Volume 6, No.3, March 2019
Journal of Global Research in Mathematical Archives
RESEARCH PAPER
Available online at http://www.jgrma.info
ISSN 2320 – 5822

HEAT AND MASS TRANSFER ON AN UNSTEADY MHD FLOW OF JEFFERY FLUID OVER A RADIATING ALIGNED PERMEABLE MOVING PLATE EMBEDDED IN A POROUS MEDIUM WITH INFLUENCE OF THE DUFOUR EFFECT AND HEAT SOURCE/SINK

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Abstract: The objective of this manuscript is to analyze the Heat and Mass transfer effects on an unsteady MHD Jeffrey fluid flow of a viscous, incompressible electrically conducting chemical reacting fluid along an aligned permeable moving plate embedded in auniform porous medium. The partial differential equations are reducesinto nonlinear ordinary differential equations and solved by using the perturbation technique. The behavior of the velocity, temperature and concentration has been discussed with influence of the various physical parameters.

INTRODUCTION

The order of differential system in non-Newtonian fluid situation is higher than the viscous material. A variety of non-Newtonian fluid models have been proposed in the literature keeping in view of their rheological features. In these fluids, the constitutive relationships between stress and rate of strain are much complicated. The most common and simplest model of non-Newtonian fluids is Jeffrey fluid. The Jeffrey fluid is a better model for physiological fluids and this fluid model is capable of describing the characteristics of relaxation, because Newtonian fluid model can be deduced from this as a special case by taking $\lambda_1 = 0$. The Jeffrey's fluid model degenerates to a Newtonian fluid at a very high wall shear stress that is when the wall stress is much greater than the yield stress. This fluid model also approximates reasonably well the rheological behavior of other liquids including physiological suspensions, foams, geological materials, cosmetics, and syrups. Several researchers have studied Jeffrey fluid flows under different conditions. Interest in the boundary layer flows of non-Newtonian fluids has increased due to its applications in science and engineering including thermal oil recovery, food and slurry transportation, polymer and food processing, etc.

Hassani et al. [1] analysed the steady boundary layer flow, heat transfer and nano particle fraction analytically by using the homotopy analysis method over a stretching surface in a nanofluid. The effects of nano particle inclusion in the Classical Blasius problem and the governing equations are solved by using homotopy perturbation method and variational iteration method has been presented by Malvandi et al. [2]. Chaudhary and Arpita Jain [3] presented the magnetic and mass diffusion effects on the free convection flow and the plate is made to oscillate with a specified velocity. Muthucumaraswamy and Ganesan [4] proposed the flow past an impulsively started infinite vertical plate with variable temperature and uniform mass diffusion in the presence a homogeneous chemical reaction of first-order. The boundary layer analysis of a 2D magneto hydrodyanamic flow of chemically reacting casson nanofluid flow over a semi-infinite inclined porous plate has been discussed by Sulochana et al. [5].

Sandeep and Sugunamma [6] analyzied the effects of radiation and inclined magnetic field on free convective flow of dissipative fluid past a vertical plate through porous medium with heat source by applying a simple perturbation technique. Sharma and Chardhary [7] proposed the effects of variable suction on transient free convection flow past an infinite vertical plate in slip-flow regime and the temperature of the plate oscillates in time about a constant mean. The influence of slip on the behavior of fluid flow and thermal transport of some electrically conducting nanofluid over a permeable stretching / shrinking sheet has been investigated by Turkyilmazoglu [8]. Prakash et al. [9] examined the heat and mass transfer effect on the unsteady MHD mixed convection flow of a binary mixture over a moving semi-infinite vertical porous plate with the influence of chemical reaction and buoyancy. Abdul Hakeem et al. [10] investigated the effect of radiation absorption, mass diffusion, chemical reaction and heat source parameter of heat generating fluid past a vertical porous plate subjected to variable suction in the presence of chemical reaction and variable viscosity.

Bhatti et al. [11] presented the mass and bioheat transfer effect in the peristaltic propulsion of two-phase sisko fluid flow towards a Darcy-Brinkman-Forchheimer porous channel. The heat and mass transfer by steady flow of an electrically conducting and heat generating / absorbing fluid on a uniformly moving vertical permeable surface in the presence of a magnetic field a first-order chemical reaction has been reported by Chamkha [12]. Madhusudhana Rao et al. [13] presented the unsteady MHD free convection flow of a viscous fluid past a vertical porous plate embedded with porous medium in presence of chemical reaction.

Yigit Aksoy et al. [14] worked new perturbation iteration algorithm is applied to three nonlinear heat equations and the variational iteration algorithm. Dulal Pal and Babulal Talukdar [15] discussed the effects of various physical parameters on the velocity, temperature and concentration profides as well as on local skin-friction coefficient and local Nusselt number.

The effect of radiation on heat and mass transfer in mercury $(\Pr = 0.025)$ and electrolytic solution $(\Pr = 1.0)$ past an infinite porous hot vertical plate in the presence of ohmic heating and transverse magnetic field has been worked by Chaudary et al.[16]. The slip effect on coupled mass and heat transference in free convective three dimensional MHD flows having periodic permeability has been investigated by Rabiya Tajammal et al. [17]. Muthucumaraswamy and Meenakshisundarm [18] proposed the effects of homogeneous chemical reaction of first order and free convection on the oscillating infinite vertical plate with variable temperature and mass diffusion. The effects of buoyancy force and first order chemical reaction in a two-dimensional MHD flow, heat and mass transfer of a viscous imcompressible fluid past a permeable vertical plate embedded in a porous medium in the presence of viscous dissipation and ohmic dissipation, heat absorption, absorption of radiation and thermal radiation has been presented by Machireddy Gnaneswara Reddy [19].

Gnaneswara Reddy [20] investigated the study of MHD and ohmic heating in steady two-dimensional boundary layer slip flow of viscous incompressible dissipating fluid past a vertical permeable plate and thermal radiation incorporating first order chemical reaction with uniform heat and mass flux. Karthikeyan et al. [21] worked perturbation technique is applied to convert the governing non-linear partial differential equations into a system of ordinary differential equation. Chamkha [22] proposed the plate is embedded in a uniform porous medium and moves with a constant velocity in the flow direction in the presence of transverse magnetic field. The unsteady MHD double-diffusive free convection for a heat generating fluid with thermal radiation and chemical reaction has received little attention has been studied by Mohamed [23]. Madhusudhana Rao [24] studied the dimensionless governing partial differential equations for analytically by using two term harmonic and non-harmonic functions.

The objective of this study is to analyze the Heat and Mass transfer effects on an unsteady MHD Jeffrey fluid flow of a viscous, incompressible electrically conducting chemical reacting fluid along an aligned permeable moving plate embedded in a uniform porous medium. The partial differential equations are reduces into non-linear ordinary differential equations and solved by using the perturbation technique. The behavior of the velocity, temperature and concentration has been discussed with influence of the various physical parameters.

