Effects of Chemical Reactions, Heat, and Mass Transfer on Nonlinear Magnetohydrodynamic Boundary Layer Flow over a Wedge with a Porous Medium in the Presence of Ohmic Heating and V...

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Effects of Chemical Reactions, Heat, and Mass Transfer on Nonlinear Magnetohydrodynamic Boundary Layer Flow over a Wedge with a Porous Medium in the Presence of Ohmic Heating and Viscous Dissipation

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ABSTRACT

An analysis is carried out to study the effects of chemical reactions, heat, and mass transfer on nonlinear magnetohydrodynamic (MHD) boundary layer flow over a wedge with a porous medium in the presence of Ohmic heating and viscous dissipation. The fluid is assumed to be incompressible, viscous, electrically conducting, and Boussinesq. A magnetic field is applied transversely to the direction of the flow. A numerical solution for the steady MHD laminar boundary layer flow over a wall of the wedge with suction in the presence of species concentration and mass diffusion has been obtained by transforming the governing equations to nonlinear ordinary differential equations through similarity transformations and further utilizing the R. K. Gill method. Numerical calculations up to the third level of truncation are carried out for different values of dimensionless parameters of the problem under consideration. An analysis of the results obtained shows that the flow field is influenced appreciably by the strength of the magnetic field, chemical reactions, and suction at the wall of the wedge.

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NOMENCLATURE

B_0	strength of the magnetic field	u, v	velocity components in the x- and y-directions, respectively
c_p	specific heat at constant pressure	U	flow velocity of the fluid away from the wedge
C	species concentration of the fluid	V_0	velocity of suction/injection
C_w	species concentration of the fluid near the wall		
C_∞	species concentration of the fluid away from the wall		**Greek Symbols**
D	binary diffusive coefficient	α	thermal diffusivity
g	acceleration due to gravity	β	coefficient of thermal expansion
k	thermal conductivity	β^*	coefficient of expansion with concentration
m	dimensionless parameter for shape factor of the velocity	μ	viscosity
T	temperature of the fluid	ν	kinematic viscosity
T_w	temperature of the wall	ρ	density of the fluid
T_∞	temperature of the fluid far away from the wall	σ	electrical conductivity of the fluid
		Ω	angle of the wedge

1. INTRODUCTION

Mixed convection flows arising from the combined buoyancies due to thermal diffusion in a porous medium are important because of the fundamental nature of the problem and the broad range of applications related to manufacturing and processing industries such as geothermal systems, fiber and granular insulation, storage of nuclear waste materials, usage of porous conical bearings in lubrication technology, solidification of castings, chemical catalytic reactors, the spreading of chemical pollutants in a saturated soil, petroleum reservoirs, electronic cooling, natural gas storage, passive solar system components, crystal manufacturing, contaminant transport in ground water, electrochemical processes, and many other areas. Near the sea stores, prevention of spreading of saline and salt dissolution into the drinking water zones has become a serious problem of research. Bejan (1990) gave a review on natural convection, heat, and the mass transfer mechanism independently in porous media. Chemical reactions can be codified as either heterogeneous or homogeneous processes. This depends on whether they occur at an interface or as a single-phase volume reaction. Frequently, the transformations proceed in a moving fluid, a situation encountered in a number of technological fields. Chambre and Acrivos (1956) analyzed catalytic surface reactions in hydrodynamic flows. The article was concerned with its counterpart, namely, an investigation of a certain special class of homogeneous volume reactions in flow systems. Chambre and Acrivos (1957) studied the diffusion of a chemically reactive species in a laminar boundary layer flow. Acrivos (1960) analyzed the laminar forced convection mass transfer with homogeneous chemical reactions. A unified boundary layer analysis was applied to the problem of steady state mass transfer of a chemical species, diffusing from a surface and reacting isothermally in a linear fluid stream.

In these types of problems, the well-known Falkner-Skan transformation is used to reduce boundary layer equations into ordinary differential equations for similar flows. It can also be used for nonsimilar flows for convenience in numerical work because it reduces, even if it does not eliminate, dependence on the x-coordinate. The solutions of the Falkner-Skan equations are sometimes referred to as wedge flow solutions, with only two of the wedge flows being common in practice. The dimensionless parameter β_1 plays an important role in such types of problems because it denotes the shape factor of the velocity profiles. It has been shown (Schlichting, 1979) that when $\beta_1 < 0$ (increasing pressure), the velocity profiles have a point of inflexion, whereas when $\beta_1 > 0$ (decreasing pressure), there is no point of inflexion. This fact is of great importance in the analysis of the stability of laminar flows with a pressure gradient.

Yih (1998a) presented an analysis of the forced convection boundary layer flow over a wedge with uniform suction/blowing, whereas Watanabe (1990) investigated the behavior of the boundary layer over a wedge with suction or injection in forced flow. Recently, magnetohydrodynamic (MHD) laminar boundary layer flow over a wedge with suction or injection has been discussed by Kafoussias et al. (1997), and Kumari (1998) discussed the effect of large blowing rates on the steady, laminar, incompressible, electrically conducting fluid over an infinite wedge with a magnetic field applied parallel to the wedge. The effect of an induced magnetic field is included in the analysis. Anjali Devi and Kandasamy (2001) studied the effects of heat and mass transfer on nonlinear boundary layer flow over a wedge with suction or injection.

