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Application of Approximation Technique for the Effects of Chemical Reaction and Radiation Absorption of MHD Fluid flowing past an inclined porous plate in the presence of inclined magnetic field

Research Article

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Abstract: The objective of this paper is to present an approximate analytical solution for a steady two-dimensional MHD convective flow driven by vertical porous plate under the influence of chemical reaction and radiation absorption in the presence of inclined magnetic field. The governing flow equations of mass conservation, momentum, energy, and concentration are reduced to a system of ordinary differential equations and solved using Temimi-Ansari method. The effect of surface conditions on the flow characteristics have been studied. Results are presented for different values of the parameters entering the problem such as Casson parameter, Hartmann number, inclined magnetic parameter, porosity parameter, angle of inclination, Grashof number, modified Grashof number, Prandtl number, Eckert number, heat source parameter, Schmidt number and chemical reaction parameter graphically and discussed. We observe in our study that, the control parameters have significant consequences on the velocity, temperature, and concentration gradients of the fluid. To demonstrate the dependability, consistency, and accuracy of the obtained solution, we compare the result obtained with those in established literature and found an excellent agreement. The achieved result reveal that, the Casson parameter, Grashof number and modified Grashof number have positive correlation with the velocity gradient, whereas the presence of Hartmann number, inclined magnetic parameter, porosity, and angle of inclination lead to a declination of the velocity profile. Similarly, acceleration of Eckert number, magnetic parameter and heat source enhance the temperature distribution while it reduced with increase in Prandtl and inclined magnetic parameters. Concentration profile decreased with positive increment in Schmidt and chemical reaction parameters.

MSC: 76W05 • 35Q35 • 34B60

Keywords: Temimi-Ansari method (TAM) • Velocity • Temperature profile • Inclined porous plate • MHD • Chemical reaction • Radiation

1. Introduction

In many aspects of industrial operations, environmental processes, scientific and in the academia, convective heat and mass transfer which involves coupled transfer of mass due to temperature gradient is of paramount significance and stimulated considerable interest. Due to this growing interest, understanding and modelling of flow of convective fluid under the influence of several factors across different flow geometries or media are both fundamental and of practical significance in industrial and engineering applications. Cursory examination of studies in this subject

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among different flow characteristics abound and have been subject of intense research in literature. For instance, some of the applications of this novel phenomenon can be found in astrophysical flows, evaporation of water from open reservoirs, heating and cooling of chambers, Solar power technology among many others. Equally, magnetohydrodynamics flow of Casson fluid of convective fluid subject to chemical reaction and radiation absorption in the presence of inclined magnetic field has recently caught the fascination of researchers and studied extensively. Elbashbeshy [1] have considered heat and transfer flow along a vertical plate with variable surface tension and concentration in the presence of magnetic field. MHD free convection through a vertical surface with Ohmic heating and viscous dissipation with combined heat and mass transfer have been discussed by Chen [2]. Lorenzini et al. [3] studied free convective heat and mass transfer flow of Casson fluid flow over an unsteady permeable stretching surface under the influence of viscous dissipation. A numerical Investigation was considered for an unsteady mixed convective mass and heat transfer MHD flow with Soret effect and viscous dissipation in the presence of thermal radiation and heat source/sink by Veena et al. [4]