FORMULATION OF THE PROBLEM

Consider an unsteady MHD flow of a laminar, Jeffrey, incompressible, electrically conducting, double diffusive and generating fluid past a semi-infinite inclined permeable moving plate embedded in a uniform porous medium and subjected to a uniform transverse magnetic field B_0 in the presence of thermal radiation and the first order homogeneous chemical reaction. It is assumed that there is no applied voltage which implies the absence of an electrical field. The transversely applied magnetic field and magnetic Reynolds number are assumed to be very small so that the induced magnetic field x' -Axis is taken in the upward direction along with the flow and y' -axis is taken perpendicular to it. At $y' = 0$ the plate is initially assumed to be moving with a uniform velocity $u_p{}'$ in the direction of the fluid flow, and the free stream velocity follows the exponentially increasing small perturbation law. Besides that, it is assumed that the temperature and the concentration at the wall as well as the suction velocity are exponentially varying with time. By considering the above assumptions, the governing equation are given as follows

$$\frac{\partial v'}{\partial y'} = 0 \quad (1)$$

$$\frac{\partial u'}{\partial t'} + v'\frac{\partial u'}{\partial y'} = -\frac{1}{\rho}\frac{\partial p'}{\partial x'} + \frac{v}{(1+\lambda_1)}\frac{\partial^2 u'}{\partial y'^2} + g\beta_T\left(T'-T'_\infty\right) + g\beta_c\left(C'-C'_\infty\right) - \frac{\sigma B_0^2}{\rho}\sin^2\psi u' - \frac{v}{k'}u' \quad (2)$$

$$\frac{\partial T'}{\partial t'} + v'\frac{\partial T'}{\partial t'} = \frac{k}{\rho C_p}\frac{\partial^2 T'}{\partial y'^2} - \frac{1}{\rho C_p}\frac{\partial q_r{}'}{\partial y'} - \frac{Q'}{\rho C_p}\left(T'-T'_\infty\right) + \frac{D_m K_T}{C_s C_P}\frac{\partial^2 C'}{\partial y'^2} + \frac{Q'_1}{\rho C_P}\left(C'-C'_\infty\right) \quad (3)$$

$$\frac{\partial C'}{\partial t'} + v'\frac{\partial C'}{\partial y'} = D\frac{\partial^2 C'}{\partial y'^2} - K_c\left(C'-C'_\infty\right) \quad (4)$$

Under the above assumptions, the appropriate boundary conditions for the distributions of velocity, temperature and concentration are given by

$$u' = u'_p,\ T' = T'_w + \in e^{n't'}\left(T'_w - T'_\infty\right), C' = C'_w + \in e^{n't'}\left(C' - C'_\infty\right) \qquad \text{at } y' = 0 \ (5)$$

$$u' \to u'_\infty = U_0\left(1 + \in e^{n't'}\right), T' \to T'_\infty, C' \to C'_\infty \qquad \text{as } y' \to \infty \quad (6)$$

It is known from equation (1) that the suction velocity at the plate surface is a function of time in assumed in the following form

$$v' = -V_0\left(1 + \in Ae^{n't'}\right) \quad (7)$$

Outside the boundary layer equation (2) modifies as

$$-\frac{1}{\rho}\frac{\partial P'}{\partial x'} = \frac{dU'_\infty}{dt'} + \frac{v}{k'}U'_\infty + \frac{\sigma}{\rho}B_0^2 U'_\infty \sin^2\psi \quad (8)$$

We consider a mathematical model, for an optically thin limit gray gas near equilibrium in the form given by

$$\frac{\partial q_r'}{\partial y'} = 4\left(T' - T'_w\right)I_1 \quad (9)$$

Where $I_1 = \int_0^\infty K_{\lambda w}\left(\frac{\partial e_{b\lambda}}{\partial T}\right)_W d\lambda$, $K_{\lambda w}$ is the absorption coefficient at the wall and $e_{b\lambda}$ is the Planck'sFunction

Introducing the following non-dimensional quantities and parameter

$$\left.\begin{array}{l}
u = \frac{u'}{V_0}, v = \frac{v'}{V_0}, \eta = \frac{V_0 y'}{v}, U_\infty = \frac{U'_\infty}{V_0}, U_P = \frac{u_p'}{V_0}, t = \frac{t'V_0^{\,2}}{v}, \theta = \frac{T' - T'_{\infty m}}{T_w' - T_\infty'}, C = \frac{C' - C'_\infty}{C_w' - C_\infty'}, \\
n = \frac{n'v}{V_0^{\,2}}, K = \frac{K'V_0^{\,2}}{v^2}, \Pr = \frac{\rho C_p}{K}, Sc = \frac{v}{D}, M = \frac{\sigma}{\rho}\frac{B_0^{\,2}v}{V_0^{\,2}}, Kr = \frac{K_c'v}{V_0^{\,2}}, \\
F = \frac{4I_1 v}{\rho C_P V_0^{\,2}}, Gr = \frac{v\beta_T g\left(T_w' - T_\infty'\right)}{V_0^{\,3}}, Gm = \frac{v\beta_C g\left(C_w' - C_\infty'\right)}{V_0^{\,3}}, \varphi = \frac{Q'v}{\rho CpV_0^{\,2}}, \\
Q_1 = \frac{vQ_1'\left(C'_w - C'_\infty\right)}{\rho C_p V_0^2\left(T'_w - T'_\infty\right)}, D_f = \frac{D_m K_T\left(C'_w - C'_\infty\right)}{C_s C_p v\left(T'_w - T'_\infty\right)}
\end{array}\right\} \quad (10)$$

In view equations (7) to (10), using from (2) to (4) are reduced to the following non-dimensional form

$$\frac{\partial u}{\partial t} - \left(1 + \in Ae^{nt}\right)\frac{\partial u}{\partial t} = \frac{dU_\infty}{dt} + \frac{1}{1+\lambda_1}\frac{\partial^2 u}{\partial \eta^2} + Gr\theta + GmC + N\left(U_\infty - u\right) \quad (11)$$

$$\frac{\partial \theta}{\partial t} - \left(1 + \in Ae^{nt}\right)\frac{\partial \theta}{\partial \eta} = \frac{1}{P_r}\frac{\partial^2 \theta}{\partial \eta^2} + D_f\frac{\partial^2 C}{\partial \eta^2} - \chi\theta + Q_1 C \quad (12)$$

$$\frac{\partial C}{\partial t} - \left(1 + \in Ae^{nt}\right)\frac{\partial C}{\partial \eta} = \frac{1}{Sc}\frac{\partial^2 C}{\partial \eta} - K_r C \quad (13)$$

Where $\chi = \phi + F$

The dimensionless from of the boundary conditions are become

$$u = U_p, \theta = 1 + \in e^{nt}, C = 1 + \in e^{nt} \text{ at } \eta = 0 \quad (14)$$

$$u \to U_\infty = 1 + \in e^{nt}, \theta \to 0, C \to 0 \text{ at } \eta \to \infty \quad (15)$$

SOLUTION OF THE PROBLEM

The set of equations (11) to (13) are partial differential equations which cannot be solved in closed form.However, these can be solved by reducing them into a set of ordinary differential equations using the following perturbation technique. We now represent the velocity, temperature and concentration distributions in terms of harmonic and non-harmonic functions as

$$U = u_0(\eta) + \in e^{nt} u_1(\eta) + 0\left(\in^2\right) + ---- \quad (16)$$

$$\theta = \theta_0(\eta) + \in e^{nt} \theta_1(\eta) + 0\left(\in^2\right) + ----- \quad (17)$$

$$C = C_0(\eta) + \in e^{nt} C_1(\eta) + 0\left(\in^2\right) + ----- \quad (18)$$

Substituting equations (16) to (18) into equations (11) to (13) and equating the harmonic and non-harmonic terms, and neglecting the higher order terms of $\in$, we obtain the following pairs of equations of order zero and order one.

$$\frac{d^2u_0}{d\eta^2} + (1+\lambda_1)\frac{du_0}{d\eta} - N(1+\lambda_1)u_0 = -(1+\lambda_1)N - (1+\lambda_1)Gr\theta_0 - (1+\lambda_1)GmC_0 \quad (19)$$

$$\frac{d^2\theta_0}{d\eta^2} + \Pr\frac{d\theta_0}{d\eta} - \Pr\chi\theta_0 = -\Pr D_f \frac{d^2C_0}{d\eta^2} - \Pr Q_1 C_0 \quad (20)$$

$$\frac{d^2C_0}{d\eta^2} + Sc\frac{dC_0}{d\eta} - ScK_r C_0 = 0 \quad (21)$$

$$\frac{d^2u_1}{d\eta^2} + (1+\lambda_1)\frac{du_1}{d\eta} - (1+\lambda_1)(N+n)u_1 = (1+\lambda_1)\left[-(N+n) - A\frac{du_0}{d\eta} - Gr\theta_1 - GmC_1\right] \quad (22)$$

$$\frac{d^2\theta_1}{d\eta^2} + \Pr\frac{d\theta_1}{d\eta} - \Pr(n+\chi)\theta_1 = -D_f \Pr\frac{d^2C_1}{d\eta^2} - A\Pr\frac{d\theta_0}{d\eta} - \Pr Q_1 C_1 \quad (23)$$

$$\frac{d^2C_1}{d\eta^2} + Sc\frac{dC_1}{d\eta} - Sc(Kr+n)C_1 = -ASc\frac{dC_0}{d\eta} \quad (24)$$