Early studies of combined heat and mass transfer in natural convection boundary layer flows over a heated surface with various geometries can be found in the monograph by Gebhart et al. (1998). Recently, some investigations have been carried out to include various physical aspects of the problem of combined heat and mass transfer. The transient free convection flow has been investigated (Muthukumaraswamy and Ganesan, 1998) for an impulsively started vertical plate with heat and mass transfer. Chamkha and Khaled (2001) investigated the problem of coupled heat and mass transfer by MHD free convection from an inclined plate in the presence of internal heat generation or absorption. Combined heat and mass transfer in MHD free convection from a vertical surface with Ohmic heating and viscous dissipation has been discussed (Chen, 2004). For the problem of coupled heat and mass transfer in MHD free convection, the effects of viscous dissipation and Ohmic heating with chemical reactions are not studied in the above investigation. However, it is more realistic to include these effects to explore the impact of the magnetic field on the thermal transport in the buoyancy layer. With this awareness, the effect of Ohmic heating on the MHD free convection heat transfer has been examined for a Newtonian fluid (Hossian, 2002) and for a micropolar fluid (El-Hakiem et al., 1999). Kandasamy et al. (2005) studied the problem of the effect of chemical reactions, heat, and mass transfer along a wedge with a heat source and concentration in the presence of suction. Kumari et al. (2001) investigated the effect of heat and mass transfer on mixed convection flow over a vertical wedge embedded in a highly porous medium. The effect of a heat source and sink on MHD mixed convection in stagnation flow on a vertical permeable plate in porous media has been analyzed by Yih (1998b). Anjali Devi and Kandasamy (2002) studied the effect of chemical reactions, heat, and mass transfer on nonlinear MHD laminar boundary layer flow over a wedge with suction or injection.

Since no attempt has been made to analyze the effects of chemical reactions, heat, and mass transfer on MHD mixed convection flow over a wall of the wedge with a porous medium in the presence of Ohmic heating and viscous dissipation, we have investigated it in this article. The similarity transformation has been utilized to convert the governing partial differential equations into ordinary differential equations, and then the numerical solution of the problem is drawn using the R. K. Gill method. This method has the following advantages over other available methods: (1) it utilizes less storages registers, (2) it controls the growth of rounding errors and is usually stable, and (3) it is computationally economical. Numerical calculations up to the third level of truncation were carried out for different values of dimensionless parameters of the problem under consideration for the purpose of illustrating the results graphically. Examination of such flow models reveals the influence of chemical reactions, Ohmic heating, and magnetic effects on velocity, temperature, and concentration profiles. The analysis of the results obtained shows that the flow field is influenced appreciably by the presence of chemical reactions, a magnetic effect, and suction at the wall of the wedge.

2. MATHEMATICAL ANALYSIS

Two-dimensional MHD laminar boundary layer flow of an incompressible, viscous, electrically conducting double diffusive and Boussinesq fluid over a wall of the wedge with a porous medium is considered. The x-axis is taken parallel to the wedge, and the y-axis is taken normal to it, as cited in Fig. 1. A uniform transverse magnetic field of strength B_0 is

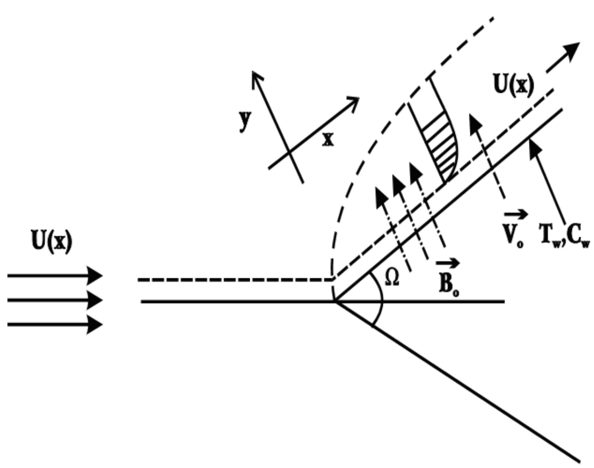

Figure 1. Flow analysis along the wall of the wedge

applied parallel to the y-axis. The Soret and Dufour effects are neglected as the concentration of diffusing species is very small in comparison to other chemical species, and the concentration of species far from the wall, C_∞, is infinitesimally small (Bird et al., 1992). The chemical reactions are taking place in the flow, and the physical properties μ, D, α, and the rate of chemical reaction k_1 are constant throughout the fluid. In writing the following equations, it is assumed that the induced magnetic field, the external electric field, and the electric field due to the polarization of charges are negligible. Now the governing boundary layer equations of momentum, energy, and diffusion for the flow under Boussinesq's approximation are

$$\partial u/\partial x + \partial v/\partial y = 0 \tag{1}$$

$$\begin{aligned} &u\partial u/\partial x + v\partial u/\partial y = \nu\partial^2 u/\partial y^2 + UdU/dx \\ &-(\sigma B_0^2/\rho)(u-U)-(\nu/k)(u-U)+g\beta(T-T_\infty) \\ &\times \sin(\Omega/2)+g\beta^*(C-C_\infty)\sin(\Omega/2) \end{aligned} \tag{2}$$

$$\begin{aligned} &u\partial T/\partial x + v\partial T/\partial y = \alpha\partial^2 T/\partial y^2 \\ &+ (\mu/\rho c_p)(\partial u/\partial y)^2 + (\sigma B_0^2/\rho c_\rho)u^2 \end{aligned} \tag{3}$$

$$u\partial C/\partial x + v\partial C/\partial y = D\partial^2 C/\partial y^2 - k_1 C \tag{4}$$

The boundary conditions are

$$u = 0 \quad v = v_0 \quad C = C_w \quad T = T_w \quad \text{at} \quad y = 0 \tag{5}$$

$$u = U(x) \quad C = C_\infty \quad T = T_\infty \quad \text{as} \quad y \to \infty \tag{6}$$

Following the lines of Bansal (1986), the following change of variables is introduced:

$$\begin{aligned} &\psi(x,y) = (2U\nu x/(1+m))^{1/2} \quad f(x,\eta) \\ &\eta(x,y) = y((1+m)U/2\nu x)^{1/2} \end{aligned} \tag{7}$$

Under this consideration, the potential flow velocity can be written as

$$U(x) = cx^m \quad \beta_1 = 2m/(1+m) \tag{8}$$

where c and m are constants and β_1 is the Hartree pressure gradient parameter that corresponds to $\beta_1 = \Omega/\pi$ for a total angle Ω of the wedge.