Using semi-analytical Adomian decomposition method, Ebiwareme et al. [5] have implemented an approximate analytical solution for MHD Casson flow of convective fluid through a semi-infinite vertical porous plate influenced by chemical reaction and thermal radiation. The study reported that, the behaviour of the emerging flow parameters significantly impacted the velocity, temperature, and concentration gradients of the fluid. Ebiwareme et al. [6] have examined the magnetohydrodynamic fluid flow past a vertical porous plate subject to transverse magnetic field. The obtained solution best approximates the closed form solution of the problem. Radiative heat and mass transfer effect on a moving isothermal vertical plate in the presence of chemical reaction have been reported by Muthucummaraswamy and Chandrakala [7]. Postelnicu [8] have analysed significance of heat and mass transfer through natural convection from a vertical surface in porous media under the dual effects of Dufour and thermo-diffusion. Mass transfer effect on magnetohydrodynamic flow of Casson fluid with suction and chemical reaction has been studied by Asghar et al. [9]. Thermal radiation effects of free convection with mass transfer flowing past a moving vertical plate have been investigated by Makinde [10]. MHD convective flow over porous plate through a porous medium in the presence of heat generation with coupled chemical reaction and radiation has been presented by Mohammed and Lavanya [11]. Samad and Mohebujjaman [12] addressed the problem of MHD heat and mass transfer free convection flow along a vertical stretching sheet in the presence of magnetic field and heat generation. Combined effect of Hall current and chemical reaction on hydromagnetic flow of a stretching vertical surface with internal heat generation/absorption have been dealt with by Salem and El-Aziz [13]. Sharma and Gupta [14] have worked on unsteady MHD free convective flow and heat transfer along a vertical porous plate with variable suction and internal heat generation. Soundalgekar [15] conducted an analytical study on mass transfer effects on flow past an impulsively started infinite vertical plate with constant heat flux and chemical reaction. Free convection flow of heat transfer through a porous plate immersed in a porous medium with variable suction has been inspected by Rahman et al. [16]. Sharma [17] explored free convection effects on the flow past a porous medium bounded by a vertical infinite surface with constant suction and constant heat flux. Hossiah and Begun [18] scrutinized the effects of mass transfer and free convection on the flow past a vertical plate. Unsteady free convection flow past an infinite vertical plate with constant suction and mass transfer has been exposed by Soundalgekar [19]. Sanatan et al. [20] have looked at natural convection near a vertical plate embedded in a porous medium with ramped wall temperature and radiation effects. Biswal et al. [21] obtained a numerical solution to the problem of magnetohydrodynamic unsteady free convection flow past an infinite vertical plate with constant suction and heat sink. Heat and mass transfer on MHD free convective flow over an infinite non-conducting vertical flat porous plate has been computed by Gangadhara and Veera [22]. Nagarathna and Sadiq [23] obtained an approximate solution for heat and mass transport on MHD free convective flow through a porous medium past an infinite vertical plate using regular perturbation method. Rahman et al. [24] probed the impact of magnetic field and thermophoresis on transient forced convective heat and mass transfer along a porous wedge with variable thermal conductivity and variable Prandtl number. Combined influence of radiation and chemical reaction on MHD free convection from an impulsively started infinite vertical plate in the presence of viscous dissipation has been perused by Jithender et al. [25]. A numerical study on changes in Soret-Dufour, radiation, chemical reaction, and viscous dissipation on unsteady MHD flow past an inclined porous plate embedded in porous medium with heat generation or absorption has been carried out by Shukla and Subham [26].

Temimi and Ansari drawing inspiration from the Homotopy analysis method (HAM) proposed semi-analytical iterative method namely (TAM). The main advantage of this novel technique is that it doesn't require any restrictive assumptions for nonlinear terms like the Adomian polynomials for nonlinear terms in the Adomian decomposition method (ADM), does not use small parameters like in other iterative methods such as HAM and HPM and no large computational work. TAM has been successfully implemented to solve linear and nonlinear ODEs, Duffing equation, Korteweg-De Vries equation, chemistry problems, nonlinear thin flow problems, linear and nonlinear PDEs [27] - [36].

In view of the above studies and realizing the ever-increasing practical importance of MHD flows, we consider a steady two-dimensional MHD convective fluid flow through a vertical porous plate in the presence of chemical reaction and radiation absorption with an externally oriented inclined magnetic field. The physical quantities of interest and their effects on the fluid distribution are calculated and presented in graphical form. The study is organized as follows: in the next section, the governing flow equations are presented. Section three gives the basic idea of the Temimi-Ansari method (TAM). The solutions of the flow distributions in dimensionless form using the solution technique are implemented in section four. Section five gives the variations in pertinent parameters against the flow gradients in graphical form and their extensive discussions while the conclusions and findings of the study are reported in section 6.

2. Governing Equation

$$v^* \frac{\partial u^*}{\partial y^*} = v\left(1+\frac{1}{\beta}\right)\frac{\partial^2 u^*}{\partial y^{*2}} + g\beta^*\left(C^*-C_\infty\right) + g\beta^*\left(T^*-T_\infty\right) - \frac{\sigma B_0^2}{\rho}\sin^2\gamma u^2 - \frac{v u^*}{K^*} \tag{1}$$

$$v^* \frac{\partial T^*}{\partial y^*} = \frac{\kappa}{\rho C_\rho}\frac{\partial^2 T^*}{\partial y^{*2}} + \frac{v}{C_\rho}\left(\frac{\partial u^*}{\partial y^*}\right)^2 + \frac{\sigma B_0^2 \sin^2\gamma}{\rho} u^{*2} + \frac{Q_0}{\rho C_\rho}\left(T^*-T_\infty\right) \tag{2}$$

$$v^* \frac{\partial C^*}{\partial y^*} = D\frac{\partial^2 C^*}{\partial y^{*2}} - K_1\left(C^*-C_\infty\right) \tag{3}$$

The boundary conditions are as follows

$$u^* = 0,\ C^* = C_w,\ T^* = T_w \text{ at } y^* = 0$$

$$u^* \longrightarrow 0,\ C^* \longrightarrow C_\infty,\ T^* \longrightarrow T_\infty \text{ as } y^* \longrightarrow \infty \tag{4}$$