The corresponding boundary conditions are

$$u_0 = U_p, u_1 = 0, \theta_0 = 1, \theta_1 = 1 \; C_0 = 1, C_1 = 1 \text{ at } \eta = o \quad (25)$$

$$u_0 \to 1, u_1 \to 1, \theta_0 \to 0, C_0 \to 0, C_1 \to 0 \text{ at } \eta \to \infty \quad (26)$$

Now by using the boundary conditions (25) to (26) and solving the set of equations (19) to (24) we get the following solutions

$$u_0 = 1 + K_5 e^{-m_{10}\eta} + K_4 e^{-m_2\eta} + K_2 e^{-m_6\eta} \quad (27)$$

$$u_1 = 1 + K_{18} e^{-m_{12}\eta} + K_6 e^{-m_{10}\eta} + K_{11} e^{-m_8\eta} + K_{16} e^{-m_6\eta} + K_{17} e^{-m_4\eta} + K_{15} e^{-m_2\eta} \quad (28)$$

$$\theta_0 = (1 - L_4) e^{-m_6\eta} + L_4 e^{-m_2\eta} \quad (29)$$

$$\theta_1 = (1 - L_{13}) e^{-m_8\eta} + L_9 e^{-m_6\eta} + L_{11} e^{-m_4\eta} + L_{12} e^{-m_2\eta} \quad (30)$$

$$C_0 = e^{-m_2\eta} \quad (31)$$

$$C_1 = (1 - L_1) e^{-m_4\eta} + L_1 e^{-m_2\eta} \quad (32)$$

In view of the above solutions, the velocity, temperature and concentration distributions in the boundary layer become

$$\begin{aligned} U(\eta,t) = {} & 1 + K_5 e^{-m_{10}\eta} + K_4 e^{-m_2\eta} + K_2 e^{-m_6\eta} \\ & + \in e^{nt}\left[1 + K_{18} e^{-m_{12}\eta} + K_6 e^{-m_{10}\eta} + K_{11} e^{-m_8\eta} + K_{16} e^{-m_6\eta} + K_{17} e^{-m_4\eta} + K_{15} e^{-m_2\eta}\right] \end{aligned} \quad (33)$$

$$\theta(\eta,t) = (1 - L_4) e^{-m_6\eta} + L_4 e^{-m_2\eta} + \in e^{nt}\left[(1 - L_{13}) e^{-m_8\eta} + L_{11} e^{-m_4\eta} + L_{12} e^{-m_2\eta} + L_8 e^{-m_6\eta}\right] \quad (34)$$

$$C(\eta,t) = e^{-m_2\eta} + \in e^{nt}\left[(1 - L_1) e^{-m_4\eta} + L_1 e^{-m_2\eta}\right] \quad (35)$$

SKIN FRICTION

Very important physical quantity at the boundary is the skin function which is given in the non-dimensional form and derives as $\eta = 0$

$$C_f = \frac{\tau_w'}{\rho U_0 V_0} = \left.\frac{\partial u}{\partial \eta}\right|_{\eta=0} \quad (36)$$

$$C_f = (-m_{10}K_5 - m_2K_4 - m_6K_2) + \in e^{nt}\left[-m_{12}K_{18} - m_{10}K_6 - m_8K_{11} - m_6K_{16} - m_4K_{17} - m_2K_{15}\right]$$

NUSSELT NUMBER

The rate of heat transfer in the form of **Nusselt number**is given by

$$N_u = \frac{x \left.\dfrac{\partial T'}{\partial y'}\right|_{y=0}}{T_w' - T_\infty'}$$

$$N_u \operatorname{Re}_x^{-1} = \left.\frac{\partial \theta}{\partial \eta}\right|_{\eta=0}$$

$$N_U \operatorname{Re}_x^{-1} = -m_6\left(1-L_4\right) - m_2 L_4 + \in e^{nt}\left[-m_8\left(1-L_3\right) - m_4 L_{11} - m_2 L_{12} - m_6 L_8\right] (37)$$

SHERWOOD NUMBER

The rate of mass transfer in the form of **Sherwood number**is given by

$$S_h = x \frac{x \left.\frac{\partial C'}{\partial y'}\right|_{y=0}}{C_w' - C_\infty'}$$

$$\left.\frac{\partial C}{\partial \eta}\right|_{\eta=0} = -m_2 + \in e^{nt}\left[-m_4\left(1-L_1\right) - m_2 L_1\right] \; (38)$$

RESULT AND DISCUSSION

Velocity Profiles-I

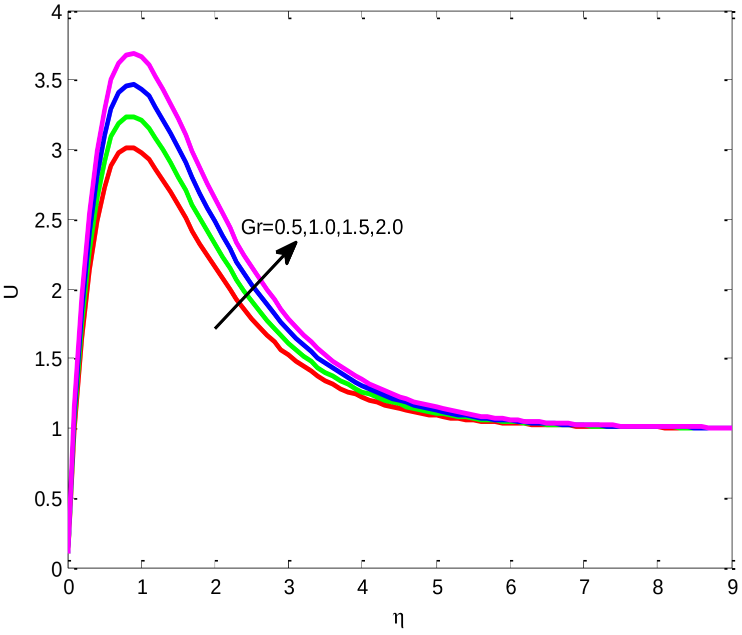

Figure 1. The velocity profile (U) for different values of Grashof number (Gr).

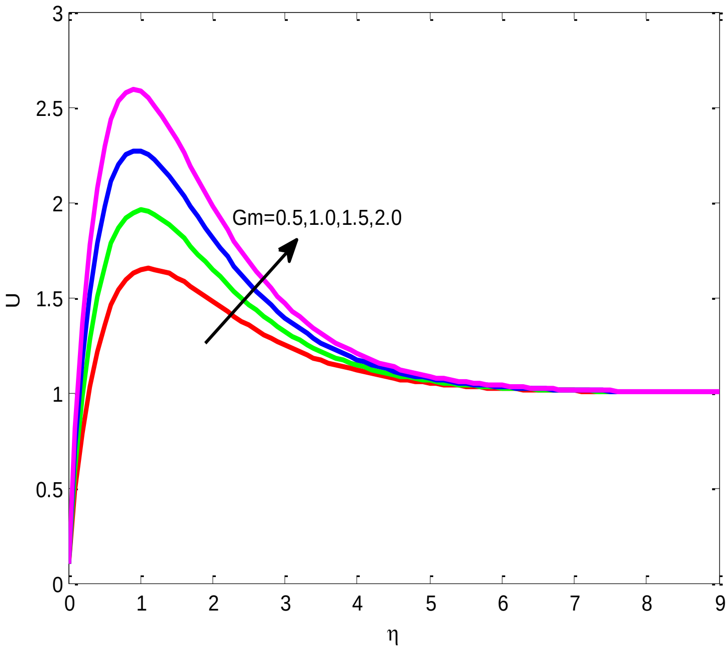

Figure 2. The velocity profile (U) for different values of modified Grashof number (Gm).

