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MHD CASSON FLUID FLOW WITH AN INCLINED PLATE IN THE PRESENCE OF HALL AND ALIGNED MAGNETIC EFFECTS

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ABSTRACT

MHD Casson flow fluid over an inclined plate with aligned magnetic, Hall current and thermal radiation in the presence of Chemical reaction is examined. The governing equations are solved using perturbation method. The effects of various physical parameters like as chemical reaction parameter, radiation parameter, Casson parameter, Schmidt number, Grashof number, modified Grashof number, Prandtl number, magnetic parameter, inclined angle, Hall parameter and Aligned parameter are discussed for velocity, temperature and concentration. The skin-friction, Nusselt number and Sherwood number are also obtained and are shown in tabular form.

Keywords: *Casson fluid, MHD, Chemical reaction, inclined surface.*

1. INTRODUCTION

In recent years, MHD non-Newtonian fluid flow in the presence of chemical reaction and radiation effects have received more attention. In industrial environment, non-Newtonian fluid flow plays a vital role. There are many transport processes occurring in nature due to temperature and chemical differences. The process of heat and mass transfer is encountered in aeronautics, fluid fuel nuclear reactor, chemical processing industries and many engineering applications in which the fluid is a working medium. Magneto-hydrodynamic equations are ordinary electromagnetic and hydrodynamic equations modified to take into account the interaction between the motion of the fluid and the electromagnetic field. The formulation of the electromagnetic theory in a mathematical form is known as Maxwell's equation. The effect of the gravity field is always present in forced flow heat transfer as a result of the buoyancy forces connected with the temperature differences. Usually they are of a small order of magnitude so that the external forces may be neglected. There has recently been a considerable interest in the effect of body forces on forced convection phenomena. However, In certain engineering problems they cannot be left out of consideration. It is important to realize that the heat transfer in mixed convection can be significantly different from that both in pure natural convection and in pure forced convection. The study of forced and free convection flow and heat transfer for electrically conducting fluids past a semi-infinite porous plate under the influence of a magnetic field has attracted the interest of many investigators in view of its applications in many engineering problems such as geophysics, astrophysics, boundary layer control in the field of aerodynamics. Engineers employ MHD principle, in the design of heat exchangers pumps and flow meters, in space vehicle propulsion, thermal protection, braking, control and re-entry, in creating novel power generating systems etc.

The radiation effects have important applications in physics and engineering, particularly in space technology and high temperature processes. But very little is known about the effects of radiation on the boundary layer. Thermal radiation effects on the boundary layer may play important role in controlling heat transfer in polymer processing industry where the quality of the final product depends on the heat controlling factors to some extent. High temperature plasmas, cooling of nuclear reactors, liquid metal fluids, power generation systems are some important applications of radiative heat transfer. Actually, many processes in new engineering areas occur at high temperatures and knowledge of radiation heat transfer beside the convective heat transfer becomes very important for the design of the pertinent equipment. Nuclear power plants, gas turbines and the various propulsion devices for aircraft, missiles, satellites and space vehicles are examples of such engineering areas. Moreover, when radiative heat transfer takes place, the fluid involved can be electrically conducting since it is ionized due to the high operating temperature. Accordingly, it is of interest to examine the effect of the magnetic field on the flow. Studying such effect has great importance in the application fields where thermal radiation and MHD are correlative. In all these applications understanding the behavior of MHD free and forced convective flow and the various problem parameters that influence is a very important asset to designers developing applications that aim to control this flow. For example, the process of fusing of metals in an electrical furnace by applying a magnetic field and the process of cooling of the first wall inside a nuclear reactor containment vessel where the hot plasma is isolated from the wall by applying a magnetic field.

Arifizzaman et al. (2018) studied chemically reactive and Naturally Convective High-Speed MHD Fluid Flow through an Oscillatory Vertical Porous-Plate with Heat and Radiation Absorption Effect. Arifizzaman et al. (2017a) investigated MHD Maxwell fluid flow in presence of nano-particle through a vertical porous–plate with heat-generation, radiation absorption and chemical reaction. Arifizzaman et al. (2017b) explored chemically reactive viscoelastic fluid flow in presence of Nano particle through porous stretching sheet. Bala Anki Reddy (2016) considered two - dimensional MHD convective boundary layer flow of a Casson fluid over an exponentially inclined permeable

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stretching surface in the presence of thermal radiation and chemical reaction. Hussanan et al.(2014) investigated Unsteady Boundary Layer Flow and Heat Transfer of a Casson Fluid Past an Oscillating Vertical Plate with Newtonian Heating. The convective boundary layer flow of Casson nanofluid from an isothermal sphere surface is presented by Nagendra et al. (2017). Bhattacharyya (2013) examined the stagnation point flow of Casson fluid towards a shrinking/stretching sheet. Swati Mukhopadhyay et al. (2013) investigated Casson fluid flow over an unsteady stretching surface where the rate of cooling can be increased by using the Prandtl number in conducting flows. The unsteady heat transfer flow for a Casson fluid over a moving flat plate was investigated by Mustafa et al.(2011) by using homotopic method and also reported that by increasing Casson parameter the surface shear stress and surface heat transfer are improved. Khalid et al. (2015) investigated unsteady MHD flow of Casson fluid past over an oscillating vertical plate embedded in a porous medium and found that when the Casson parameter is large enough ie., β→∞, the non-Newtonian behavior disappear and the fluid purely behaves like a Newtonian fluid. Rushi Kumar et.al (2015) studied thermal diffusion effects on MHD heat and mass transfer flow past a moving vertical plate when the magnetic field relative to the fluid or to the plate. Charan Kumar et al. (2016) have been reported that chemical reaction and soret effects on casson mhd fluid over a vertical plate. Vedavati et al. (2016) have been explained the chemical reaction, radiation and dufour effects on casson magneto hydro dynamics fluid flow over a vertical plate with heat source /sink. Dharmaiah et al. (2017) have been discussed the effect of chemical reaction on mhd casson fluid flow past an inclined surface with radiation.

