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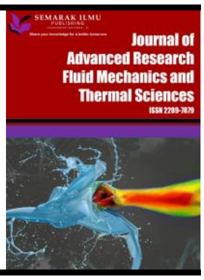

Heat and Mass Transfer on Unsteady MHD Chemically Reacting Rotating Flow of Jeffrey Fluid Past an Inclined Plates under the Impact of Hall Current, Diffusion Thermo and Radiation Absorption

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ABSTRACT

An analytical solution for two dimensional unsteady MHD free convective double diffusive heat and mass transfer rotating flow of viscous incompressible optically thin non Newtonian fluid (Jeffrey fluid) past a semi-infinite porous plate in the presence of generation of heat absorption with hall current, radiation absorption and Dufour effects are presented in this paper. Lorentz force is applied perpendicular direction to the plate with a first-order chemical reaction. The governing PDEs transformed into ODEs by applying the perturbation technique. The effects of various physical parameters like Hall current, heat absorption, radiation parameter, radiation absorption parameter, Grashof number, modified Grashof number, Dufour effect, magnetic field parameter, inclined angle, chemical reaction parameter, etc., are studied with graphically. Temperature profile is increased by raising the values of Dufour effect, radiation absorption parameter and reverse effect of the heat absorption parameter and also concentration profile distribution is downfall by raising the values of Schmited number, chemical reaction parameter. Another significant finding of the current study is that the numerical data are displayed with the use of Matlab programmes to investigate the outcomes of the skin friction solution. the rate of heat and mass transfer at the wall rising under the influence of Dufour effect. Tables, graphs, and reports can be used to display the impact of all pertinent parameters.

1. Introduction

Considerable progress has been made in studying flows of non-Newtonian fluids throughout the last few decades. Due to their viscoelastic nature non-Newtonian fluids, such as oils, paints, ketchup, liquid polymers and asphalt exhibit some remarkable phenomena. Amplifying interest of many researchers has shown that these flows are imperative in industry, manufacturing of food and paper,

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polymer processing and technology. Dissimilar to the Newtonian fluid, the flows of non-Newtonian fluids cannot be explained by a single constitutive model. In general, the rheological properties of fluids are specified by their so-called constitutive equations. Exact recent solutions for constitutive equations of viscoelastic fluids are given by Rajagopal and Bhatnagar [1], Tan and Masuoka [2,3], Khadrawi *et al.,* [4] and Chen *et al.,* [5] etc. Among non-Newtonian fluids the Jeffrey model is considered to be one of the simplest types of models which best explain the rheological effects of viscoelastic fluids. The Jeffrey model is a relatively simple linear model using the time derivatives instead of convected derivatives. Nadeem *et al.,* [6] obtained analytic solutions for stagnation flow of Jeffrey fluid over a shrinking sheet. Khan [7] investigated partial slip effects on the oscillatory flows of fractional Jeffrey fluid in a porous medium.

Hall current is the output of the difference in voltage through an electrical conductor, transverse to the conductor's electrical current, and a magnetic field normal to the current. When the magnetic field is very high, the influence of hall current is extremely crucial. When the magnetic field is highly powerful, it reduces the electrical conductivity of a fluid, so to improve the electrical conductivity of fluid it is required to produce a current in a path which is normal to both x and y directions, i.e., in the z-direction, this current is called hall current. Kumar *et al.,* [8] was deliberated their idea about an unsteady MHD with possible effects of hall current on an instantaneously movable vertical plate with some other effects. Raghunath and Mohanaramana [9] have investigated Hall, Soret, and rotational effects on unsteady MHD rotating flow of a second-grade fluid through a porous medium in the presence of chemical reaction and aligned magnetic field. Kodi *et al.,* [10] have analyzed Hall and ion slip radiative flow of chemically reactive second grade through porous saturated space via perturbation approach. Raghunath *et al.,* [11] have discussed Effects of Soret, Rotation, Hall, and Ion Slip on Unsteady MHD Flow of a Jeffrey Fluid through a Porous Medium in The Presence of Heat Absorption and Chemical Reaction.

Nowadays, so many professionals are paying close attention to the characteristics of the fluid flows. It is quite useful, in various technical and medical fields. Specifically, more interest is bestowing on MHD flow due to the functionalities in an assortment of fluid flows. Some of functionalities are: in Metrology, Solar Physics etc. Later on, there are numerous advancements of MHD flow have been allowed to develop in different industrial fields. Kumaresan and Kumar [12] conducted a numerical literature review of Walter’s liquid-B model MHD flow with the presence of species diffusion and uniform temperature on a plate. Thermophoretic MHD Flow has been thoroughly addressed by Jain and Choudhary [13] with the effects of Soret and Dufour and adopting heat transfer mechanism by considering chemical reaction through a non linear stretching sheet. Prabhakar and Sademaki [14] quantitatively investigated on MHD Casson flow under the influence of Newtonian heating via porous plate that oscillates vertically.