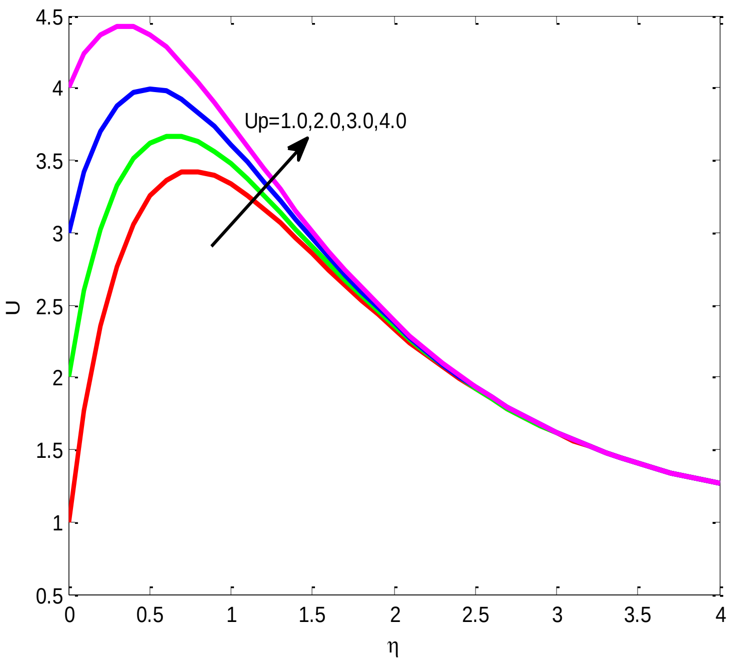

Figure 3. The velocity profile (U) for different values of moving velocity of the plate (U_p).

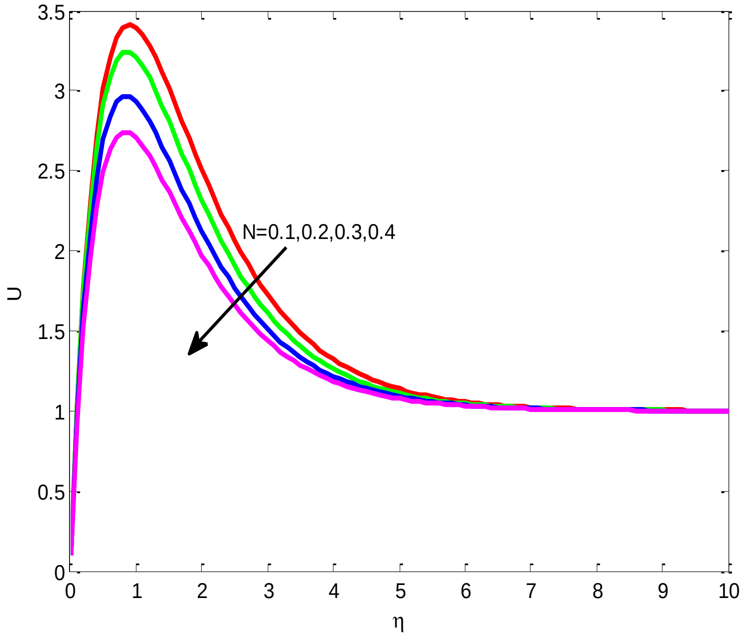

Figure 4. The velocity profile (U) for different values of Dimension less exponential index (N).

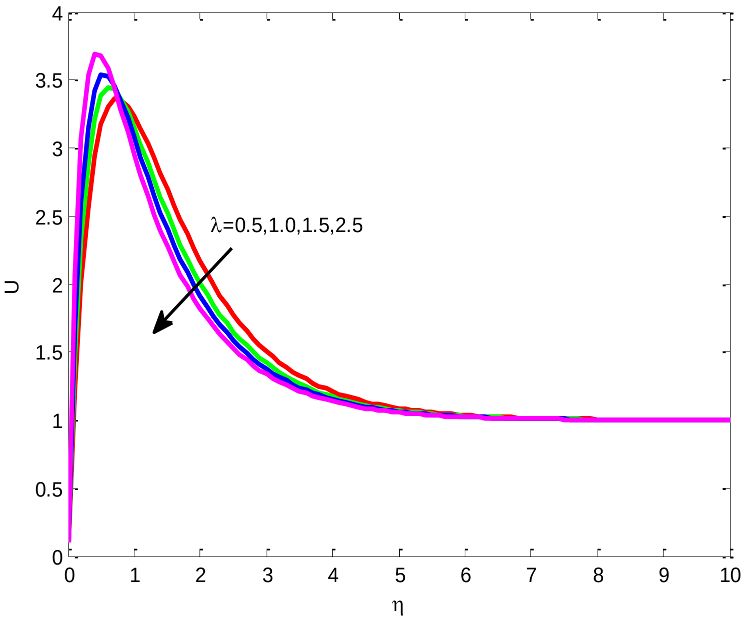

Figure 5. The velocity profile (U) for different values of Jeffrey parameter (λ).

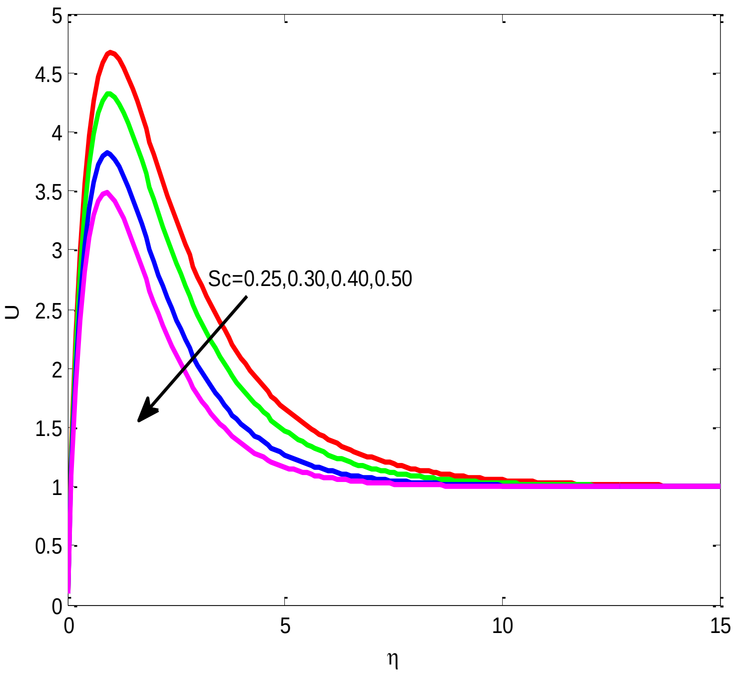

Figure 6. The velocity profile (U) for different values of Schmidt number (Sc).