To make the physics of the problem easier to understand, we introduce the following non-dimensional parameters of the form

$$u = \frac{u^*}{v_0},\ y = \frac{v_0 y^*}{v},\ Pr = \frac{\upsilon_\rho C_\rho}{\kappa},\ \theta = \frac{T^*-T_\infty}{T_0-T_\infty},\ \phi = \frac{C^*-C_\infty}{C_0-C_\infty}, Gr = \frac{v g\beta\left(T_w-T_\infty\right)}{v_0^3} \tag{5}$$

Putting Eq. (6) into Eqs. (1-4), we obtain the following simplified non-dimensional equations as follows

$$\left(1+\frac{1}{\beta}\right)\frac{\partial^2 u}{\partial y^2} + \frac{\partial u}{\partial y} - \left(M^2\sin^2\gamma + K_0\right)u + Gr\cos\alpha\,\theta + Gm\cos\alpha\,\varphi = 0 \tag{6}$$

$$\frac{\partial^2\theta}{\partial y^2} + Pr\frac{\partial\theta}{\partial t} + PrEc\left(\frac{\partial u}{\partial y}\right)^2 + PrEcM^2\sin^2\gamma\, u^2 + PrQ\theta = 0 \tag{7}$$

$$Sc\frac{\partial^2\varphi}{\partial y^2} + \frac{\partial\varphi}{\partial t} - Kr\varphi = 0 \tag{8}$$

The resulting boundary conditions are:

$$u = 0,\ \theta = 1,\ \varphi = 1,\ \text{as } y = 0$$

$$u \longrightarrow 0,\ \theta \longrightarrow 1,\ \varphi \longrightarrow 1 \text{ as } y \longrightarrow \infty \tag{9}$$

3. Basics of Temimi-Ansari Method (TAM)

Following Temimi [24] - [25] and Ebiwareme [31] - [33], we consider the general differential equation in operator form as follows

$$L\left(y\left(x\right)\right)+N\left(y\left(x\right)\right)+f\left(x\right)=0,\ \ x\in D \tag{10}$$

$$B\left(y,\frac{dy}{dx}\right)=0,\ \ x\epsilon\mu \tag{11}$$

Where x is the independent variable, $y(x)$ is an unknown function, $f(x)$ is a given known function, L is a linear operator, N is a nonlinear operator and B is a boundary operator.

To implement TAM, we first assume an initial guess of the form, $y_0(x)$ satisfy the equation in the form

$$L\left(y_0\left(x\right)\right)+f\left(x\right)=0,\ \ B\left(y_0,\frac{dy_0}{dx}\right)=0 \tag{12}$$

The second iteration as follows

$$L\left(y_1\left(x\right)\right)+N\left(y_0\left(x\right)\right)+f\left(x\right)=0,B\left(y_1,\frac{dy_1}{dx}\right)=0 \tag{13}$$

We consider the next iteration as follows

$$L\left(y_2\left(x\right)\right)+N\left(y_1\left(x\right)\right)+f\left(x\right)=0,B\left(y_2,\frac{dy_2}{dx}\right)=0 \tag{14}$$

Continuing the same way, we obtain nth iterative procedure to give the subsequent iterates as

$$L\left(y_{n+1}\left(x\right)\right)+N\left(y_n\left(x\right)\right)+f\left(x\right)=0,\ \ B\left(y_{n+1},\frac{dy_{n+1}}{dx}\right)=0 \tag{15}$$

From Eq.(6), each $y_i(x)$ is considered alone as a solution of Eq.(10). This method is easy to implement and straightforward. The method gives better approximate solution which converges to the exact solution with only few members.

4. Analytical Solution of the problem via TAM

To solve the systems of Eqs.(6) - (8) subject to Eq.(9) using TAM, we proceed as follows

The first problem to be solved become

$$L\left(u_0\left(y,t\right)\right)=0,\ u_0\left(0\right)=0,\ u_0'\left(0\right)=\alpha_1 \tag{16}$$

$$L\left(\theta_0\left(y,t\right)\right)=0,\ \theta_0\left(0\right)=0,\ \theta c_0'\left(0\right)=\alpha_2 \tag{17}$$

$$L\left(\varphi_0\left(y,t\right)\right)=0,\ \varphi_0\left(0\right)=0,\ \varphi_0'\left(0\right)=\alpha_3 \tag{18}$$

$$N_1\left(u\left(y,t\right)\right)=\frac{\beta}{\beta+1}\left(M^2\sin^2\gamma+K_0\right)u-\frac{\partial u}{\partial y}-Gr\cos\alpha\,\theta-Gm\cos\alpha\,\varphi \tag{19}$$

$$N_2\left(\theta\left(y,t\right)\right)=-\left(Pr\frac{\partial\theta}{\partial t}+PrEc\left(\frac{\partial u}{\partial y}\right)^2+PrEcM^2\sin^2\gamma\,u^2+PrQ\theta\right) \tag{20}$$

$$N_3\left(\varphi\left(y,t\right)\right)=\frac{-1}{Sc}\left(Kr\varphi-\frac{\partial\varphi}{\partial t}\right) \tag{21}$$