Silpisikha and Dipak (2021) observed the Casson fluid flow by considering the effect of the induced magnetic field. Ganesh and Sridhar (2021) examined the study of flow above an exponentially stretching sheet with the radiation effect on MHD boundary layer flow using Keller Box method. Vijaya et. al. (2020) proposed to explore binary chemical reaction along with activation energy of an electrically conducting incompressible Casson fluid induced due to stretching surface. Stanford Shateyi and Hillary Muzara (2020) examined the unsteady laminar two phase (Blasius and Sakiadis) MHD nanofluid flow filled with porous medium under the combined effects of Brownian motion and thermophoresis as well as variable thermal conductivity. Alkasasbeh et al. (2020) looked into d the Heat and mass transfer effect of free convection on MHD Casson nanofluid over a stretching sheet subject to the constant wall temperature. Vijaya and Venkata Ramana Reddy (2020) studied e the effect of non-linear thermal radiation and velocity slip on the MHD non -Darcy flow of an incompressible, electrically conducting Casson fluid past a permeable stretching sheet taking joule heating and thermophoresis. Dharmaiah et al. (2019) investigated the effect of viscous dissipation on a radiative, mixed convection aligned MHD flow of a viscous, incompressible, electrically conducting and Newtonian fluid on a moving inclined porous plate in the presence of aligned magnetic field. Vedavathi et al. (2019) exposed the heat source and radiation effects on the free convection heat and mass transfer flow of nanofluid over a vertical plate.

In this work it is examined along an inclined moving plate with aligned magnetic, hall current and thermal radiation in the presence of Chemical reaction This Problem is solved using the perturbation technique for the velocity, the temperature and the concentration species. The skin friction, Nusselt number and Sherwood number are also obtained and are shown in tabular form.

2. GFORMULATION OF THE PROBLEM

MHD Casson fluid of incompressible, viscous, electrically- conducting fluid over a vertical plate moving with constant velocity with radiation and chemical reaction in the presence of Soret effect is considered. The rheological equation of state for an isotropic and incompressible flow of Casson fluid is

$$\tau_{ij} = \begin{cases} \left(\mu_B + p_y/\sqrt{2\pi}\right)2e_{ij}, \pi > \pi_c \\ \left(\mu_B + p_y/\sqrt{2\pi_c}\right)2e_{ij}, \pi < \pi_c \end{cases} \tag{1}$$

Where μ_B is plastic dynamic viscosity, p_y is yield stress, π_c is critical value of π and π is the product of the component of deformation rate with itself, namely, $\pi = e_{ij}e_{ij}$, e_{ij} is the (i, j)th component of deformation rate. The x - axis is taken along the plate in the vertical upward direction and the y - axis is taken normal to the plate. The surface temperature of the plate oscillates with small amplitude about a non-uniform mean temperature. The fluid is assumed to have constant properties except for the influence of the density variations with temperature and concentration which are considered only in the body force term. The temperature of the plate oscillates with little amplitude about a non-uniform temperature.

- The flow is Unsteady and laminar.
- The plate is sufficiently long enough, so all the physical quantities are functions of y and t only.
- It is assumed that there exist a homogeneous chemical reaction of first order with constant rate Kr between the diffusing species and the fluid.
- A uniform magnetic field is applied in the direction perpendicular to the plate.
- The viscous dissipation and the Joule heating effects are assumed to be negligible in the energy equation.
- The temperature in the fluid flowing is governed by the energy concentration equation involving radiative heat temperature.

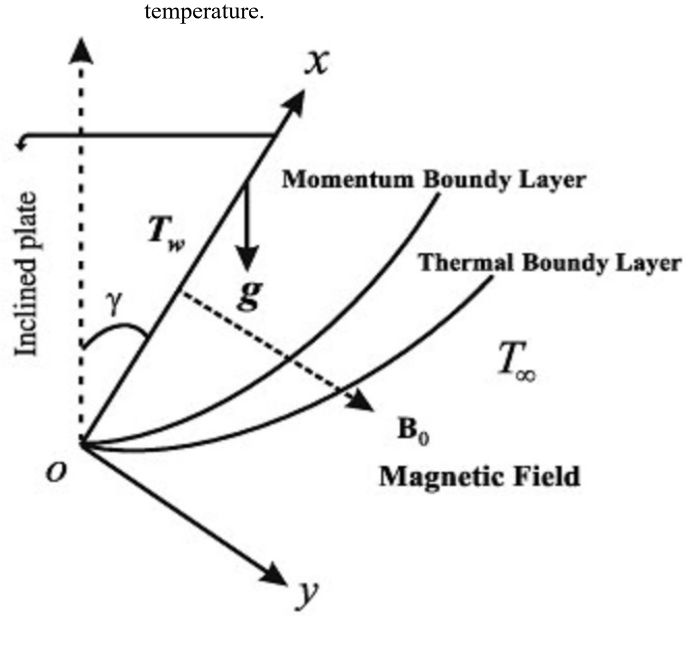

Fig. 1 Geometry of the flow

By usual Boussinesq's approximation, the flow is governed by the following equations.

$$\frac{\partial u'}{\partial t'} = \left(1+\frac{1}{\beta}\right)\frac{\partial^2 u'}{\partial y'^2} - \left(\frac{m}{1+m^2}\sin^2\xi\right)\frac{\sigma}{\rho}B_0^2 u' + g\beta^*\cos\alpha\left(C'-C'_\infty\right) + g\beta\cos\alpha\left(T'-T'_\infty\right) \tag{2}$$

$$\frac{\partial T'}{\partial t'} = \frac{k}{\rho C_p}\frac{\partial T'}{\partial y'^2} - \frac{1}{\rho C_p}\frac{\partial q_r'}{\partial y'} + \frac{Q_0}{\rho C_p}\left(T'-T'_\infty\right) \tag{3}$$

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$$\frac{\partial C'}{\partial t'} = D\frac{\partial C'}{\partial y'^2} - K_r^{'}\left(C' - C'_{\infty}\right) \tag{4}$$

Equations (2), (3) and (4) refer Momentum equation, Energy Equation and Species Equation respectively. Where u is the velocity of the fluid, β is Casson parameter, Q_0 is the heat source/sink parameter, D is the molecular diffusivity, k is thermal conductivity, C is mass concentration, t is time, υ is the kinematics viscosity, g is the gravitational constant, β *and* β^* are the thermal expansions of fluid and concentration, T is temperature of fluid , ρ is density, C_p is the specific heat capacity at constant pressure, y is distance, q_r is the radiative flux, β_0 is the magnetic field, kr_0 is the chemical reaction rate constant. R.H.S. of equation (1), second term is thermal concentration effect, third term is magnetic effect, fourth term is thermal buoyancy effect. R.H.S. of equation (3) second term is thermal radiation flux and third term is thermal radiation. R.H.S. of equation (4), second term is chemical reaction and third term soret (Thermo Diffusion) effect. Under the above assumptions the physical variables are functions of y and t.