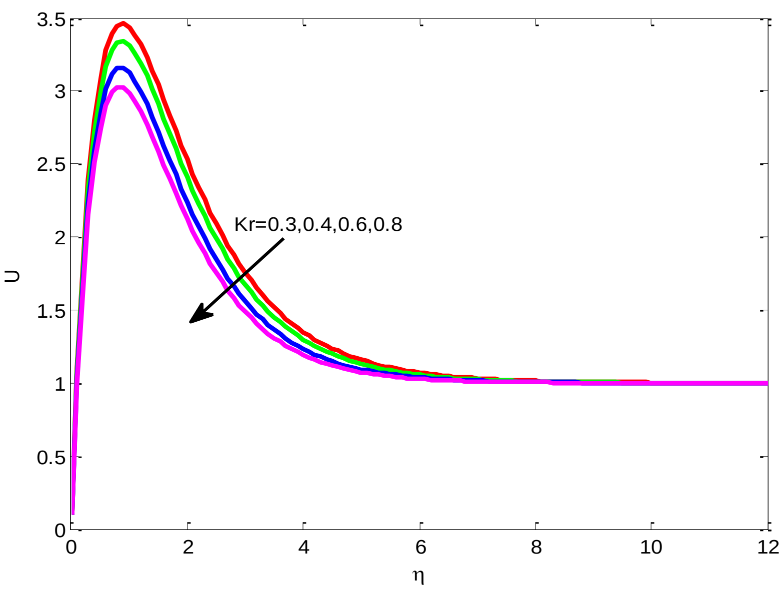

Figure 7. The velocity profile (U) for different values of Chemical reaction parameter (Kr).

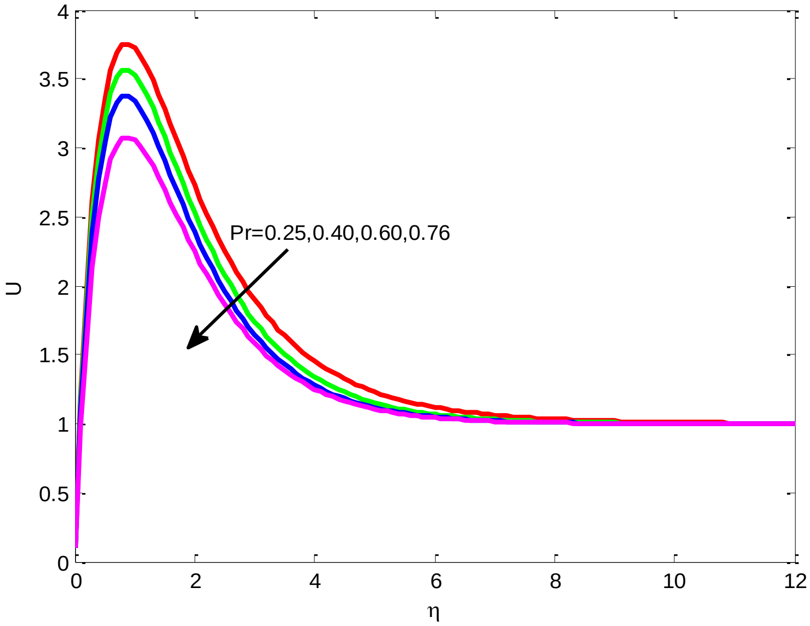

Figure 8. The velocity profile (U) for different values of Prandtl number (Pr).

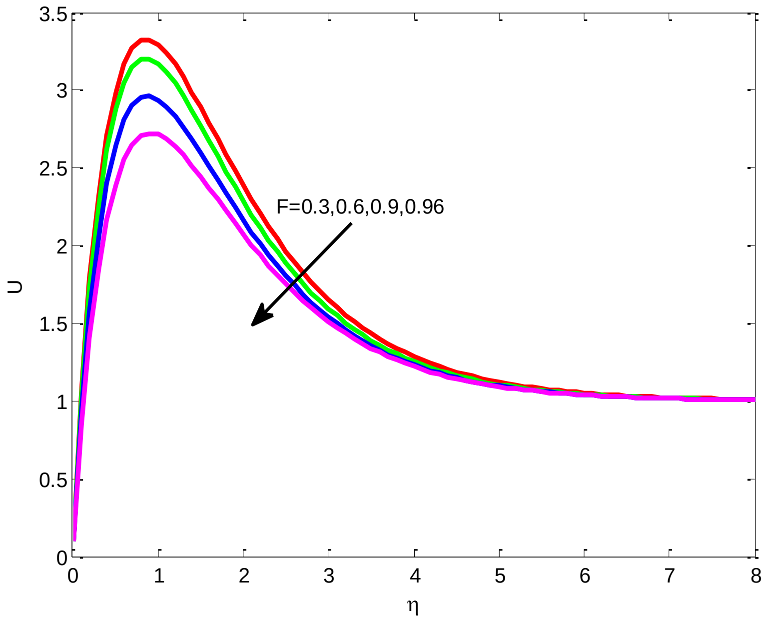

Figure 9. The velocity profile (U) for different values of Radiation parameter (F).

Fig 1.representthe variation in velocity profile for different values of Grashof number (Gr), it is seen that velocity increases with increasing values of (Gr). **Fig 2.** shows that the fluid velocity profile for different values of modified Grashof number (Gm), it is seen that velocity increases with growing values of (Gm). **Fig 3.**indicates that a rise in (U_p) for different values of moving velocity of plate increasing the velocity of (U_p). **Fig 4.**illustrates the influence of Dimensionless exponential index (N) on the velocity decreases with rising of (N). **Fig 5.** represent the variations in velocity distribution for different values of Jeffrey parameter (λ_1), it is seen that velocity increases with the lessening values of (λ_1).**Fig 6.**Shows that the velocity profile for different values of Schmidt number (Sc), here we observe that the velocity increases with a decreasing of (Sc).**Fig 7.** Indicates that the velocity profile for different value of chemical reaction parameter (Kr), it is observed that the velocity decreases with increasing of (Kr). **Fig 8**. Illustrates the influence of Prandtl number $(\Pr)$, here that the velocity decreases with an increasing of $(\Pr)$.**Fig 9.** Shows the velocity profile for different value of Radiation parameter (F), we observed that the velocity is decreases with a growing of (F).

Temperature Profiles - II

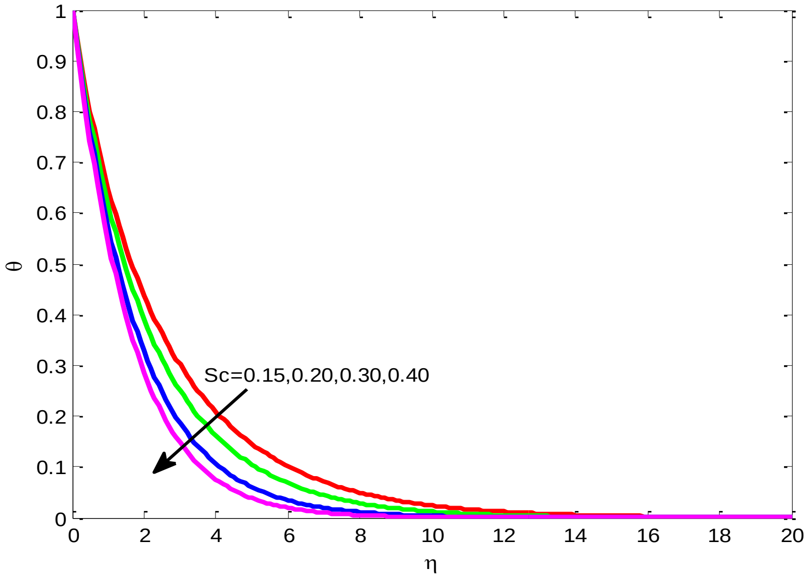

Figure 10. The temperature profile (θ) for different values of Schmidt number (Sc).