Integrating Eqs. ((19) - (21)) from 0 to y twice and invoking the given boundary conditions at $y = 0$, we obtain the expressions of the form.

$$u_0(y,t) = \delta_1 y,\ \theta_0(y) = 1+\delta_2 y,\ \varphi_0(y) = 1+\delta_3 y \tag{22}$$

The second problem to be solved is of the form

$$\begin{aligned} u_1(y,t) &= N(u_0(y)),\ u_1(0)=0,\ u_1'(0)=\alpha_1 \\ \theta_1(y,t) &= N(\theta_0(y)),\ \theta_1(0)=0,\ \theta_1'(0)=\alpha_2 \\ \varphi_1(y,t) &= N(\varphi_0(y)),\ \varphi_1(0)=0,\ \varphi_1'(0)=\alpha_3 \end{aligned} \tag{23}$$

Integrating Eq. (23) twice from 0 to y, and substituting the given boundary conditions, we get the following integrals.

$$\int_0^y\int_0^y u_1''(\xi)\,d\xi d\xi = \frac{\beta}{\beta+1}\int_0^y\int_0^y\left[\left(M^2\sin^2\gamma+K_0\right)u_0-\frac{\partial u_0}{\partial y}-Gr\cos\alpha\,\theta_0-Gm\cos\alpha\,\varphi_0\right]dydy \tag{24}$$

$$\int_0^y\int_0^y \theta_1''(\xi)\,d\xi d\xi = -\int_0^y\int_0^y\left(Pr\frac{\partial\theta_0}{\partial t}+PrEc\left(\frac{\partial u_0}{\partial y}\right)^2+PrEcM^2\sin^2\gamma\ u_0^2+PrQ\theta_0\right)dydy \tag{25}$$

$$\int_0^y\int_0^y \varphi_1''(\xi)\,d\xi d\xi = \frac{-1}{Sc}\int_0^y\int_0^y\left(Kr\varphi_0-\frac{\partial\varphi_0}{\partial t}\right)dydy \tag{26}$$

The third problem to be solved is given as follows

$$\begin{aligned} u_2''(y,t) &= N(u_1(y)),\ u_2(0)=0,\ u_2'(0)=\alpha_1 \\ \theta_2''(y,t) &= N(\theta_1(y)),\ \theta_2(0)=0,\ \theta_2'(0)=\alpha_2 \\ \varphi_2''(y,t) &= N(\varphi_1(y)),\ \varphi_2(0)=0,\ \varphi_2'(0)=\alpha_3 \end{aligned} \tag{27}$$

Integrating the above equation (24) twice from 0 to y, we get the expression of the form

$$\int_0^y\int_0^y u_2''(\xi)\,d\xi d\xi = \frac{\beta}{\beta+1}\int_0^y\int_0^y\left[\left(M^2\sin^2\gamma+K_0\right)u_1-\frac{\partial u_1}{\partial y}-Gr\cos\alpha\,\theta_1-Gm\cos\alpha\,\varphi_1\right]dydy \tag{28}$$

$$\int_0^y\int_0^y \theta_2''(\xi)\,d\xi d\xi = -\int_0^y\int_0^y\left(Pr\frac{\partial\theta_1}{\partial t}+PrEc\left(\frac{\partial u_1}{\partial y}\right)^2+PrEcM^2\sin^2\gamma\ u_1^2+PrQ\theta_1\right)dydy \tag{29}$$

$$\int_0^y\int_0^y \varphi_2''(\xi)\,d\xi d\xi = \frac{-1}{Sc}\int_0^y\int_0^y\frac{-1}{Sc}\left(Kr\varphi_1-\frac{\partial\varphi_1}{\partial t}\right)dydy \tag{30}$$