MHD including heat absorption has also provoked the special interest for many engineers and academics due to its involvement in a wide collection of applications in both nature and industry related to fluid flows. Kabir and Al Mahbub [15] have provided a conceptual point stated comment on Thermophoresis impact on MHD free with heat generation by applying a magnetic field. Sinha and Mahanta [16] have been bestowed the investigation on parametric study on MHD unsteady flow with mass and heat transfer. Subhakar *et al.,* [17] investigation went by pertaining Heat generation on MHD flow in stationary ambient fluid on a movable non-isothermal plate in vertical position. Steady MHD flow with radiation occurrence and including the heat source influence on a porous medium had explicated by Sandhya *et al.,* [18]. Das *et al.,* [19] have endeavored to observe the various effects like chemical reaction, heat absorption and thermal radiation on Casson fluid. Kumaresan and Kumar [20] briefly exhibited the thermal radiation existence on MHD visco elastic fluid including species concentration.

The Dufour effect is the term used to describe a heat flux that results from a chemical potential gradient. Research on this phenomenon in gases has been comprehensive. Nevertheless, to a certain extent because of the relatively smallness of the effect, precise measurements of the Dufour effect in liquids have only in recent times been carried out. Dagana and Amos [21] sought to offer several findings on MHD free flow with dufour effect as well as chemical reaction impacts. The research of Podder and Samad [22] has been extended to investigate Dufour effect on Non-Newtonian fluid on a constantly moving sheet containing homogeneous surface temperature. Srinivasacharya and Reddy [23] presented a motivational work on mixed convection with dufour effect and variable wall temperature in power-law fluid. Jha and Sarki [24] has been given some compressive study on Dufour effects in a fluid flow on a porous plate.

Combined heat and mass transfer problems with chemical reaction are of importance in many processes and have, therefore received a considerable amount of attention in recent years. In processes such as drying, evaporation at the surface of a water body, energy transfer in a wet cooling tower and the flow in a desert cooler heat and the mass transfer occur simultaneously. Possible application if this type of flow can be found in many industries. For example, in the power industry among the methods of generation electric power is one in which electrical energy is extracted directly form a moving conducting fluid. Many practical diffusive operations involve the molecular diffusion of a species in the presence of chemical reaction within or at the boundary. There are two types of reactions. A homogeneous reaction is one that occurs uniformly throughout a give phase. The species generation in a homogeneous reaction is analogous to internal source of heat generation. In constraint a heterogeneous reaction takes place in a restricted region or within the boundary of a phase. It can therefore be treated as a boundary condition similar to the constant heat flux condition in heat transfer the study of heat and mass transfer with chemical reaction is of great practical importance to engineers and scientists because of its almost universal occurrence in many branches of science and engineering. Recently, Kodi and Mopuri [25] and Kodi *et al.,* [26] studied the chemical reaction effects on dissimilar flow geometries. Vaddemani *et al.,* [27] have discussed effects of Soret on unsteady free convection flow of viscous incompressible fluid through a porous medium with high porosity bounded by a vertical infinite moving plate under the influence of thermal diffusion, chemical reaction, and heat source. Very recently Mohanaramana *et al.,* [28] studied Chemical reaction with aligned magnetic field effects on unsteady MHD Kuvshinski fluid flow past an inclined porous plate in the presence of radiation and Soret effects.

In all the above studies heat and radiation absorption effect is not considered in the presence of Magnetic field and Chemical reaction as well as diffusion thermo effect. Hence an attempt has been made in this paper to address the issues related to Hall current, radiation absorption effect and Dufour effect in the presence of magnetic field and chemical reaction as well as heat source. This problem is an extension work to the paper of Raghunath and Mohanaramana [9] by considering MHD free convection from a semi-infinite vertical porous plate with Hall current and thin radiative jeffrey fluid, in which radiation and heat absorption is not studied. A regular perturbation technique is used to solve the governing equations. The effects of emerging parameters are studying through graphs and tables.

2. Derivation of the Problem

Consider an unsteady MHD free convective flow of a viscous incompressible and electrically conducting fluid past an infinite inclined porous plate with time-dependent variable plate velocity, heat and mass transfer in a saturated porous medium. The x^* - axis is taken along the leading edge of an inclined plate with an angle of inclination α to the vertical direction. The y^* - axis is taken normal to the plate. Initially, both the fluid and the plate were at rest with constant temperature T_∞ and constant concentration C_∞.

The plate temperature and mass diffusion from the plate into the fluid are increased linearly with reference to time. A uniform magnetic field of strength B_0 is applied transversely to the plate along the y*- direction (Figure 1).