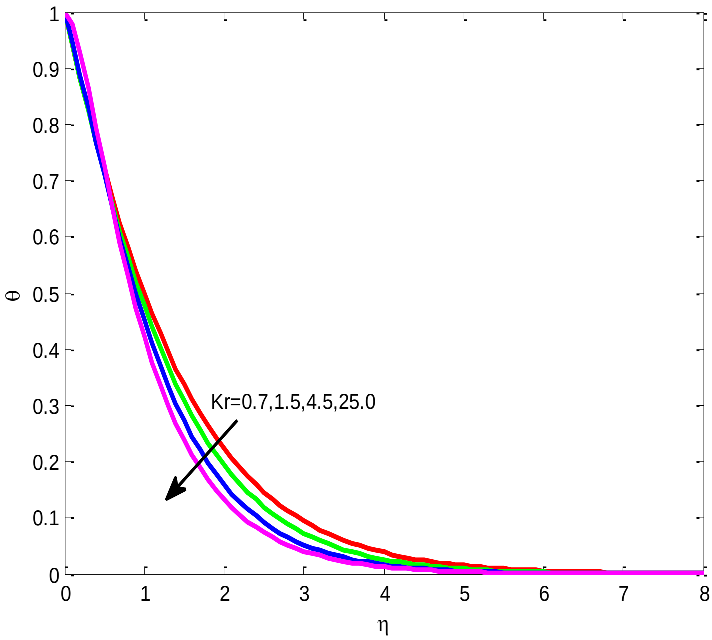

Figure 11. The temperature profile (θ) for different values of Chemical reaction parameter (Kr).

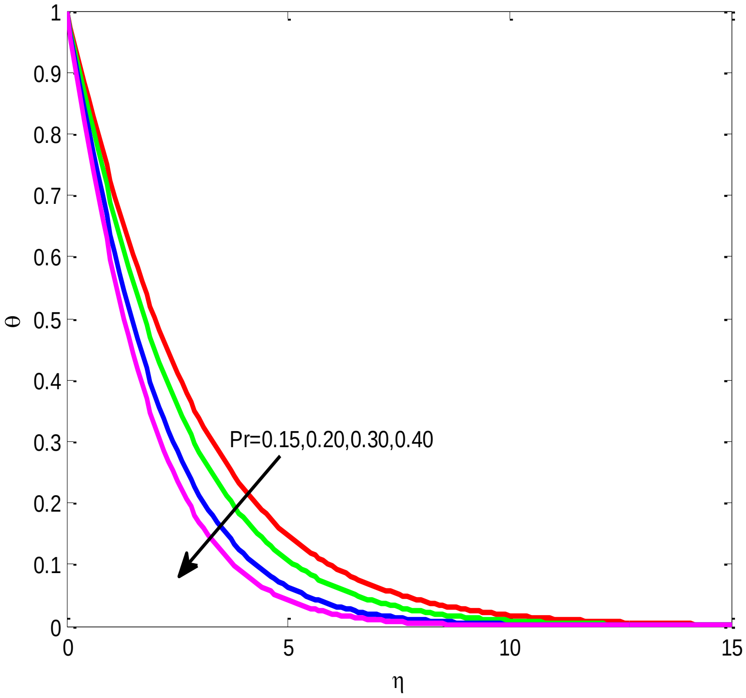

Figure 12. The temperature profile (θ) for different values of Prandtl number $(\Pr)$.

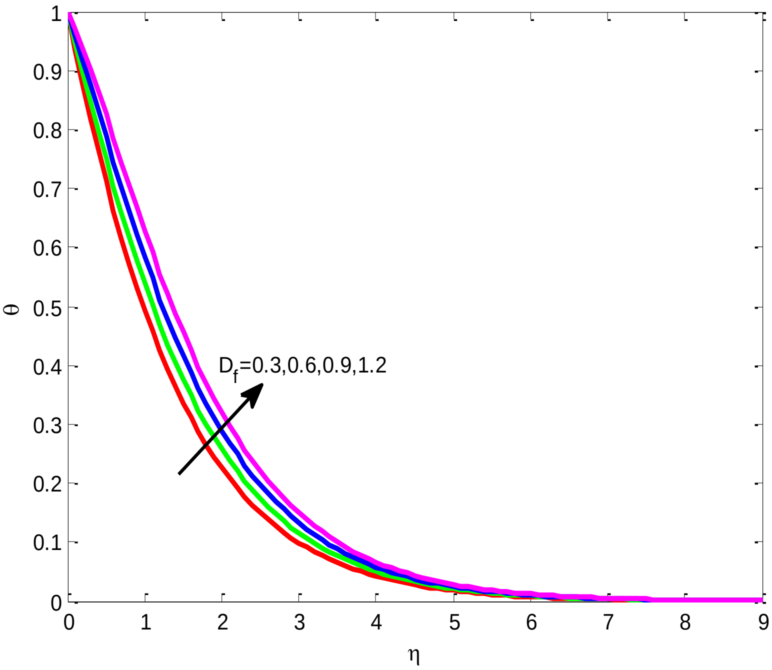

Figure 13. The temperature profile (θ) for different values of Dufour Parameter $\left(D_f\right)$.

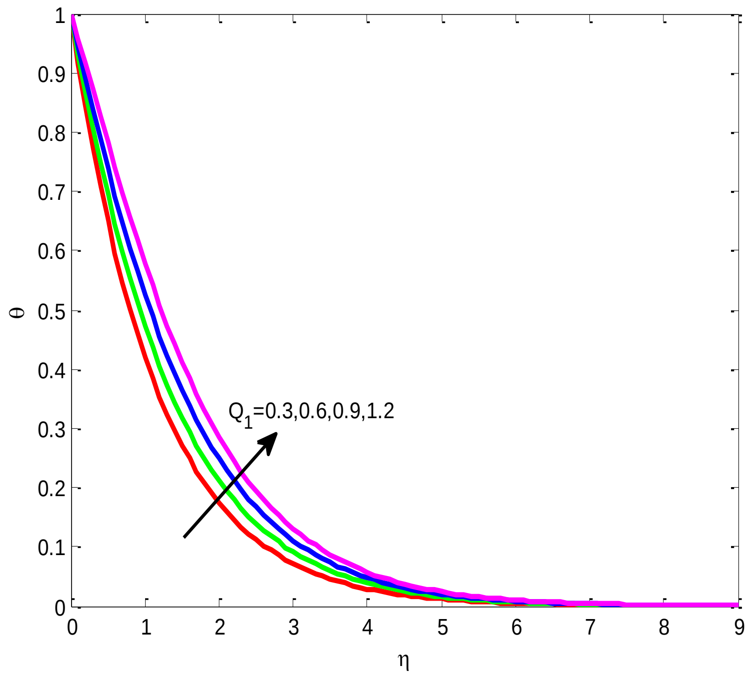

Figure 14. The temperature profile (θ) for different values of absorption of radiation parameter (Q_1).

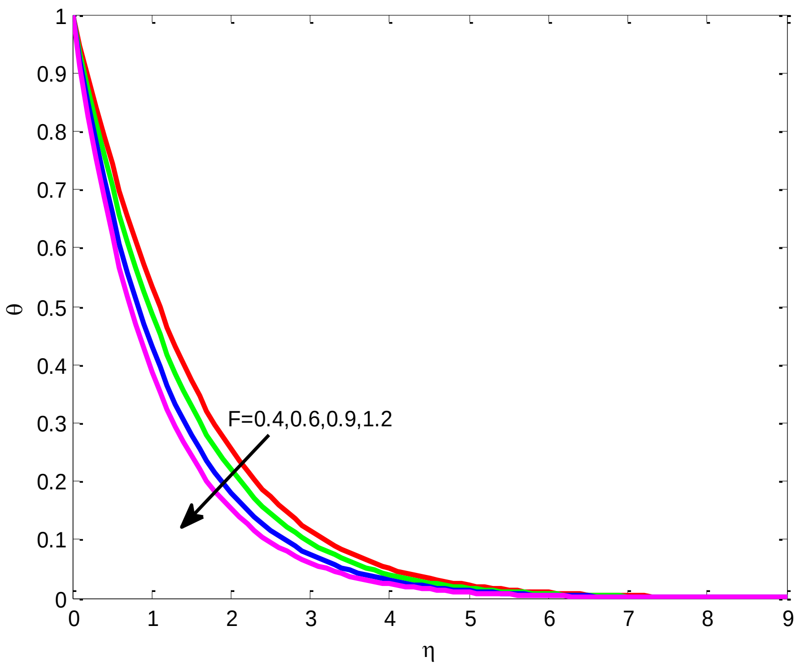

Figure 15. The temperature profile (θ) for different values of Radiation parameter (F).