Evaluating the integrals in Eqs.(24) - (26), we obtain the first iterates in the form

$$u_1(y,t) = \frac{\beta}{1+\beta}\Big(-\frac{1}{2}\text{Gm}y^2\text{Cos}[\alpha]-\frac{1}{2}\text{Gr}y^2\text{Cos}[\alpha]-\frac{y^2\delta_1}{2}+\frac{1}{3}\text{Ko}y^3\delta_1 + \frac{1}{3}M^2\text{Sin}^2y^3\gamma\delta_1-\frac{1}{3}\text{Gr}y^3\text{Cos}[\alpha]\delta_2 - \frac{1}{3}\text{Gm}y^3\text{Cos}[\alpha]\delta_3\Big) \tag{31}$$

$$\theta_1(y,t) = \frac{1}{2}\text{Pr}Qy^2-\frac{1}{2}\text{EcPr}y^2\delta_1^2-\frac{1}{4}\text{Ec}M^2\text{PrSin}^2y^4\gamma\delta_1^2-\frac{1}{3}\text{Pr}Qy^3\delta_2 \tag{32}$$

$$\varphi_1(y,t) = -\frac{1}{\text{Sc}}\left(\frac{\text{Kr}y^2}{2}+\frac{1}{3}\text{Kr}y^3\delta_3\right) \tag{33}$$

The terms $u_k(y,t), \theta_k(y,t)$ and $\varphi_k(y,t)$ for $k \geq 2$ are too large to present graphically, hence are omitted here. Therefore, the three-term solution of the velocity, temperature and concentration profiles are given by

$$\left.\begin{aligned} u(y,t) &= u_0(y,t)+u_1(y,t)+u_2(y,t)+\dots \\ \theta(y,t) &= \theta_0(y,t)+\theta_1(y,t)+\theta_2(y,t)+\dots \\ \varphi(y,t) &= \varphi_0(y,t)+\varphi_1(y,t)+\varphi_2(y,t)+\dots \end{aligned}\right\} \tag{34}$$

$$u(y,t) = \delta_1 y+\frac{\beta}{1+\beta}\Big(-\frac{1}{2}\text{Gm}y^2\text{Cos}[\alpha]-\frac{1}{2}\text{Gr}y^2\text{Cos}[\alpha]-\frac{y^2\delta_1}{2}+\frac{1}{3}\text{Ko}y^3\delta_1 + \frac{1}{3}M^2\text{Sin}^2y^3\gamma\delta_1-\frac{1}{3}\text{Gr}y^3\text{Cos}[\alpha]\delta_2 - \frac{1}{3}\text{Gm}y^3\text{Cos}[\alpha]\delta_3\Big) \tag{35}$$

$$\theta(y,t) = 1+\delta_2 y+\frac{1}{2}\text{Pr}Qy^2-\frac{1}{2}\text{EcPr}y^2\delta_1^2-\frac{1}{4}\text{Ec}M^2\text{PrSin}^2y^4\gamma\delta_1^2-\frac{1}{3}\text{Pr}Qy^3\delta_2 \tag{36}$$

$$\varphi(y,t) = 1+\delta_3 y-\frac{1}{\text{Sc}}\left(\frac{\text{Kr}y^2}{2}+\frac{1}{3}\text{Kr}y^3\delta_3\right) \tag{37}$$

To obtain the constants δ_1, δ_2 and δ_3 for the second boundary condition at $y \longrightarrow \infty$, we resort to Pade´ approximation, since the analytical solution obtained in Eqs.(35) - (37) using TAM does not satisfy the boundary condition. The details of these calculations are omitted for brevity.

5. Results and Discussion

This section gives the numerical illustration to analyze the significance of the salient characteristics of the flow problem. To get insight into the physical problem, numerical solutions for the velocity, temperature, and concentration profiles as well as the consistency of the implemented method for the solution have been computed and shown graphically in figs. 1 to 14. The effects of various pertinent parameters such as magnetic field parameters, (M), porosity parameter, (K_0), inclined magnetic parameter, (γ), Grashof number, (Gr), modified Grashof number, (Gm), Prandtl number, (Pr), Eckert number, (Ec), chemical reaction parameter (Kr), heat source parameter, (Q), Schmidt number, (Sc) and angle of inclination (α) have been discussed in detail. The numerical outcomes have been achieved using computational subroutine MATLAB bvp4c and Mathematica.

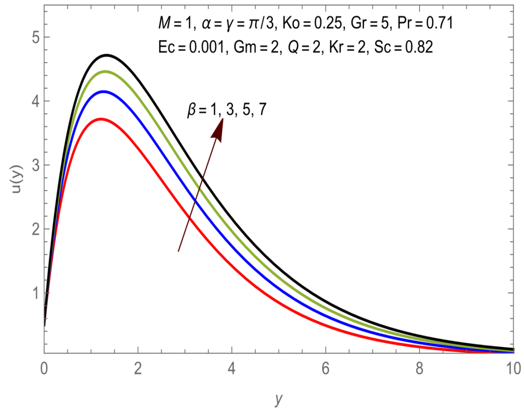

Fig. 1. Impact of variation in Casson parameter on velocity profile.