The velocity components are given by

$$u = \partial\psi/\partial y \qquad v = -\partial\psi/\partial x \tag{9}$$

It can be easily verified that the continuity Eq. (2) is identically satisfied and introduced the nondimensional form of temperature and the concentration as

$$\theta = (T - T_\infty)/(T_w - T_\infty) \tag{10}$$

$$\phi = (C - C_\infty)/(C_w - C_\infty) \tag{11}$$

Reynolds Number:

$$\mathrm{Re}_x = Ux/\nu \tag{12}$$

Grashof Number:

$$\mathrm{Gr} = \nu g\beta(T_w - T_\infty)/U^3 \tag{13}$$

Modified Grashof Number:

$$\mathrm{Gc} = \nu g\beta^*(C_w - C_\infty)/U^3 \tag{14}$$

Prandtl Number:

$$\mathrm{Pr} = \mu c_p/K \tag{15}$$

Schmidt Number:

$$\mathrm{Sc} = \nu/D \tag{16}$$

Eckert Number:

$$\mathrm{Ec} = c^2/c_p(T_w - T_\infty)(k^2)^{2m/(1-m)} \tag{17}$$

Magnetic Parameter:

$$M^2 = \sigma B_0^2/\rho c k^2 \tag{18}$$

Permeability Parameter:

$$\lambda = (\nu/k)U \tag{19}$$

Suction or Injection Parameter:

$$S = -v_0((1+m)x/2\nu U)^{1/2} \tag{20}$$

Chemical Reaction Parameter:

$$\gamma = \nu k_1/U^2 \tag{21}$$

Now Eqs. (2)–(5) become

$$\begin{aligned}\partial^3 f/\partial\eta^3 &= -f\partial^2 f/\partial\eta^2 - (2m/(1+m))(1-(\partial f/\partial\eta)^2)\\ &- (2/(1+m))(\mathrm{GcRe}_x\phi + \mathrm{GrRe}_x\theta)\sin(\Omega/2)\\ &+ (2x/(1+m))(\partial f/\partial\eta(\partial^2 f/\partial x\partial\eta)\\ &-\partial f/\partial x(\partial^2 f/\partial\eta^2)) + (\sigma B_0^2/\rho U)(\partial f/\partial\eta - 1))\\ &+ \lambda(\partial f/\partial\eta - 1)\end{aligned} \tag{22}$$

$$\begin{aligned}\partial^2\theta/\partial\eta^2 &= -\mathrm{Pr}f\partial\theta/\partial\eta + (2\mathrm{Pr}/(1+m))\theta\partial f/\partial\eta\\ &+ \mathrm{Pr}(2x/(1+m))(\partial f/\partial\eta(\partial\theta/\partial x)\\ &- \partial f/\partial x(\partial\theta/\partial\eta) - \mathrm{PrEc}(\partial^2 f/\partial\eta^2)^2\\ &- (\sigma B_0^2/\rho U)(U^2/c_p(T_w - T_\infty))(\partial f/\partial\eta)^2)\end{aligned} \tag{23}$$

$$\begin{aligned}\partial^2\phi/\partial\eta^2 &= -\mathrm{Sc}f\partial\phi/\partial\eta + (2\mathrm{Sc}/(1+m))\mathrm{Re}_x\gamma\phi\\ &+ (2\mathrm{Sc}/(1+m))\phi\partial f/\partial\eta + (2x\mathrm{Sc}/(1+m))\\ &\times (\partial f/\partial\eta(\partial\phi/\partial x) - \partial\phi/\partial\eta(\partial f/\partial x))\end{aligned} \tag{24}$$

The boundary conditions (6) can be written as

$$\begin{aligned}&\eta = 0 : \partial f/\partial\eta = 0 \qquad (f/2)(1 + (x/U)dU/dx)\\ &+ x\partial f/\partial x = -v_0((1+m)x/2\nu U)^{1/2}\\ &\theta = 1 \quad \phi = 1 \quad \eta \to \infty : \partial f/\partial\eta = 1\\ &\theta = 0 \quad \phi = 0\end{aligned} \tag{25}$$

where v_0 is the velocity of suction if $v_0 < 0$ and injection if $v_0 > 0$.

