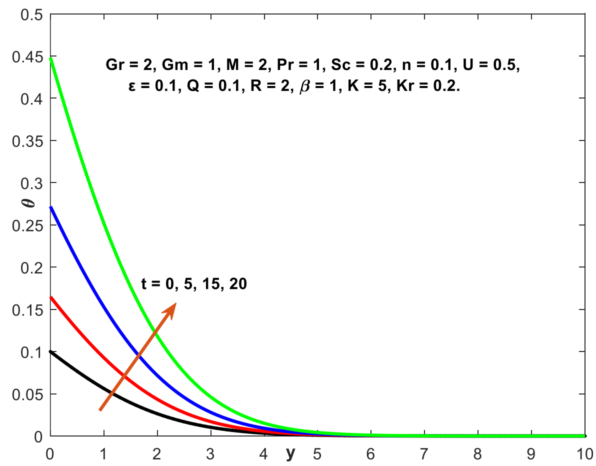

Fig. 11. Temperature against t

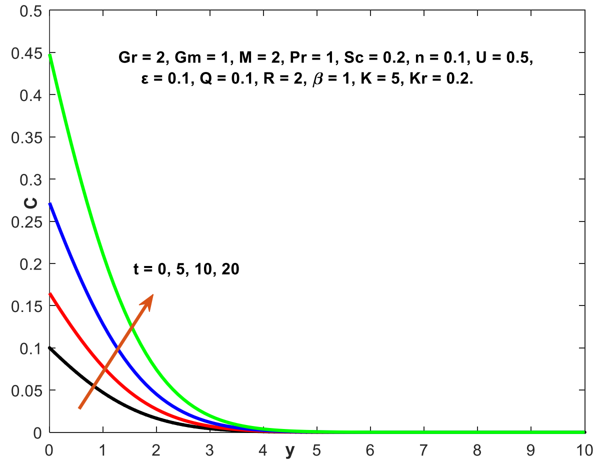

Fig. 12. Concentration against t

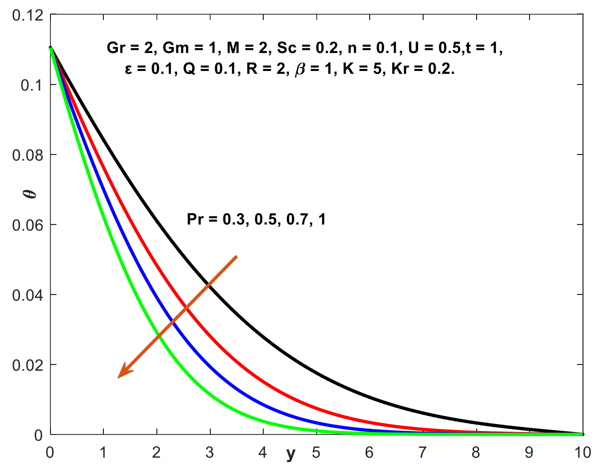

Fig. 13. Temperature against Pr

The pattern of concentration is revealed in Figure 14 for a variety of numerous values of the chemical reaction parameter. It is able to see that the concentration rises as the value of Kr rises. This is due to the fact that the chemical reaction upsurges the rate of momentum transfer, which in turn speeds up the flow

Figure 15 illustrates the concentration curve for a variety of Schmidt number Sc values. When the Sc goes up, the concentration of the substance goes down. Causing the concentration buoyant impacts to diminish, which ultimately results in a drop in the flow speed. This is due to the inverse link between the Schmidt number and mass diffusivity. As the concentration distribution drops, a fluid flow regime with a higher Sc value has lower mass diffusion values.

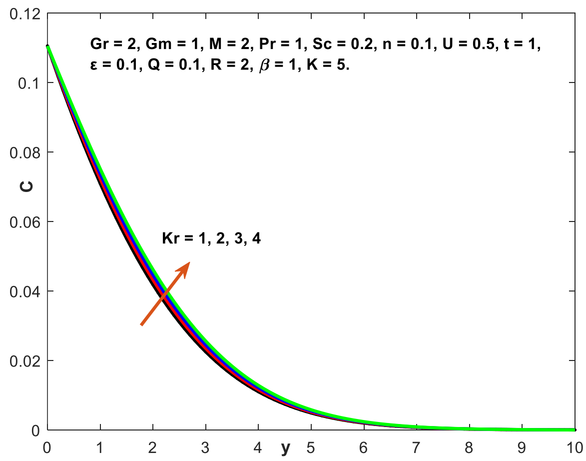

Fig. 14. Concentration against Kr.

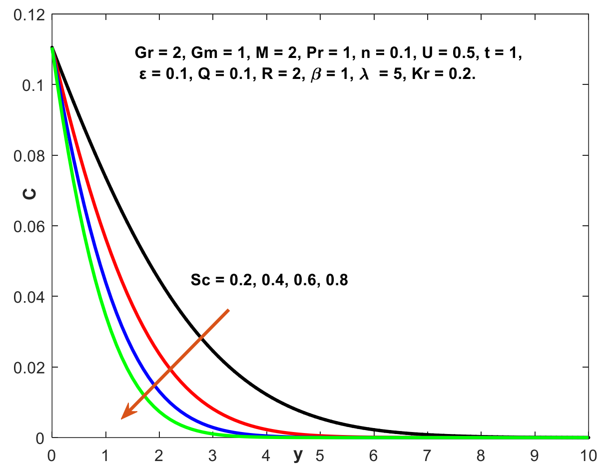

Fig. 15. Concentration against Sc

Figure 16 presents an illustration of the skin friction for a range of various M values and values. It is plain to observe that as M, β rises, the amount of friction experienced by the skin reduces. The influence that Q and Pr have on the Nusselt number is seen in Figure 17. The decrease in the Nusselt number is followed by increases in both the value of Q and the value ofPr.The Sherwood number is shown in Figure 18 for a variety of various Sc and Kr values. As the values of Sc and Kr grow, the Sherwood number drops.