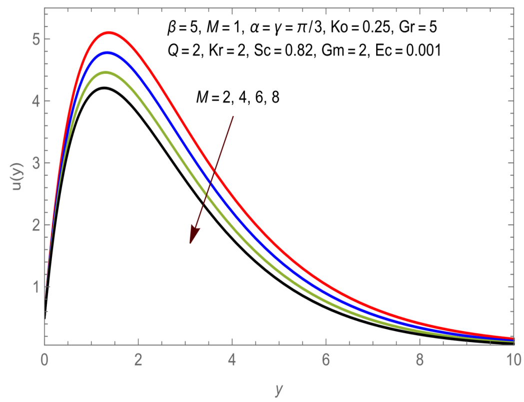

Fig. 2. Impact of variation in Hartmann parameter on velocity profile.

The effect of Casson parameter, (β) on the velocity distribution is analyzed and the resultant plot is depicted in fig. 1. It was perceived that acceleration in Casson parameter enhances the velocity profile of the fluid.

Figure 2 illustrates the variation in velocity profile with respect to the inclined magnetic parameter, (γ). We observe that increasing values of the inclined magnetic parameter cause a declination in the velocity distribution of the fluid.

In fig. 3, the variations in the velocity profile due to Prandtl number parameter are portrayed. From this plot, it can be concluded that the greater Pr values cause the velocity distribution to rapidly shift towards the boundary which reduces the thickness of the boundary layer.

Figure 4 reflects an increased temperature profile for increasing estimates of the Grashof number, (Gr). The result showed, increased values of the of Grashof number lead to a decrease in the values of velocity profile of the fluid.

The variation of velocity distribution is displayed on varying the modified Grashof number, (Gm) in fig. 5. From this figure, fluid temperature is a decreasing function of increased values of Prandtl number, (Pr)

In view of fig. 6, the temperature gradients for variation in the heat source parameter, (Q). The observation showed that, increased values of the heat source parameter cause an acceleration of the temperature profile.

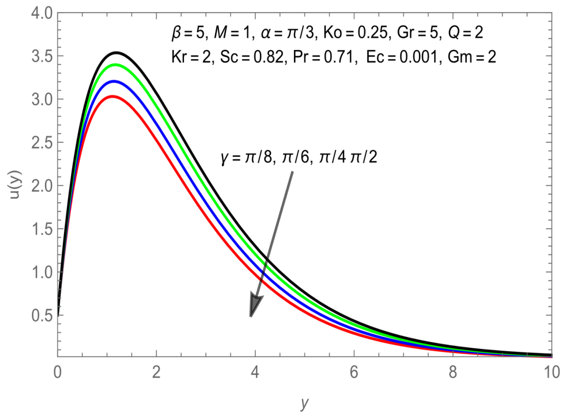

Fig. 3. Velocity profile for variation in inclined magnetic parameter.

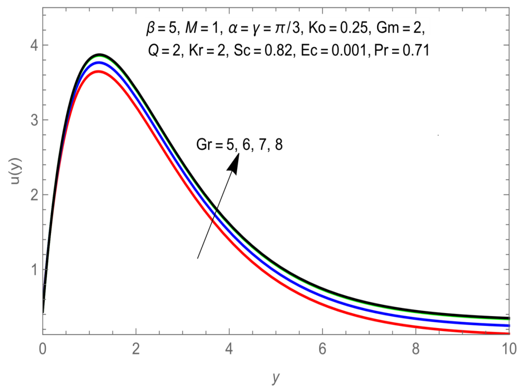

Fig. 4. Velocity profile for different values of Grashof parameter.

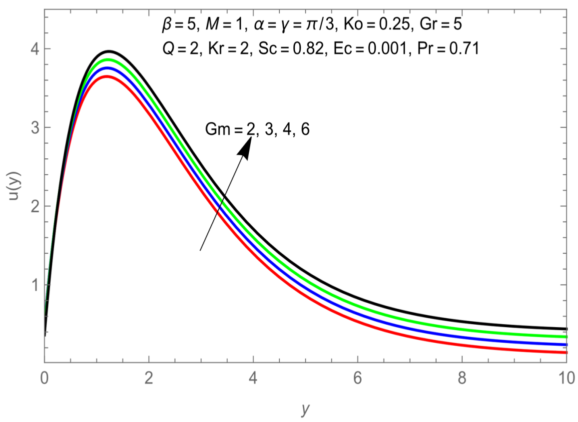

Fig. 5. Velocity profile for change in modified Grashof Number.