The boundary conditions are:

$$\left.\begin{aligned} &u = U; T' = T'_w + \varepsilon e^{\text{int}}\left(T'_w - T'_{\infty}\right);\\ &C' = C'_w + \varepsilon e^{\text{int}}\left(C'_w - C'_{\infty}\right) \quad at \quad y' = 0\\ &u' \to 0; T' \to 0; C' \to 0 \quad as \quad y' \to \infty \end{aligned}\right\} \tag{5}$$

Introducing the dimensionless quantities

$$\begin{aligned} &u = \frac{u'}{U}; y = \frac{y'U}{\upsilon}; t = \frac{t'U^2}{\upsilon}; Gc = \frac{g\beta^*\upsilon\left(C'_w - C'_{\infty}\right)}{U^3}; Q = \frac{Q_0\upsilon}{\rho C_p U^2};\\ &\theta = \frac{T' - T'_{\infty}}{T'_w - T'_{\infty}}; C = \frac{C' - C'_{\infty}}{C'_w - C'_{\infty}}; M = \frac{\sigma B_0^2\upsilon}{\rho U^2}; R = \frac{16a\sigma'\upsilon^2 T_{\infty}^{'}}{U^2\rho C_p};\\ &\mu = \upsilon\rho; \Pr = \frac{\mu C_p}{k}; Sc = \frac{\upsilon}{D}; Kr = \frac{Kr_0\upsilon}{U^2}; \end{aligned} \tag{6}$$

The thermal radiation flux gradient may be expressed as follows

$$\frac{\partial q'}{\partial y'} = 4a\sigma'\left(T'_{\infty} - T'^4\right) \tag{7}$$

Considering the temperature difference by assumption within the flow are sufficiently small such that T'^4 may be expressed as a linear function of the temperature. This is attained by expanding in T'^4 Taylor's series about T'_{∞} and ignoring higher orders terms.

$$T'^4 = 4T'^3_{\infty} - 3T'^4_{\infty} \tag{8}$$

Substituting the dimensionless variables (5) into (1) to (3) and using equations (7) and (8), reduce to the following dimensionless form.

$$\frac{\partial u}{\partial t} = \left(1 + \frac{1}{\beta}\right)\frac{\partial^2 u}{\partial y^2} - M_1 u + G_1\theta + G_2 C \tag{9}$$

$$\frac{\partial \theta}{\partial t} = \frac{1}{\Pr}\frac{\partial^2 \theta}{\partial y^2} - \left[R - Q\right]\theta \tag{10}$$

$$\frac{\partial C}{\partial t} = \frac{1}{Sc}\frac{\partial C}{\partial y} - KrC \tag{11}$$

Where $G_1 = Gr\cos\alpha; G_2 = Gc\cos\alpha; M_1 = \frac{m}{1+m^2}M\sin^2\xi$

The corresponding boundary conditions of (5) in dimensionless form are

$$u = 1; \theta = 1 + \varepsilon e^{i\omega t}; C = 1 + \varepsilon e^{i\omega t} \quad at \quad y = 0 \tag{12}$$

$$u \to 0; \theta \to 0; C \to 0 \quad at \quad y \to \infty \tag{13}$$

3. METHOD OF SOLUTION

Equation (9)-(11) represent a set of partial differential equations that cannot be solved in closed form. However, it can be reduced to a set of ordinary differential equations in dimensionless form that can be solved analytically. This can be done by representing the velocity, temperature and concentration as

$$u = u_0 + \varepsilon e^{i\omega t}u_1 + O\left(\varepsilon^2\right) \tag{14}$$

$$\theta = \theta_0 + \varepsilon e^{i\omega t}\theta_1 + O\left(\varepsilon^2\right) \tag{15}$$

$$C = C_0 + \varepsilon e^{i\omega t}C_1 + O\left(\varepsilon^2\right) \tag{16}$$

Substituting (14)-(16) in (9)-(11) we have

$$C_0^{''} - ScKrC_0 = 0 \tag{17}$$

$$C_1^{''} - Sc\left(Kr + iw\right)C_1 = 0 \tag{18}$$

$$\theta_0^{''} - \Pr\left(R - Q\right)\theta_0 = 0 \tag{19}$$

$$\theta_1^{''} - \Pr\left(R - Q + i\omega\right)\theta_1 = 0 \tag{20}$$

$$\left[1 + \frac{1}{\beta}\right]u_0^{''} - M_1 u_0 = -G_1\theta_0 - G_2 C_0 \tag{21}$$

$$\left[1 + \frac{1}{\beta}\right]u_1^{''} - M_1 u_1 = -G_1\theta_1 - G_2 C_1 \tag{22}$$

All primes denote differentiation with respect to y.