Equations (22)–(24) and boundary conditions (25) can be written as

$$\begin{aligned}&\partial^3 f/\partial\eta^3 + (f + ((1-m)/(1+m))\xi\partial f/\partial\xi)\partial^2 f/\partial\eta^2\\ &- ((1-m)/(1+m))\xi\partial^2 f/\partial\xi\partial\eta)\partial f/\partial\eta\\ &-\lambda(\partial f/\partial\eta - 1) - (2/(1+m))M^2\xi^2((\partial f/\partial\eta) - 1)\\ &+ (2m/(1+m))(1 - (\partial f/\partial\eta)^2) + (2/(1+m))\\ &\times (\mathrm{GcRe}_x\phi + \mathrm{GrRe}_x\theta)\sin(\Omega/2) = 0\end{aligned} \tag{26}$$

$$\begin{aligned}&\partial^2\theta/\partial\eta^2 + \mathrm{Pr}(f + ((1-m)/(1+m))\xi\partial f/\partial\xi)\partial\theta/\partial\eta\\ &+ \mathrm{Pr}\ \mathrm{Ec}(\partial^2 f/\partial\eta^2)^2 + \mathrm{Pr}(2/(1+m))M^2\\ &\times \mathrm{Ec}\xi^{2(1+m)/(1-m)}(\partial f/\partial\eta)^2 - (2\mathrm{Pr}/(1+m))\theta\partial f/\partial\eta\\ &- (((1-m)/(1+m))\xi\partial\theta/\partial\xi)\partial f/\partial\eta = 0\end{aligned} \tag{27}$$

$$\partial^2\phi/\partial\eta^2 + \mathrm{Sc} f\partial\phi/\partial\eta - (2\mathrm{Sc}/(1+m))\mathrm{Re}_x\gamma\phi$$
$$+\mathrm{Sc}((1-m)/(1+m))(\partial\phi/\partial\eta\,\xi\partial f/\partial\xi - \partial f/\partial\eta\,\xi\partial\phi/\partial\xi)$$
$$-(2\mathrm{Sc}/(1+m))\partial f/\partial\eta\phi = 0 \qquad (28)$$

$$\eta = 0 : \partial f/\partial\eta = 0$$
$$(1+m)f/2 + ((1-m)/2)\xi\partial f/\partial\xi = S$$
$$\theta = 1 \quad \phi = 1 \quad \eta \to \infty : \partial f/\partial\eta = 1$$
$$\theta = 0 \quad \phi = 0 \qquad (29)$$

where S is the suction parameter if $S > 0$ and the injection parameter if $S < 0$, and where $\xi = kx^{(1-m)/2}$ is the dimensionless distance along the wedge ($\xi > 0$). In this system of equations, $f(\xi,\eta)$ is the dimensionless stream function, $\theta(\xi,\eta)$ is the dimensionless temperature, $\phi(\xi,\eta)$ is the dimensionless concentration, Pr is the Prandtl number, Re_x is the Reynolds number, and so on, all of which are defined in Eqs. (10)–(21). The parameter ξ indicates the dimensionless distance along the wedge ($\xi > 0$). It is obvious that to retain the ξ-derivative terms, it is necessary to employ a numerical scheme suitable for partial differential equations for the solution. In addition, owing to the coupling between adjacent streamwise locations through the ξ-derivatives, a locally autonomous solution, at any given streamwise location, cannot be obtained. In such a case, an implicit marching numerical solution scheme is usually applied, causing the solution to proceed in the ξ-direction, that is, calculating unknown profiles at $\xi_{\iota+1}$ when the same profiles at ξ_ι are known. The process starts at $\xi = 0$, and the solution proceeds from ξ_ι to $\xi_{\iota+1}$ but such a procedure is time consuming. However, when the terms involving $\partial f/\partial\xi$, $\partial\theta/\partial\xi$, and $\partial\phi/\partial\xi$ and their η derivatives are deleted, the resulting system of equations resembles, in effect, a system of ordinary differential equations for the functions f, θ, and ϕ with ξ as a parameter, and the computational task is simplified. Furthermore, a locally autonomous solution for any given ξ can be obtained because the streamwise coupling is severed. So, following the lines of Anjali Devi and Kandasamy (2002), a recent numerical solution scheme is utilized for obtaining the solution of the problem. Now, owing to the above-mentioned factors, Eqs. (26)–(28) are changed to

$$f''' + ff'' + (2m/(1+m))(1-(f')^2)$$
$$+ (2/(1+m))(\mathrm{Gc}\mathrm{Re}_x\phi + \mathrm{Gr}\mathrm{Re}_x\theta)\sin(\Omega/2)$$
$$-(2/(1+m))M^2\xi^2(f'-1) - \lambda(f'-1) = 0 \qquad (30)$$

$$\theta'' + \mathrm{Pr} f\theta' - (2\mathrm{Pr}/(1+m))f'\theta - \mathrm{PrEc}(f'')^2$$
$$+(2\mathrm{Pr}/(1+m))M^2\mathrm{Ec}\xi^{2(1+m)/(1-m)}(f')^2 = 0 \qquad (31)$$

$$\phi'' + \mathrm{Sc} f\phi' - (2\mathrm{Sc}/(1+m))f'\phi$$
$$-(2\mathrm{Sc}/(1+m))\mathrm{Re}_x\gamma\phi = 0 \qquad (32)$$

with boundary conditions

$$\eta = 0 : f(0) = (2/(1+m))S \qquad f'(0) = 0$$
$$\theta(0) = 1 \qquad \phi(0) = 1 \qquad \eta \to \infty : f'(\infty) = 1$$
$$\theta(\infty) = 0 \qquad \phi(\infty) = 0 \qquad (33)$$

Equations (30)–(32) with boundary conditions (33) are integrated using the R. K. Gill method. Effects of chemical reactions, heat, and mass transfer are studied for different values of suction/injection at the wall of the wedge and strengths of the applied magnetic field.

3. RESULTS AND DISCUSSION

To get clear insight of the physical problem, numerical results are displayed with the help of graphical illustrations.