Figure 7 represents the effect of Eckert number, (Ec) on the velocity profile. The velocity distribution, $u(y)$ increased with increase in the Eckert number, (Ec)

The dimensionless temperature profiles variation with the Prandtl number, (Pr) is portrayed in fig. 8. It was found that, increased values of the Prandtl number cause a decrease in the temperature profile of the fluid

Figure 9 indicates the effect of thermal radiation parameter, (Kr) on the temperature profile. As the thermal radiation parameter increases, the velocity profile, $\theta(y, t)$

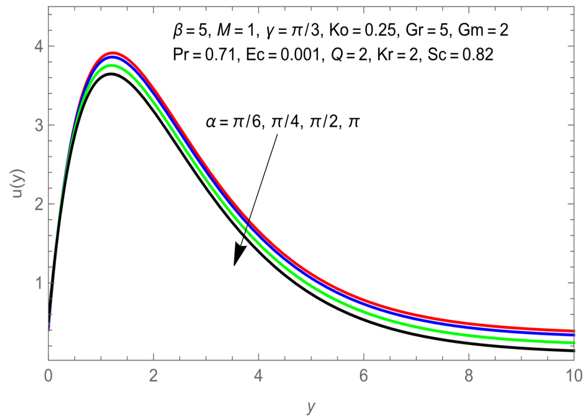

Fig. 6. Velocity profile for variation in angle of inclination Number.

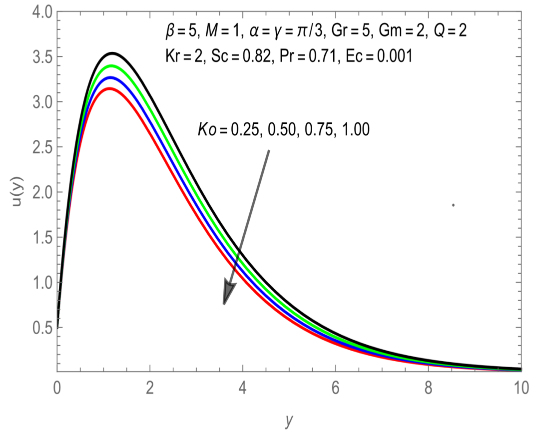

Fig. 7. Velocity profile for variation in porosity number.

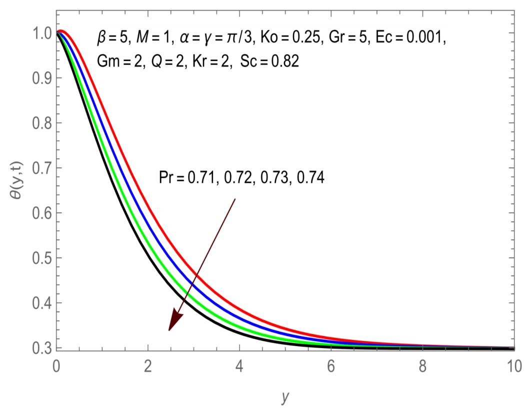

Fig. 8. Temperature profile for different values of Prandtl number.

The variation of magnetic field parameter versus the temperature profile is depicted in fig. 10. We observe that, increasing the value of magnetic field parameter, (M) makes the temperature of the fluid to increase.

Figure 11 shows the temperature profile for different values of the inclined magnetic parameter. It can be observed that, the effect of increasing the inclined magnetic parameter, (γ) decelerate the temperature of the fluid.

Figure 12 illustrates the temperature gradient for variation in the heat source parameter, (Q). We observe that there is positive correlation between the heat source and temperature distribution of the fluid.

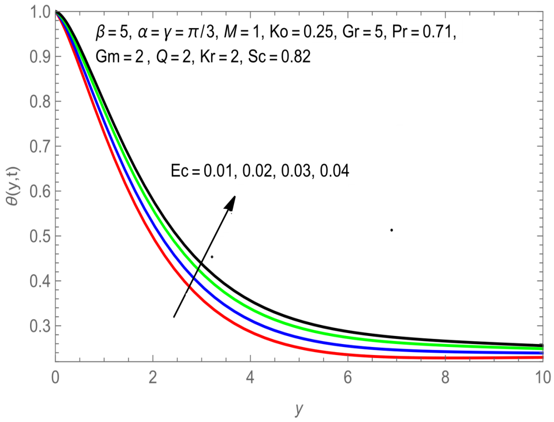

Fig. 9. Temperature profile for different values of Eckert number.

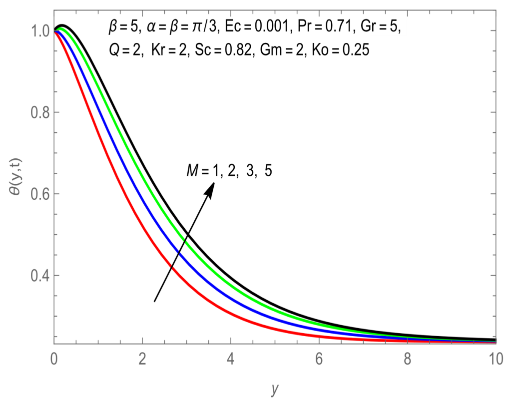

Fig. 10. Influence of magnetic number on temperature profile.