The boundary conditions are

$$\left.\begin{aligned} &u_0 = 1, \theta_0 = 1, C_0 = 1,\\ &u_1 = 0, \theta_1 = 1, C_1 = 1 \end{aligned}\right\} \quad at \quad y = 0 \tag{23}$$

$$\left.\begin{aligned} &u_0 \to 0, \theta_0 \to 0, C_0 \to 0,\\ &u_1 \to 0, \theta_1 \to 0, C_1 \to 0 \end{aligned}\right\} \quad as \quad y \to \infty \tag{24}$$

In view of above solutions, the concentration, the temperature and the velocity distributions along with Sherwood number, Nusselt number and Skin-friction coefficient in the boundary layer:

$$C(y,t) = e^{-A_1 y} + \varepsilon e^{i\omega t}e^{-A_2 y} \tag{25}$$

$$\theta(y,t) = e^{-A_3 y} + \varepsilon e^{i\omega t}e^{-A_4 y} \tag{26}$$

$$\begin{aligned} u(y,t) = &\left(a_3 e^{-A_5 y} - a_1 e^{-A_5 y} - a_2 e^{-A_1 y}\right) +\\ &\varepsilon e^{i\omega t}\left(a_6 e^{-A_6 y} - a_4 e^{-A_4 y} - a_5 e^{-A_2 y}\right) \end{aligned} \tag{27}$$

$$C_f = -\left(\frac{\partial u}{\partial y}\right)_{y=0}, \quad Nu = -\left(\frac{\partial \theta}{\partial y}\right)_{y=0}; \quad Sh = -\left(\frac{\partial C}{\partial y}\right)_{y=0} \tag{28}$$

Where

$$A_1 = \left(ScKr\right)^{\frac{1}{2}}; \; A_2 = \left(Sc\left(i\omega + Kr\right)\right)^{\frac{1}{2}}; \; A_3 = \left(\Pr(R - Q)\right)^{\frac{1}{2}};$$

$$A_4 = \left(\Pr\left(iw + R - Q\right)\right)^{\frac{1}{2}}; \; A_5 = \left[\frac{M_1}{\left(1 + \frac{1}{\beta}\right)}\right]^{\frac{1}{2}}; \; A_6 = \left[\frac{M_1 + i\omega}{\left(1 + \frac{1}{\beta}\right)}\right]^{\frac{1}{2}};$$

$$a_1 = \frac{G_1}{\left(1 + \frac{1}{\beta}\right)A_3^2 - M_1}; \; a_2 = \frac{G_2}{\left(1 + \frac{1}{\beta}\right)A_1^2 - M_1};$$

$$a_3 = 1 + a_1 + a_2\,;\; a_4 = \frac{G_1}{\left(1+\frac{1}{\beta}\right)A_4^2 - \left(M_1 + i\omega\right)}\,;$$

$$a_5 = \frac{G_2}{\left(1+\frac{1}{\beta}\right)A_2^2 - \left(M_1 + i\omega\right)}\,;\; a_6 = a_4 + a_5\,.$$

4. RESULTS AND DISCUSSION

Casson MHD flow over an inclined moving plate with chemical reaction, radiation, aligned magnetic and hall current have been formulated and analysed analytically. Fig. 2 illustrates the effect of Schmidt (Sc) on the concentration. It is noticed that as the Schmidt number increases, there is a decreasing trend in the concentration field. The effect of chemical reaction parameter on the concentration field is illustrated in Fig. 3. As the chemical reaction parameter increases the concentration is found to be decreasing. An influence of perturbation parameter (ε) on the concentration distribution in figure 4. It is observed that perturbation parameter increases; there is a increasing trend in the concentration field. Fig. 5(a & b) shows the effect of the prandtl number (Pr) on the temperature. It is noticed that as the Prandtl number increases, the temperature decreases in both cases. Fig. 6 shows the variation of the thermal boundary-layer with the perturbation parameter (ε). It is observed that the thermal boundary layer thickness increases with an increase in the perturbation parameter. Fig. 7 illustrates the effect of the thermal radiation parameter (R) on the temperature. It is noticed that as the thermal radiation increases, the temperature decreases. Fig. 8(a & b) shows the effect of the heat source/sink parameter (Q) on the temperature. It is noticed that as the heat source/sink parameter increases, the temperature increases from 8(a) and reverse trend occurs from 8(b). Fig. 9 shows the effect of the heat source/sink parameter (Q) on the velocity boundary-layer. It is noticed that as the heat source/sink parameter increases, the velocity boundary-layer decreases. The effect of velocity for different values of magnetic parameter (M) is presented in Fig. 10. It is now a well-established fact that the Hartmann number presents a damping effect on the velocity field by creating drag force that opposes the fluid motion, causing the velocity is decrease. The effect of mass (solutal) Grashof number (Gc) on the velocity illustrated in Fig. 11. The mass (solutal) Grashof number defines the ratio of species buoyancy force to the viscous hydrodynamic force. It is noticed that the velocity increases with increasing values of solutal Grashof number. Fig. 12 illustrates the effect of the thermal Grashof number (Gr) on the velocity field. The thermal Grashof number signifies the relative effect of the thermal buoyancy force to the viscous hydrodynamic force. The flow is accelerated due to the enhancement in buoyancy force corresponding to an increase in the thermal Grashof number, i.e., free convection effects. It is noticed that thermal Grashof number (Gr) increases, the velocity field increases. The effect of Casson parameter (β) in velocity is shown in Fig. 13. It is observe that velocity increases near the plate and decreases far away the plate with raising the cassson parameter. The effect of the thermal radiation conduction (R) on the velocity is illustrated in Fig. 14. It is observed that as the thermal radiation increases, the velocity decreases. The effect of inclination of the plate on velocity is shown in Fig.15. From Fig.15, we observe that fluid velocity is decreased in increasing angle ϕ. The fluid has higher velocity when the plate is vertical i.e. ϕ = 0, than when inclined because of the fact that the buoyancy effect decreases due to gravity components g cosϕ, as the plate is inclined. The influence of perturbation parameter (ε) on the velocity is illustrated in Fig.16. The velocity is decreases as the perturbation parameter (ε) increases.