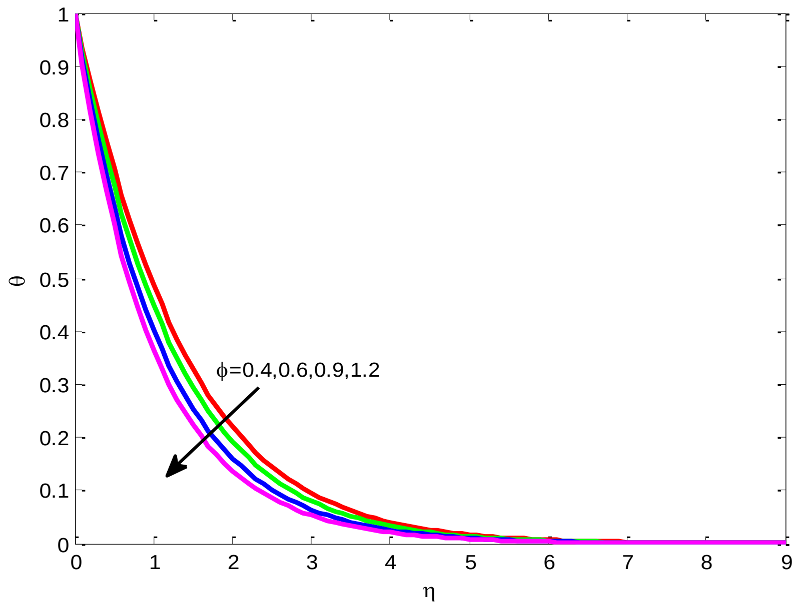

Figure 16. The temperature profile (θ) for different values of Heat absorption coefficient (ϕ).

Fig 10. indicates that the temperature profile for different values of Schmidt number (Sc), it can be found from Fig.10.the Solutal boundary layer thickness of the fluid decreases with the diminishing of (Sc). **Fig 11.**represent the variations in temperature profile for different value of chemical reaction parameter (Kr), here we observe that the temperature decreases with a growing of (Kr).**Fig 12.**shows that the temperature profile for different values of Prandtl number (Pr), here we observe that the temperature decreases with a rising of (Pr). **Fig 13.** represent the variations in temperature distribution for different values of Dufour parameter (D_f), it is seen that temperature increases with the increasing values of (D_f). **Fig 14.**illustrates the influence of absorption of Radiation parameter (Q_1) on the temperature; it is observed that the temperature increases with increasing of (Q_1). **Fig 15.**indicates that a rise in (F) substantially reduces the temperature in the viscous fluid, here we observed decreases with the increasing (F). **Fig 16**. illustrates the influence of heat absorption coefficient (ϕ) on the velocity. From this figure, it is observed that the velocity decreases with increasing of (ϕ).

Concentration Profiles - III

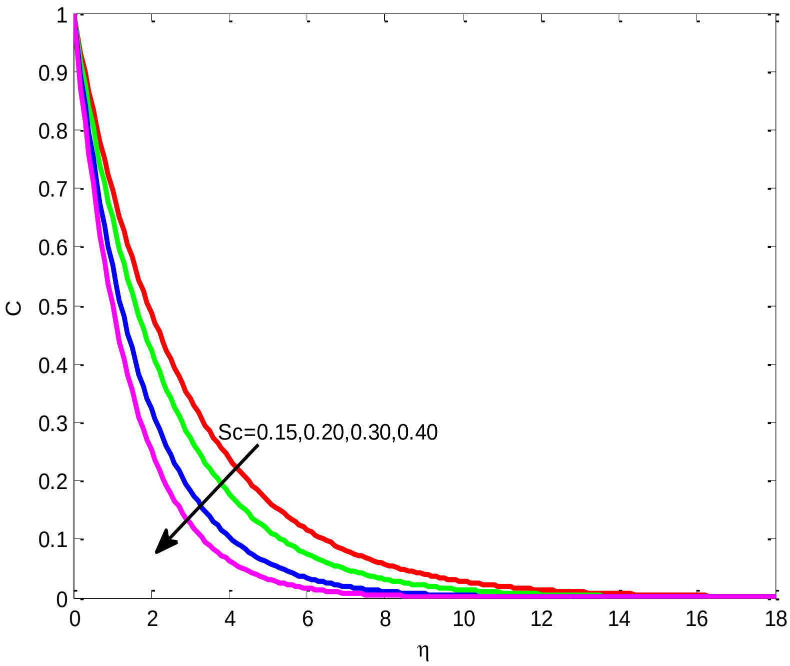

Figure 17. The concentration profile (C) for different values of Schmidt number (Sc).

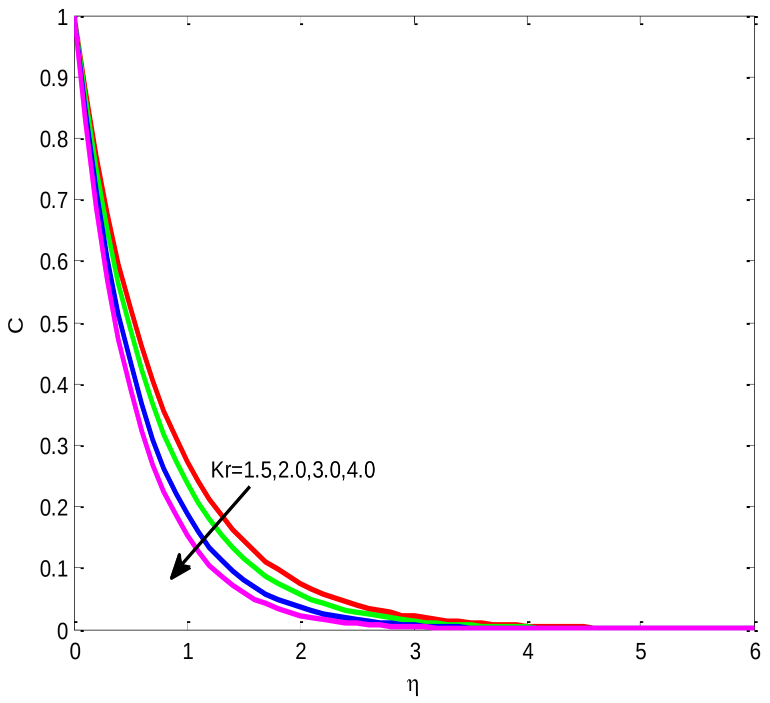

Figure 18. The concentration profile (C) for different values of Chemical reaction parameter (Kr).

Fig 17.shows that the concentration profile for different values of Schmidt number (Sc), here we observe that the concentration decreases with an increasing of (Sc). **Fig 18.**illustrates the influence of chemical reaction parameter (Kr). From this figure it is observed that decreases with the increasing of (Kr)

CONCLUSIONS

Heat and Mass Transfer on an unsteady MHD flow of Jeffery fluid over a Radiating aligned permeable moving plate embedded in a porous medium influence of the Dufour effect and Heat Source/Sink. The above surveys of conclusions are follows.

a) Velocity distribution is observe to increases with increasing in the Grashof number, modified Grashof number, moving velocity of the plate, where as it shows reverse effect in the case of Dimensionless exponential index, Jeffrey parameter, Schmidt number, Chemical reaction parameter, Prandtl number, Radiation parameter with increasing.

b) Temperature distribution increases with an increasing in the Dufour parameter, absorption of the radiation parameter, where as it shows reverse effect in the case of the Schmidt number, Chemical reaction parameter, Prandtl number, Radiation parameter, Heat absorption coefficient with increasing.

c) Concentration distribution decreases as Schmidt number, Chemical reaction parameter is increasing.