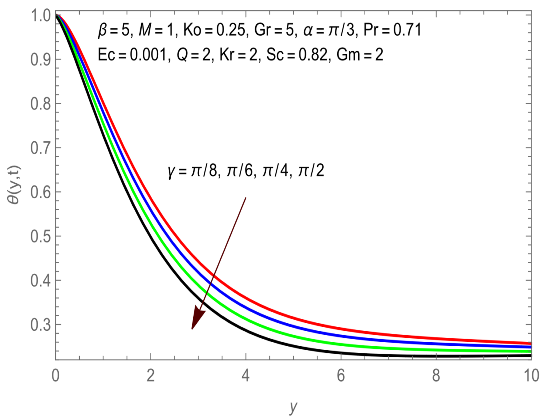

Fig. 11. Influence of inclined magnetic parameter on temperature profile.

The effects of thermal radiation, (Kr) and Schmidt number, (Sc) on the concentration profile of the fluid is displayed in figures (13 - 14). It is seen concentration profile of the fluid decreased in the presence of both Schmidt and thermal radiation parameters.

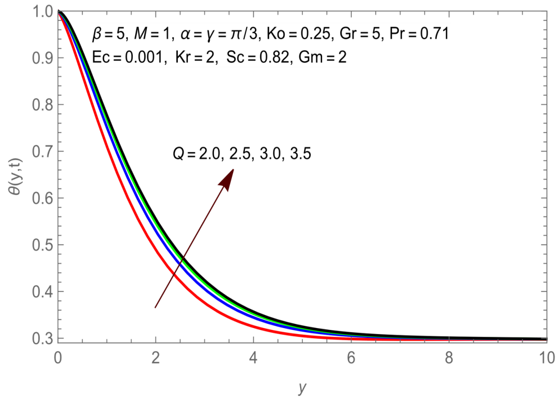

Fig. 12. Temperature profile for change in heat source Parameter.

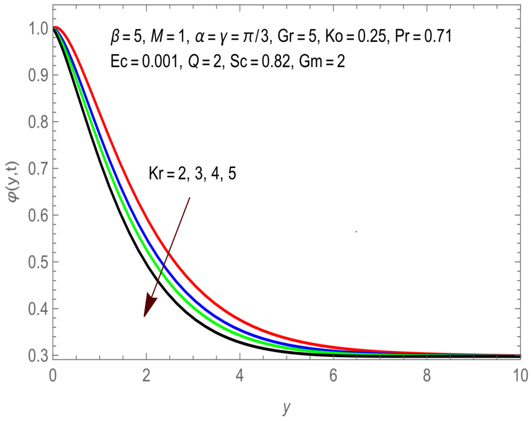

Fig. 13. Concentration profile for variation in chemical reaction parameter.

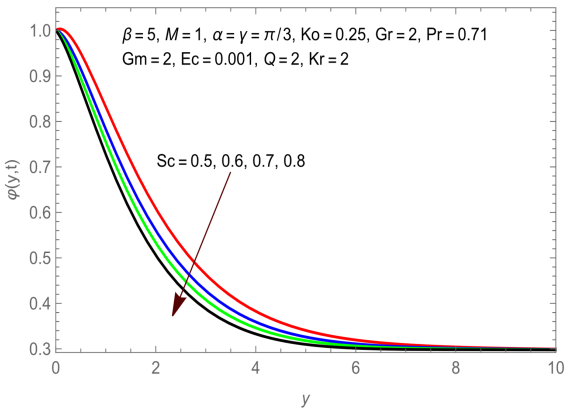

Fig. 14. Concentration profile for variation in Schmidt number.

6. Conclusion

The chemical reaction and radiation absorption effects on MHD flow of convective fluid through a vertical porous plate under the influence of inclined magnetic field is investigated analytically using semi-analytical method. The expressions for the velocity, temperature and concentration are obtained in the form of converging series solution. The outcome of our study is summarized as follows.

1. It is observed that increase in the values of Casson parameter, Grashof number and modified Grashof number enhanced the velocity profile of the fluid
2. We observe that the velocity distribution declines in the presence of Hartmann number, inclined magnetic parameter, porosity, and angle of inclination.
3. Increasing the Eckert number, magnetic parameter and heat source parameters results in increase in the temperature profile of the fluid
4. It is seen that temperature decrease with increase in the Prandtl number and inclined angle parameter
5. The effects of increasing both Schmidt and chemical reaction parameters lead to decrease in the concentration distribution of the fluid.

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