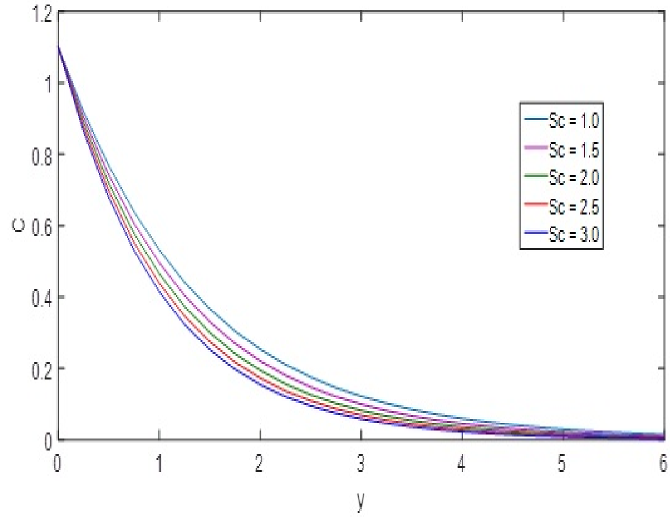


Fig. 2 Variation of the concentration profiles with Schmidt number

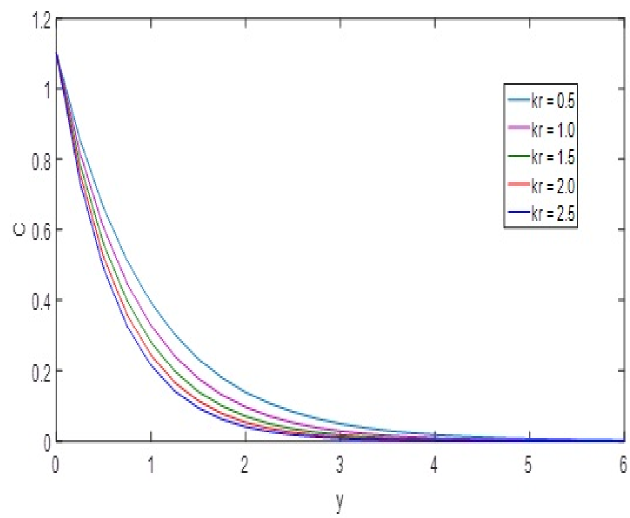


Fig. 3 Variation of the concentration profiles with Chemical reaction parameter

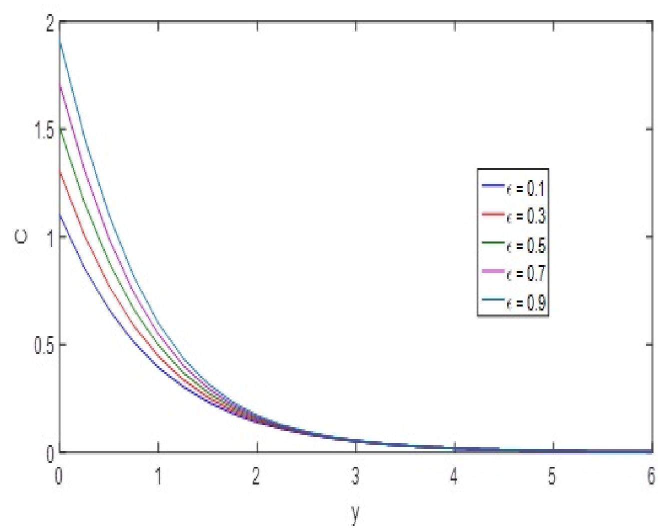
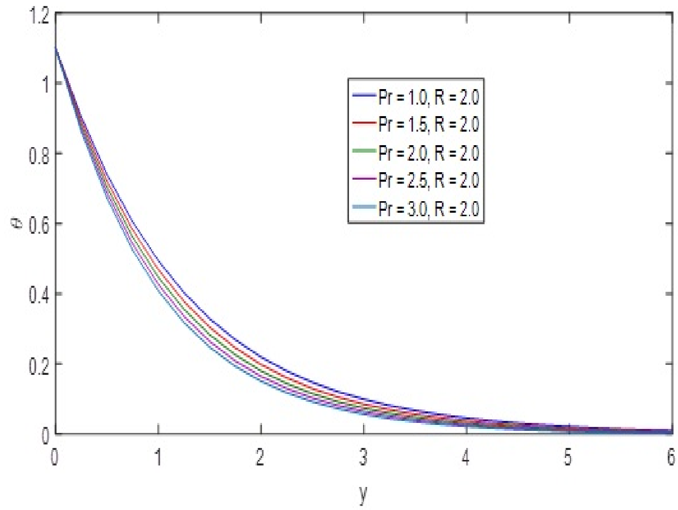
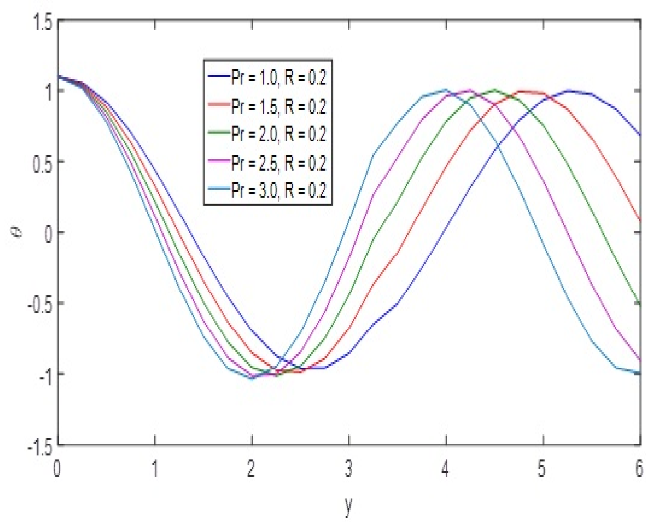


Fig. 4 Variation of the concentration profiles with perturbation parameter



5(a)



5(b)