In the absence of viscous dissipation, the results have been compared with those of previous work (Anjali Devi and Kandasamy, 2002), and it is found that they are in good agreement. The numerical results are illustrated by means of Figs. 2–10. Figures 2–4 represent the dimensionless velocity, temperature, and concentration profiles for different values of the permeability parameter. In the presence of constant chemical reactions with a uniform magnetic field and suction, it is clear that the velocity of the fluid increases, and

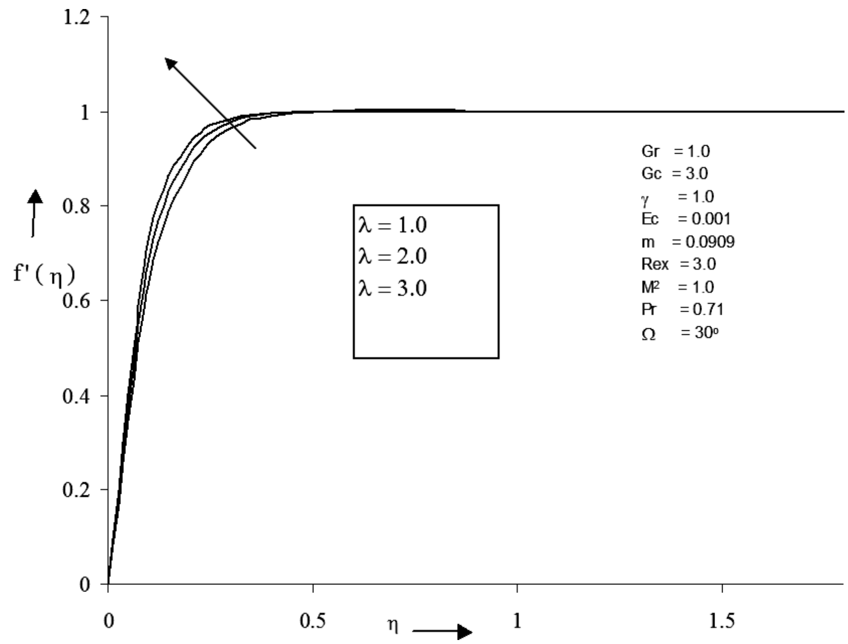

Figure 2. Effects of permeability over the velocity profiles

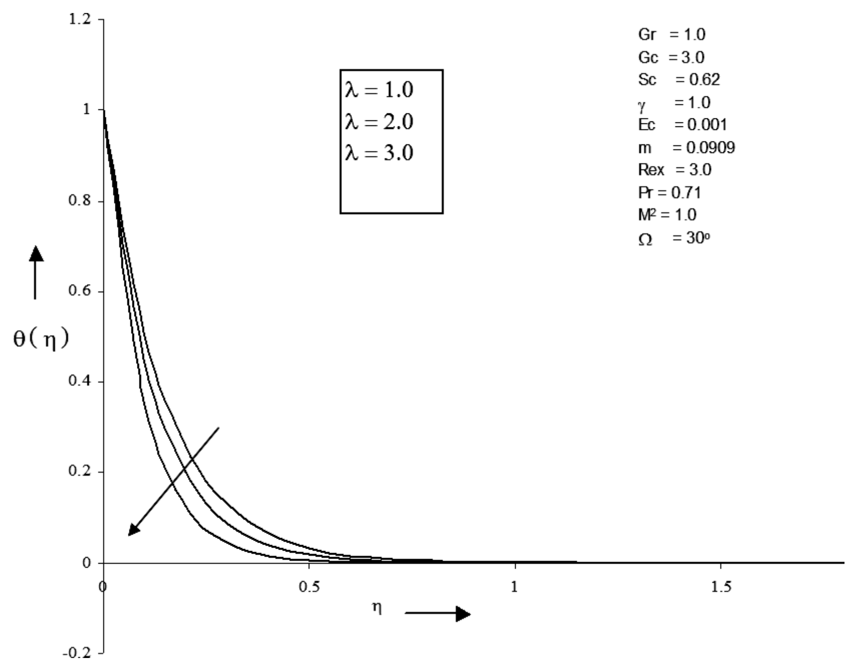

Figure 3. Effects of permeability over the temperature profiles

the dimensionless temperature $\theta(\eta)$ and concentration $\phi(\eta)$ of the fluid reduce with an increase in the permeability parameter; these are shown in Figs. 2, 3, and 4, respectively. It is also observed that the fluid motion gradually changes from a lower value to a higher value, and the temperature and concentration