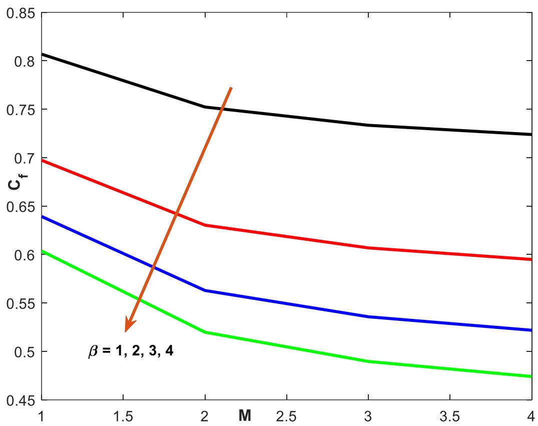

Fig. 16. Skinfriction Cf against M,with β

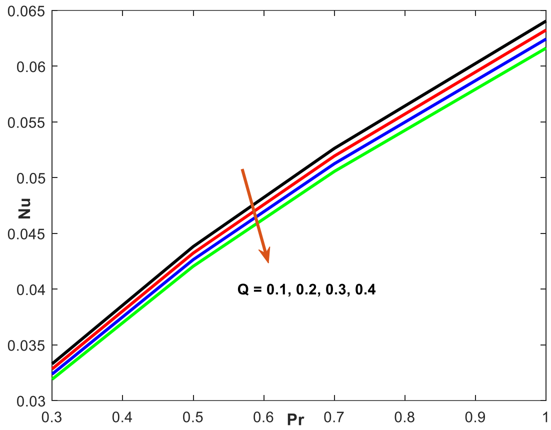

Fig. 17. Nusselt number Nu against Pr with Q

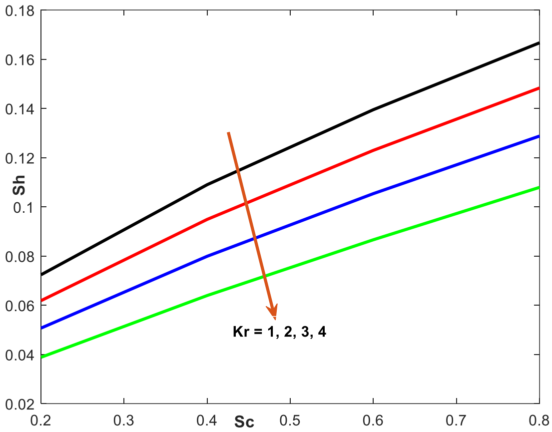

Fig. 18. Sherwood number against Sc & Kr

The various nondimensional parameters effects on friction factor, rate of heat transfer, Sherwood numbers are presented in the Table 1-3. From Table 1, we can see that the skin friction goes up as the magnetic parameter rises. While it declines when Gr, Gm, and K are present. From Table 2, we can see that the impact of the rate of change in temperature keeps rising as Pr and R go up, but it decreases gradually as Q gets higher. Table 3 shows that when Sc values are raised, the impact of the Sherwood number grows, whereas Kr values bring it down.

Table 1
Skin friction values for the numerous values of M, Gr, Gm and K with fixed values of $Pr = 0.71; Q = 0.1; R = 0.1;\ Kr = 0.1; Sc = 0.2; n = 0.1; U = 0.5; \varepsilon = 0.1; t = 1; \beta = 1$

M	Gr	Gm	K	Cf
1				0.7676
2				0.8218
3				0.8733
1	2			0.7455
	3			0.7235
	1	2		0.7506
		3		0.7337
		1	2	0.7105
			3	0.6908

Table 2
Nusselt number values for the various values of Q, R and Pr with fixed values of $M = 1; Gr = 1; Gm = 1; K = 1;\ Kr = 0.1; Sc = 0.2; n = 0.1; U = 0.5; \varepsilon = 0.1; t = 1; \beta = 1$

Q	R	Pr	Nu
0.1	0.1	0.71	0.0378
0.2			0.0373
0.3			0.0367
	0.2		0.0530
	0.3		0.0640
		1	0.0454

Table 3
Sherwood number values for the various values of Kr and Sc with fixed values of$M = 1; Gr = 1; Gm = 1; K = 1; Pr = 0.71; Q = 0.1; R = 0.1;\ n = 0.1; U = 0.5; \varepsilon = 0.1; t = 1; \beta = 1$

Kr	Sc	Sh
0.1	0.2	0.0813
0.2		0.0804
0.3		0.0794
0.1	0.4	0.1210
	0.6	0.1535

5. Conclusions

Taking into account both the heat source and the chemical reaction, this work presents the results of a numerical analysis of a vertically, infinitely permeable MHD oscillating plate. The most important outcomes from the computations are briefly discussed below:

i. The velocity rises as the values of K, Gr, Gm, β, t, and improve, whereas it drops when the values of M, Pr, and Sc enhance.
ii. The Temperature drops as the values of Pr and Q rise, but it rises as t grows.
iii. That the skin friction increases as M increases. While it decreases in the presence of Gr, Gm, and K.
iv. The Nusselt number rises as Pr and R increase, but it progressively declines as Q increases.
v. When Sc values are increased, the influence of the Sherwood number increases, but Kr values have the opposite effect.

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