Fig. 5 (a&b) Variation of the temperature profiles with prandtal number

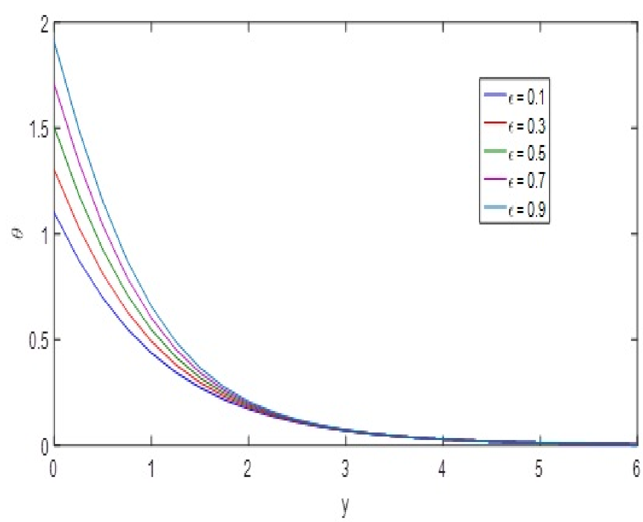


Fig. 6 Variation of the temperature profiles with perturbation parameter

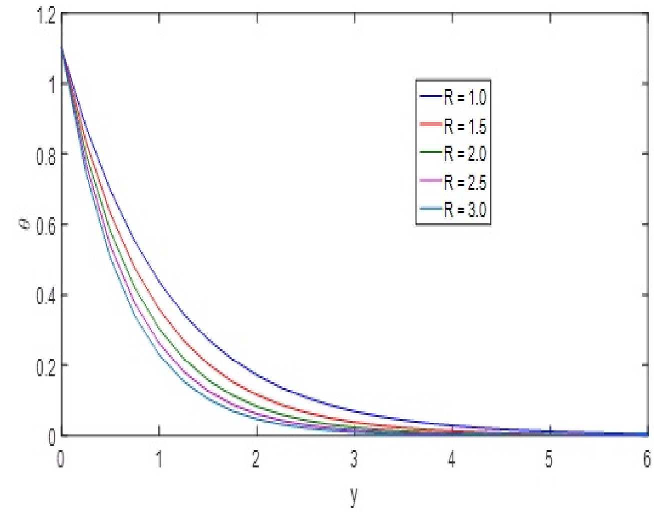
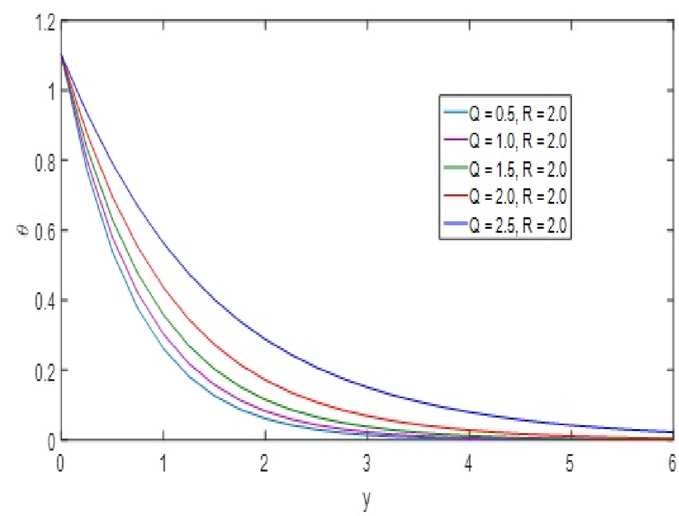
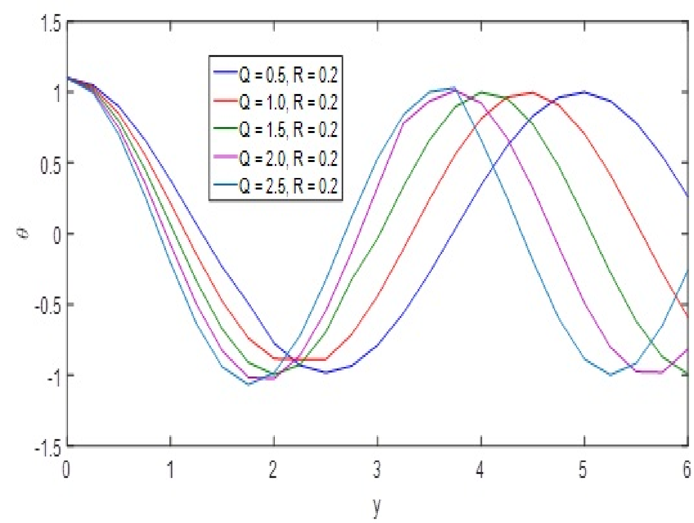


Fig. 7 Variation of the temperature profiles with Thermal radiation conduction



8. (a)



8. (b)

Fig. 8 (a&b) Variation of the temperature profiles with heat source/sink parameter