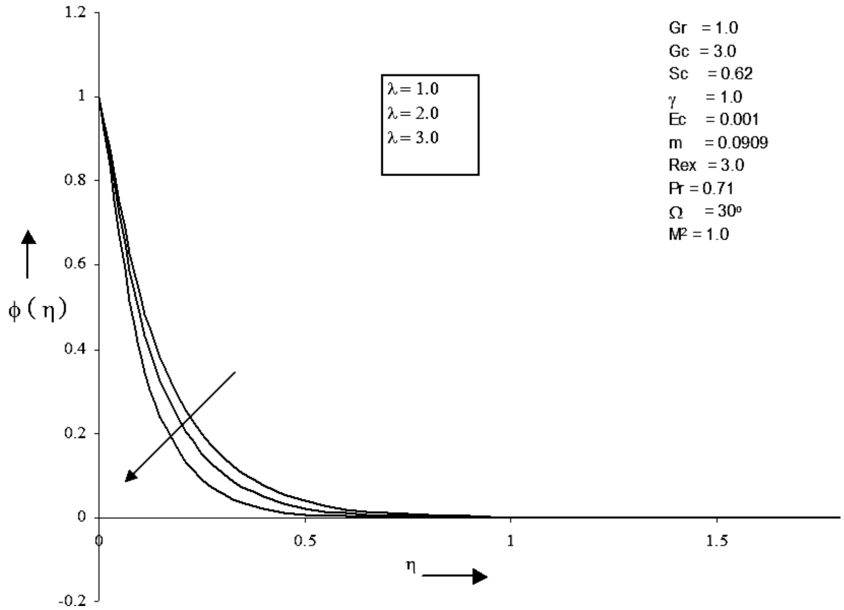

Figure 4. Effects of permeability over the concentration profiles

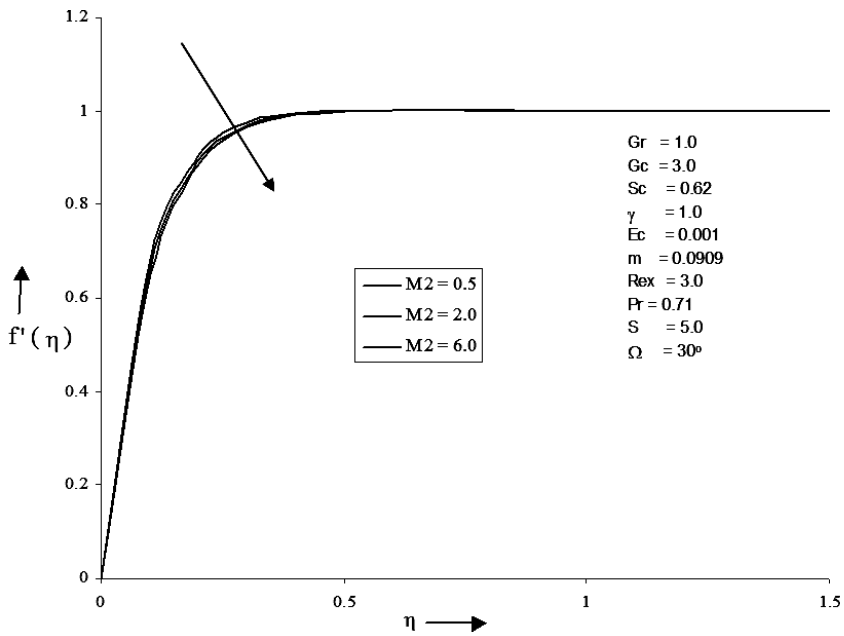

Figure 5. Influence of magnetic field over the temperature profiles

of the fluid change from a higher value to a lower value, only when the thermal conductivity of the fluid is smaller than the kinematic viscosity of the fluid. All these physical behaviors are due to the combined effects of uniform chemical reactions and the strength of the heat source along the wall of the wedge. The dimensionless velocity profiles for different values of the strength of the applied magnetic field are plotted in Fig. 5. Owing to the uniform heat source and chemical reactions, it is clear that the velocity of the