NOMENCLATURE

A - Amplitude of suction velocity

B_0 - Magnetic field strength

C - Concentration

C_p - Specific heat at constant pressure

C_f -Skin friction coefficient

D - Mass diffusion coefficient

D - Molecular diffusivity

D_1 -Thermal diffusion coefficient

D_f -Dufour parameter

$e_{b\lambda}$ -Plank's function

F -Radiation parameter

G -Acceleration due to gravity

Gr -Thermal Grashof number

Gm - Solutal Grashof number

K' -Permeability of the porous medium

Kr -Chemical reaction parameter

$K_{\lambda w}$ -Absorption coefficient

M -Magnetic field parameter

N -Dimension less material parameter

N -Dimension less exponential index

Nu -Nusselt number

$\Pr$ -Prandtl number

Q_0 -Heat absorption coefficient

Q_1 - Absorption of radiation parameter

Re_x -Local Reynolds number

Sc -Schmidt number

λ_1 -Jeffrey parameter

S_0 -Soret Number

β_c -Coefficient of volumetric concentration expansion

β_T -Coefficient of volumetric thermal expansion

S_h -Sherwood number

T -Temperature

t -Dimensional time

t - Dimension less time

U_0 -Scale of free stream velocity

u', v' -Dimensional velocity components

u, v -Velocity components

V_0 -Scale of suction velocity

x, y - Distance along and perpendicular to the plate respectively

Greek Symbols

χ -Dimensional less material parameter

α -Aligned angle parameter

$\in$ -Scalar constant

φ -Dimensionless heat absorption coefficient

k -Thermal conductivity

σ -Electrical conductivity

ρ - Density of the fluid

μ -Dynamic viscosity

ν -Kinematic viscosity

τ -Skin friction coefficient

η -Dimensionless normal distance

β_c -Coefficient of volumetric concentration expansion

β_T -Coefficient of volumetric thermal expansion

Subscripts and Superscripts

$'$ - Dimensional properties

P -Plate

W -Wall condition

∞ -Free stream condition

K_c -Dimensionless Chemical reaction parameter

U_p -Moving velocity of the plate

u_p' -Moving plate velocity

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All Roots

$$m_1=\frac{-Sc+\sqrt{Sc^2+4K_rSc}}{2},\ m_2=\frac{Sc+\sqrt{Sc^2+4K_rSc}}{2},\ m_3=\frac{-Sc+\sqrt{Sc^2+4Sc\left(K_r+n\right)}}{2}$$

$$m_4=\frac{Sc+\sqrt{Sc^2+4Sc\left(K_r+n\right)}}{2},\ m_5=\frac{-\Pr+\sqrt{\Pr^2+4\Pr\chi}}{2},\ m_6=\frac{\Pr+\sqrt{\Pr^2+4\Pr\chi}}{2}$$

$$m_7=\frac{-\Pr-\sqrt{\Pr^2+4\Pr\left(n+\chi\right)}}{2},\ m_8=\frac{\Pr+\sqrt{\Pr^2+4\Pr\left(n+\chi\right)}}{2}\ m_9=\frac{-\left(1+\lambda_1\right)+\sqrt{\left(1+\lambda_1\right)^2+4N\left(1+\lambda_1\right)}}{2},$$

$$m_{10}=\frac{\left(1+\lambda_1\right)+\sqrt{\left(1+\lambda_1\right)^2+4N\left(1+\lambda_1\right)}}{2}\ m_{11}=\frac{-\left(1+\lambda_1\right)+\sqrt{\left(1+\lambda_1\right)^2+4\left(N+n\right)\left(1+\lambda_1\right)}}{2},$$

$$m_{12}=\frac{\left(1+\lambda_1\right)+\sqrt{\left(1+\lambda_1\right)^2+4\left(N+n\right)\left(1+\lambda_1\right)}}{2}\ L_1=\frac{AScm_2}{m_2^2-Scm_2-Sc\left(n+K_r\right)},\ L_2=\frac{-D_f\Pr m_2{}^2}{m_2^2-\Pr m_2-\Pr\chi},$$

$$L_3=\frac{-Q_1\Pr}{m_2^2-\Pr m_2-\Pr\chi},\ L_4=L_2+L_3$$

$$L_5=\frac{-\Pr D_f m_4^2\left(1-L_1\right)}{m_4^2-\Pr m_4-\Pr\left(n+\chi\right)},\ L_6=\frac{-\Pr D_f m_2^2 L_1}{m_2^2-\Pr m_2-\Pr\left(n+\chi\right)},\ L_7=\frac{-\Pr Q_1\left(1-L_1\right)}{m_4^2-\Pr m_4-\Pr\left(n+\chi\right)},$$

$$L_8=\frac{-\Pr Q_1 L_1}{m_2^2-\Pr m_4-\Pr\left(n+\chi\right)},\ L_9=\frac{A\Pr m_6\left(1-L_4\right)}{m_6^2-\Pr m_6-\Pr\left(n+\chi\right)},\ L_{10}=\frac{A\Pr m_2 L_4}{m_2^2-\Pr m_2-\Pr\left(n+\chi\right)},$$

$$K_1=\frac{-\left(1+\lambda_1\right)GrL_4}{m_2^2-\left(1+\lambda_1\right)m_2-N\left(1+\lambda_1\right)},\ K_2=\frac{-\left(1+\lambda_1\right)Gr\left(1-L_4\right)}{m_6^2-\left(1+\lambda_1\right)m_6-N\left(1+\lambda_1\right)},\ K_3=\frac{-\left(1+\lambda_1\right)Gm\left(1-L_4\right)}{m_2^2-\left(1+\lambda_1\right)m_2-N\left(1+\lambda_1\right)},$$

$$K_6=\frac{\left(1+\lambda_1\right)Am_{10}K_5}{m_{10}^2-\left(1+\lambda_1\right)m_{10}-\left(N+n\right)\left(1+\lambda_1\right)},\ K_7=\frac{\left(1+\lambda_1\right)Am_2K_4}{m_2^2-\left(1+\lambda_1\right)m_2-\left(N+n\right)\left(1+\lambda_1\right)},$$

$$K_8=\frac{\left(1+\lambda_1\right)Am_6K_2}{m_6^2-\left(1+\lambda_1\right)m_6-\left(N+n\right)\left(1+\lambda_1\right)}\ K_9=\frac{-\left(1+\lambda_1\right)GrL_{12}}{m_2^2-\left(1+\lambda_1\right)m_2-\left(N+n\right)\left(1+\lambda_1\right)},$$

$$K_{10}=\frac{-\left(1+\lambda_1\right)GrL_{11}}{m_4^2-\left(1+\lambda_1\right)m_4-\left(N+n\right)\left(1+\lambda_1\right)}\ K_{11}=\frac{-\left(1+\lambda_1\right)Gr\left(1-L_{13}\right)}{m_8^2-\left(1+\lambda_1\right)m_8-\left(N+n\right)\left(1+\lambda_1\right)},$$

$$K_{12}=\frac{-\left(1+\lambda_1\right)GrL_8}{m_6^2-\left(1+\lambda_1\right)m_6-\left(N+n\right)\left(1+\lambda_1\right)}\ K_{13}=\frac{-\left(1+\lambda_1\right)Gm\left(1-L_1\right)}{m_4^2-\left(1+\lambda_1\right)m_4-\left(N+n\right)\left(1+\lambda_1\right)},$$

$$K_{14}=\frac{-\left(1+\lambda_1\right)GmL_1}{m_2^2-\left(1+\lambda_1\right)m_2-\left(N+n\right)\left(1+\lambda_1\right)},\ K_4=K_1+K_3,\ K_5=U_p-\left(1+K_2+K_4\right),K_{15}=K_7+K_9+K_{14},$$

$$K_{16}=K_8+K_{12},K_{17}=K_{10}+K_{13}\ K_{18}=-\left(1+K_6+K_{15}+K_{16}+K_{17}+K_{11}\right)$$