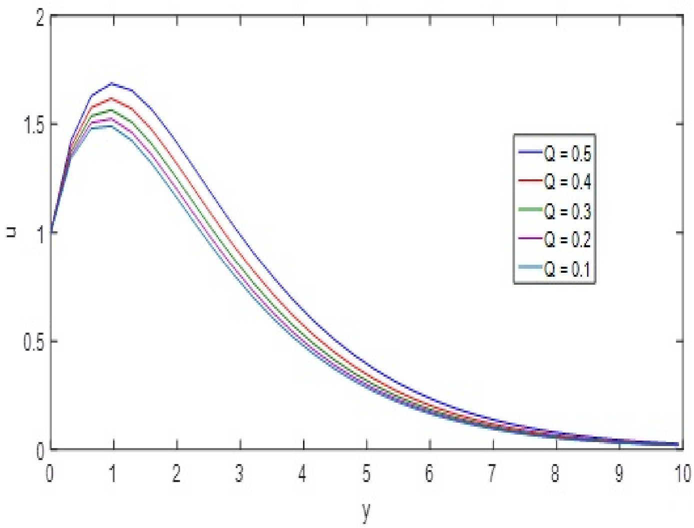


Fig. 9 Variation of the velocity profiles with heat source/sink parameter

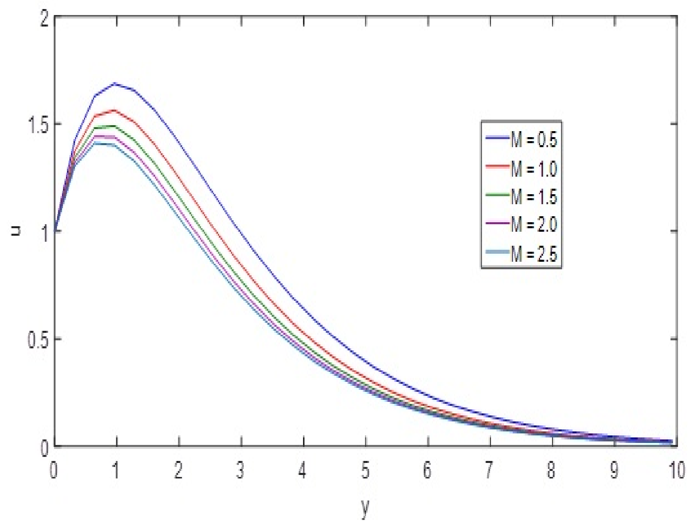


Fig. 10 Variation of the velocity profiles with magnetic parameter

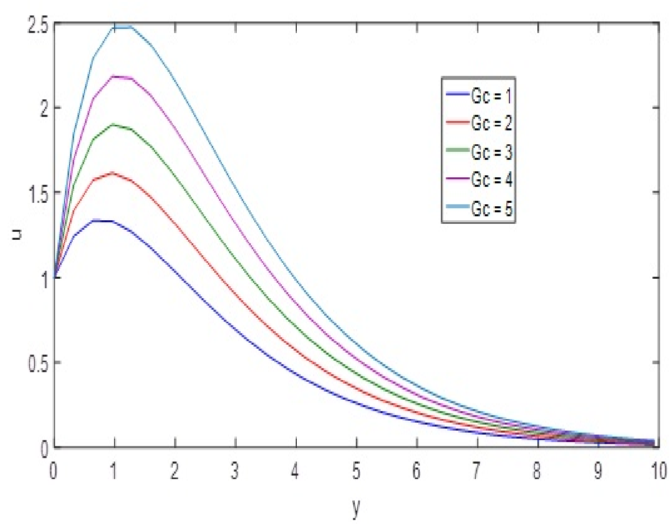


Fig. 11 Variation of the velocity profiles with thermal Grashof number

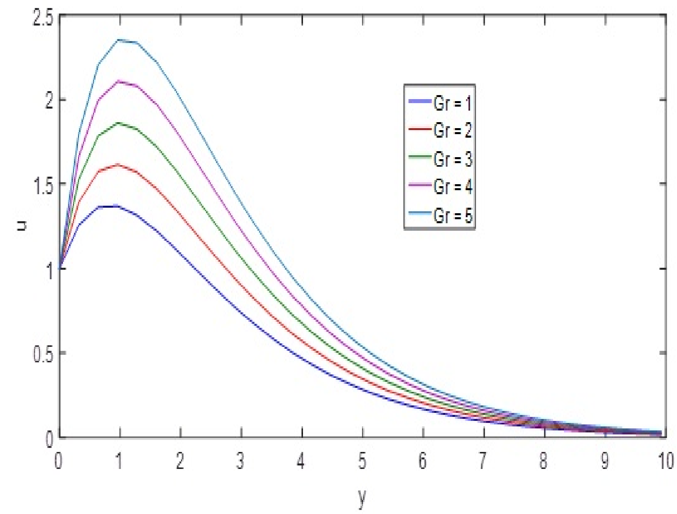


Fig. 12 Variation of the velocity profiles with mass Grashof number

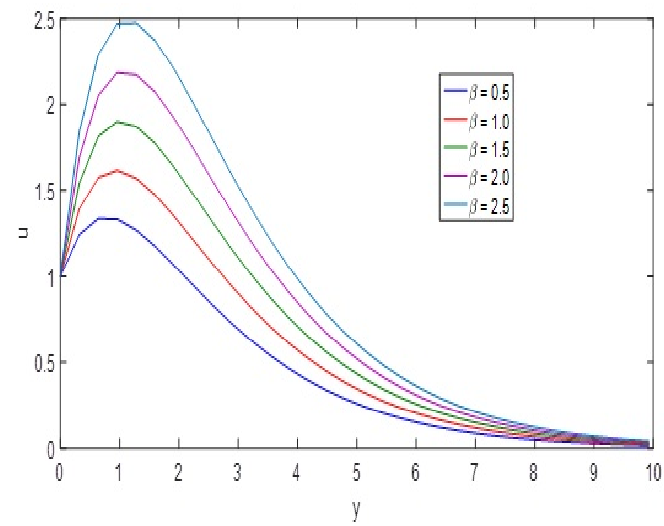


Fig. 13 Variation of the velocity profiles with casson parameter

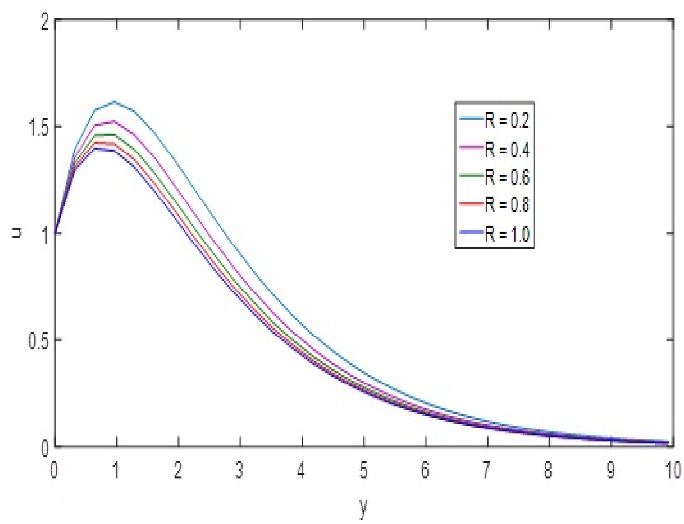


Fig. 14 Variation of the velocity profiles with thermal radiation parameter

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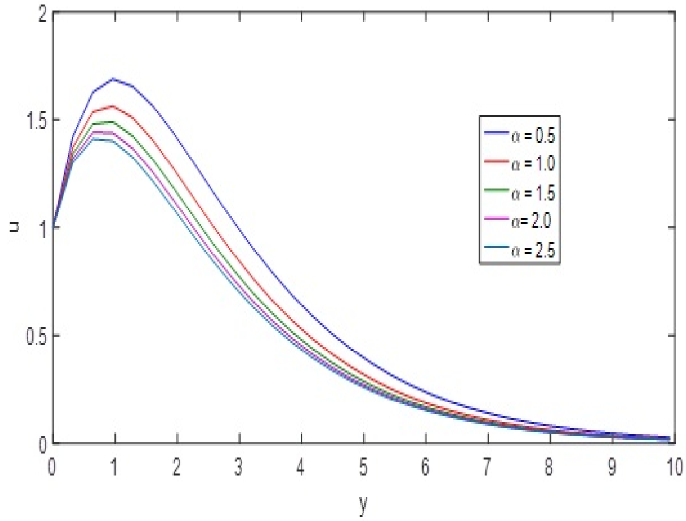