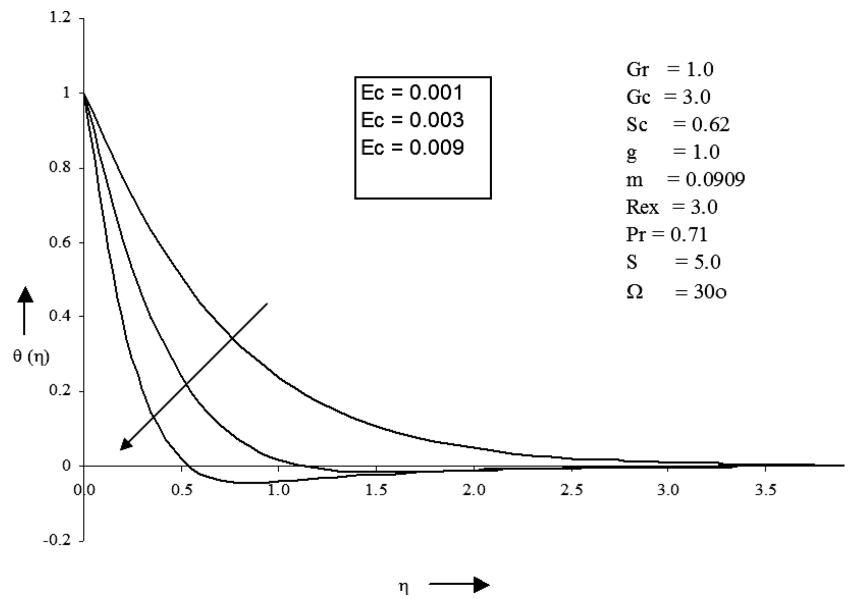

Figure 6. Effects of Eckert number on temperature profiles

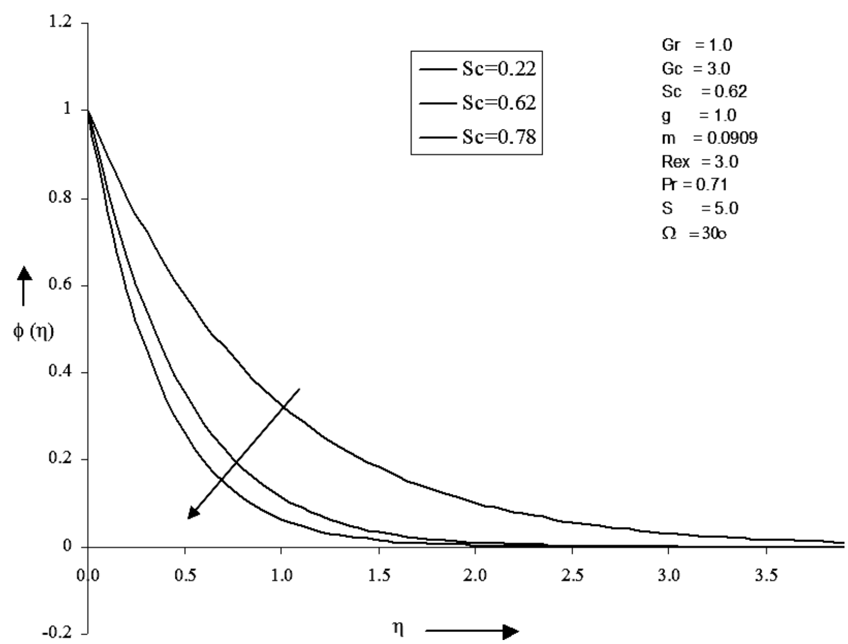

Figure 7. Effects of Schmidt number over the concentration profiles

fluid decreases with an increase of strength of the magnetic field. All these physical behaviors are due to the combined effect of the buoyancy ratio between species and thermal diffusion and the strength of the magnetic field along with uniform chemical reactions.

Figure 6 represents the dimensionless temperature profiles for different values of the Eckert number. In the case of uniform chemical reactions and magnetic effect, it is seen that the temperature of the fluid decreases with an increase of the Eckert number.

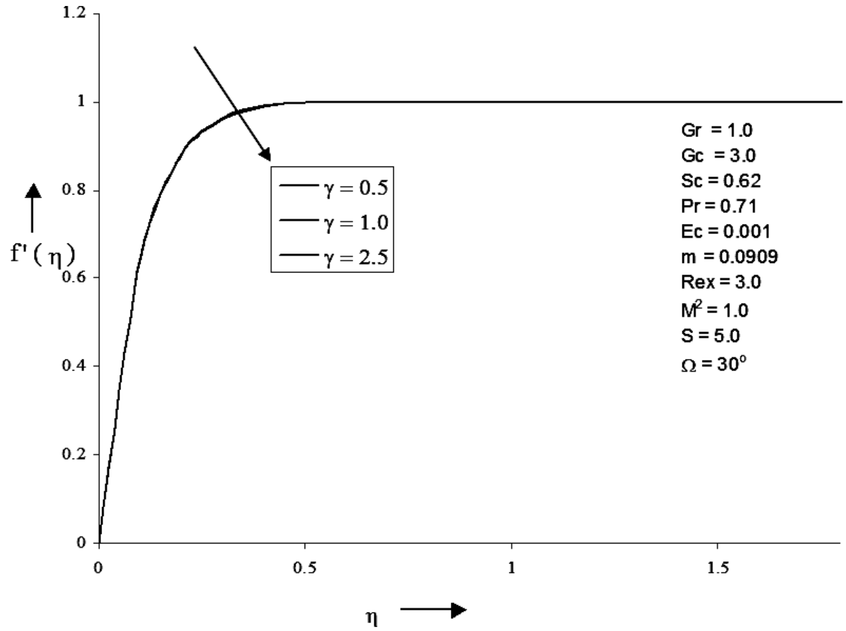

Figure 8. Influence of chemical reaction over the velocity profiles

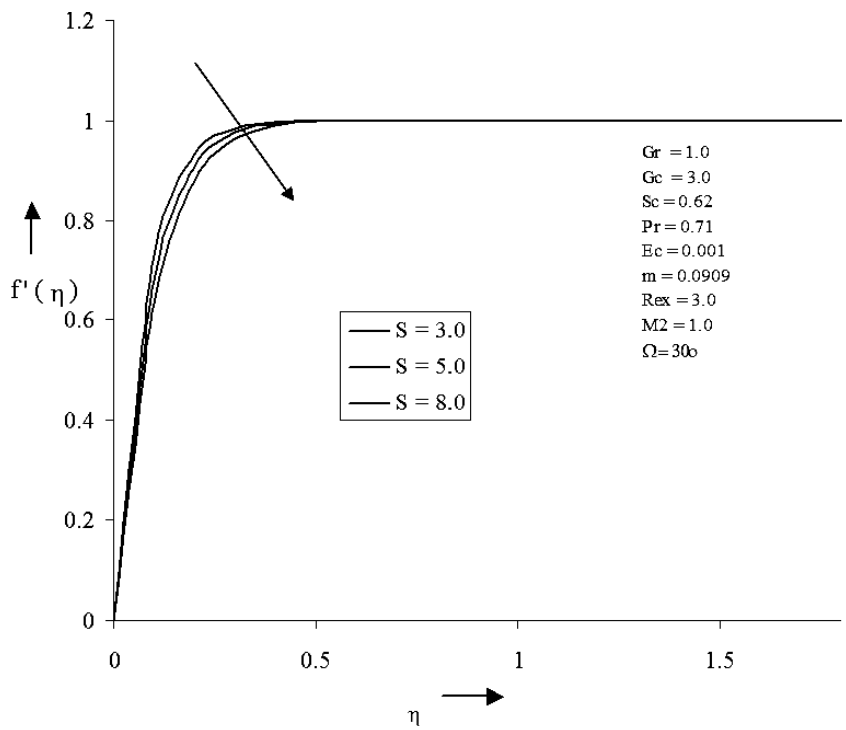

Figure 9. Effects of suction over the velocity profiles

In particular, the temperature of the fluid gradually changes from a higher value to a lower value only when the strength of the heat source is higher than the species concentration effect. For a large magnetic strength mechanism, an interesting result is the large distortion of the temperature field caused for

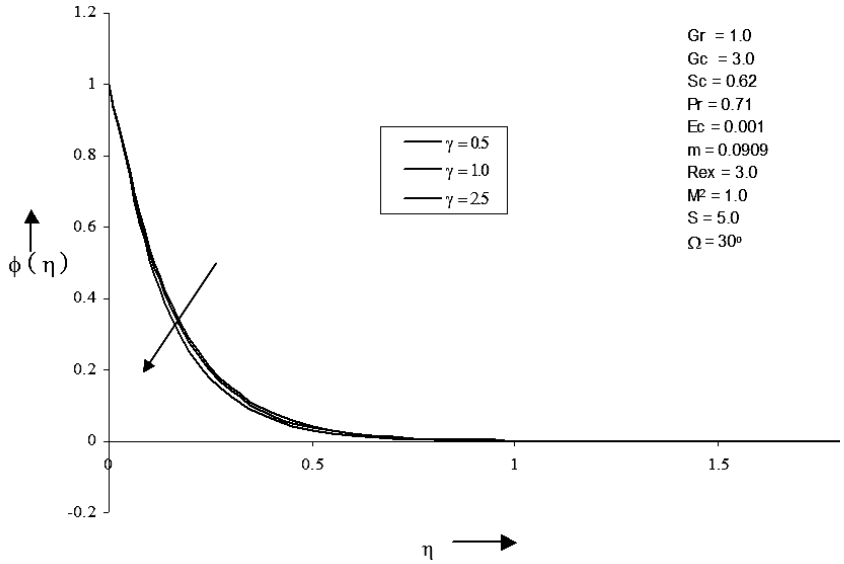

Figure 10. Influence of chemical reaction over the concentration profiles

Ec = 0.009. A negative value of the temperature profile is seen in the outer boundary region for Ec = 0.009 and $M^2 = 5.0$. All these physical behaviors are due to the combined effect of the buoyancy ratio between species and thermal diffusion and the Eckert number with a uniform magnetic field.

Figure 7 represents the dimensionless concentration profiles for different values of the Schmidt number. In the presence of constant chemical reactions with a uniform magnetic field and suction, it is clear that the concentration of the fluid reduces with an increase of the Schmidt number, and this is shown in Fig. 7. It is also observed that the concentration of the fluid changes from a higher value to a lower value only when the coefficient of diffusion of the fluid is smaller than the kinematic viscosity of the fluid. All these physical behaviors are due to the combined effects of a uniform Schmidt reaction and the strength of the magnetic field.

The dimensionless velocity profiles for different values of chemical reactions with constant suction are exhibited in Fig. 8. In the case of a uniform magnetic field, it is seen that the velocity of the fluid slightly decreases with an increase in chemical reactions. All these physical behaviors are due to the combined effect of the heat source and chemical reactions.

Figure 9 represents the dimensionless velocity profiles for different values of the suction parameter $(S > 0)$. In the presence of a uniform heat source, it is clear that the velocity of the fluid decreases with an increase in suction along the wall of the wedge. All these physical behaviors are due to the combined effects of suction at the wall and a uniform heat source of the fluid along the wall of the wedge.

The concentration of the fluid decreases with an increase in the chemical reaction parameter, and this is displayed in Fig. 10. It is also observed that the concentration of the fluid changes from a higher value to a lower value only when the coefficient of mass transfer of the fluid is smaller than the kinematic viscosity of the fluid. All these physical behaviors are due to the combined effects of chemical reactions with uniform magnetic effects along the wall of the wedge.

4. CONCLUSION

1. In the case of uniform suction and constant chemical reactions, the velocity of the fluid de-

creases with an increase of the strength of the applied magnetic field when the wall of the wedges are subjected to a uniform heat source.

2. In the presence of constant chemical reactions with a uniform magnetic field, the velocity of the fluid increases, and the temperature and concentration of the fluid reduce, with an increase of permeability at the wall of the wedge.
3. Owing to the uniform magnetic field and suction, the velocity and concentration of the fluid decrease with an increase of chemical reaction effects.
4. A comparison of velocity profiles shows that the velocity increases near the plate and thereafter remains uniform in all the cases.
5. Owing to the uniform magnetic field with constant chemical reactions, the temperature distribution along the wall of the wedge decreases with an increase of the Eckert number.
6. In the case of uniform suction with a constant magnetic field, the concentration of the fluid decreases with an increase of the Schmidt number.
7. Owing to the uniform chemical reactions and magnetic effect, it is interesting to note that the increase of suction at the wall of the wedge decelerates the fluid motion along the surface.
8. A decrease of the concentration field due to an increase in the Schmidt number Sc shows that it increases gradually as we replace hydrogen (Sc = 0.22) by water vapor (Sc = 0.62) and ammonia (Sc = 0.78) in the said sequence. It is also observed that the effect of the Schmidt reaction is very important in the concentration field.

It is hoped that the present investigation of the study of the physics of flow over a wedge can be utilized as the basis for many scientific and engineering applications and for studying more complex vertical problems involving the flow of electrically conducting fluids. The analysis of the flow of a viscous incompressible fluid through a porous medium is playing a predominant role in scientific and engineering applications. Flow of this kind has enormous importance in technical problems such as flow through packed beds, sedimentation, environmental problems, and centrifugal separation of particles and blood rheology. The results of the problem are also of great interest in geophysics in the study of the interaction of the geomagnetic field with the fluid in the geothermal region.

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