Fig. 15 Variation of the velocity profiles with inclination angle

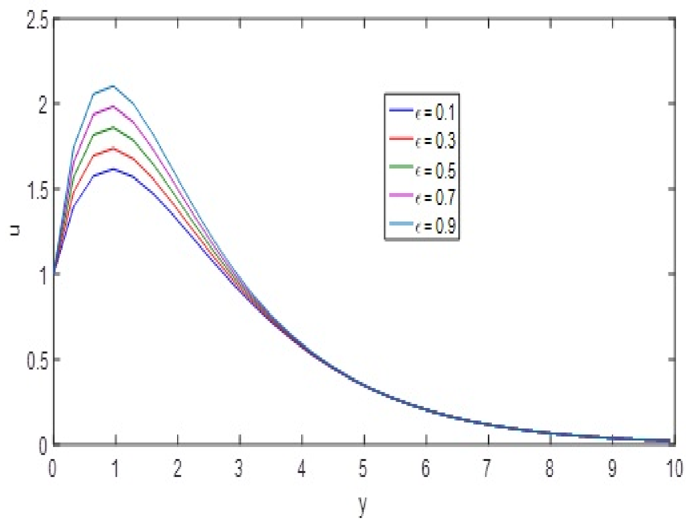

Fig. 16 Variation of the velocity profiles with perturbation parameter

Table 1 Influence of Sherwood number

Sc	Kr	Sh
0.22		0.3420939508
0.30		0.3994796692
0.45		0.4892606761
0.60		0.5649495662
	0.1	0.4764938800
	0.2	0.6622935863
	0.3	0.8049822564
	0.4	0.9253506179

Table 2 Influence of Nusselt Number

Pr	R	Q	Nu
1			0.6543216969
2			0.9253506179
3			1.1333184236
4			1.3086433939
	0.1		0.0281315874
	0.2		0.0287116811
	0.3		0.4764938800
	0.4		0.6622935863
		0.1	1.0314520708
		0.3	0.8049822647
		0.5	0.4764938800
		0.7	0.0281315874

Table 3 Influence of Skin-friction Number

M	Gr	Gc	R	m	Cf
0.1					1.2435283507
0.2					1.1776132828
0.3					1.1284043721
0.4					1.0877828784
	1.0				0.7356732584
	1.5				0.8941439435
	2.0				1.0526146287
	2.5				1.2110853138
		1.0			0.8460884758
		1.5			0.9901037463
		2.0			1.1341190168
		2.5			1.2781342873
			1.0		0.8874973419
			1.5		0.7954469079
			2.0		0.7432116156
			2.5		0.7083427473
				0.2	0.9261674782
				0.4	0.7829376790
				0.6	0.7119373875
				0.8	0.6810036287

From Table1, it is observed that the Sherwood number at an inclined plate increases with an increase in the chemical reaction parameter or Schmidt number. From Table2, it is found that the Nusselt number at an inclined plate increases with an increase in the Prandtl number or Thermal radiation conduction whereas Nusselt number at an inclined plate decreases with an increase in the heat source/sink parameter. It is noticed that, the skin-friction coefficient at an inclined plate increases with an increase in the thermal Grashof number or solutal Grashof number whereas the skin-friction coefficient at an inclined plate decreases with an increase in the thermal radiation or hall current parameter or magnetic parameter from Table 3.

5. CONCLUSIONS

Casson MHD flow over an inclined moving plate with aligned angle, hall current, chemical reaction parameter and soret parameter have been formulated. It is noticed that as the Schmidt number increases, there is a decreasing trend in the concentration field.

- As the chemical reaction parameter increases the concentration is found to be decreasing.
- It is noticed that as the Prandtl number increases, the temperature decreases.
- It is observed that the thermal boundary layer thickness increases with an increase in the perturbation parameter (ε).
- It is noticed that as the thermal radiation increases, the temperature decreases.
- It is noticed that as the heat source/sink parameter increases, the temperature increases.
- It is noticed that the velocity increases with increasing values of solutal Grashof number.
- It is noticed that thermal Grashof number (Gr) increases, the velocity field increases.
- It is observed that fluid velocity is decreased in increasing angle α.

NOMENCLATURE

B_0	Magnetic field coefficient C: Species concentration
Cf_x	Local skin friction coefficient
Cp	Specific heat at constant pressure

C_w	Wall dimensional concentration
C_∞	Ambient temperature *
C	Dimensional concentration
D	Mass diffusivity
R	Radiation parameter
g	Gravitational acceleration
Gr	Grashof number
Gc	Solutal Grashof number
Nu_x	Local Nusselt Number
Pr	Prandtl number
Q	Heat source parameter
t	Dimensionless time
T	Temperature in the boundary layer
T_w	Wall dimensional temperature
T_∞	Ambient temperature
u, v	Components of the velocities
x, y	Co-ordinate system Greek Symbols
T	Coefficient of volume expansion for heat transfer
βc	Coefficient of volume expansion for mass transfer
ε	Scalar constant (<<1)
y	Dimensionless normal distance
Kr	Chemical reaction parameter
μ	Viscosity of the fluid
ρ	Density of the fluid
σ	Magnetic permeability of the fluid
ν	Kinematic viscosity

Super & Subscripts

'	Differentiation with respect to 'y'
w	Wall condition
∞	Free stream condition

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