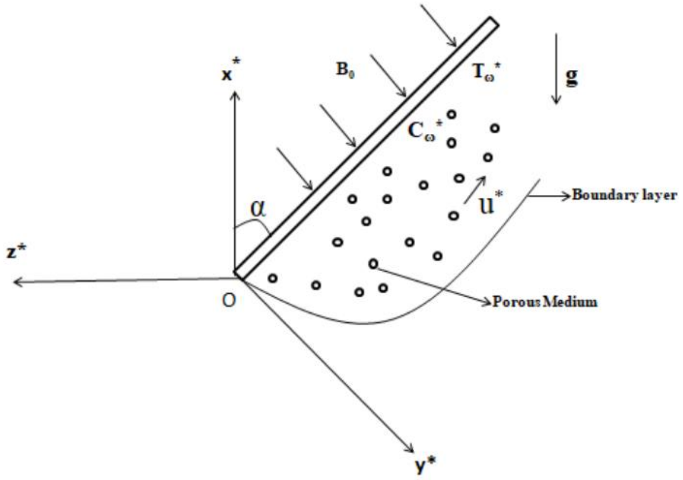


Fig. 1. The geometry of the problem

The Reynolds number is assumed to be very small which corresponds to a negligible induced magnetic field when compared to the externally applied force, and hence B = (0, B_0, 0) is the total magnetic field acting on the fluid. Further, it is considered that the viscous dissipation of energy is negligible and that the fluid is an optically thin gray radiating but non scattering medium. All the fluid properties are supposed to be of a fixed value except the density in the buoyancy force term. In view of the above assumptions, the usual Boussinesq approximation, the governing equations considered are as follows:

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

$$\frac{\partial u}{\partial t}+w\frac{\partial u}{\partial z}-2\Omega v=\mu\left(\frac{1}{1+\beta}\right)\frac{\partial^2 u}{\partial z^2}+\frac{B_0 J_y}{\rho}+g\beta(T-T_\infty)Cos\alpha+ g\beta^*(C-C_\infty)Cos\alpha-\frac{v}{k}u \tag{2}$$

$$\frac{\partial v}{\partial t}+w\frac{\partial v}{\partial z}+2\Omega u=\mu\left(\frac{1}{1+\beta}\right)\frac{\partial^2 v}{\partial z^2}-\frac{B_0 J_x}{\rho}-\frac{v}{k}v \tag{3}$$

$$\frac{\partial T}{\partial t}+w\frac{\partial T}{\partial z}=\frac{k_1}{\rho C_p}\frac{\partial^2 T}{\partial z^2}-\frac{Q_0}{\rho C_p}(T-T_\infty)+Q_1(C-C_\infty)+\frac{DK_T}{C_s C_p}\frac{\partial^2 C}{\partial z^2} \tag{4}$$

$$\frac{\partial C}{\partial t}+w\frac{\partial C}{\partial z}=D\frac{\partial^2 C}{\partial z^2}-K_c(C-C_\infty) \tag{5}$$

The proper boundary conditions are provided by under the aforementioned presumptions in the case of velocity distributions, thermodynamics and intensity

$$u^*=U_0,\quad v=0,\ T=T_w+\varepsilon(T_w-T_\infty)e^{iwt},\ C=C_w+\varepsilon(C_w-C_\infty)e^{iwt}\ \text{ at } z=0 \tag{6}$$

$$u\to U_\infty,\quad v\to 0,\quad T\to T_\infty \qquad C\to C_\infty \qquad \text{as} \quad z\to\infty \tag{7}$$

We suppose that since the equation for continuity shows that wi was either a constant or a time related function,

$$w = - w_0 (1+ A\, \varepsilon\, e^{nt}) \tag{8}$$

where A is a constant that is actually positive, ε and $A\varepsilon$ are more petite than conformity, w_0 balance of the suction speed with a non-zero optimistic consistent. Suppose the magnetic domain has enormous strength. In that case, the exhaustive Ohms condition is unique to incorporate the Hall currents. Hall currents being assumed, the generalized Ohm's law can be expressed as follows [29].

$$J+\frac{\omega_e\tau_e}{B_0}\left(J\times B\right)=\sigma\left[\frac{1}{e\eta_e}\nabla P_e+\left(E+V\times B\right)\right] \tag{9}$$

Furthermore, we presume that the electric field E=0 under suppositions diminishes to

$$mJ_y+J_x=\sigma B_0\, v \tag{10}$$

$$-mJ_x+J_y=-\sigma B_0 u \tag{11}$$

On solving above Eq. (10) and Eq. (11), we get

$$J_x=\frac{\sigma B_0}{1+m^2}\left(mu+v\right) \tag{12}$$

$$J_y=\frac{\sigma B_0}{1+m^2}\left(mv-u\right) \tag{13}$$

Substituting the Eq. (11) and Eq. (13) in Eq. (2) and Eq. (3) respectively, the resulting equations are,

$$\frac{\partial u}{\partial t}+w\frac{\partial u}{\partial z}-2\Omega v=\mu\left(\frac{1}{1+\beta}\right)\frac{\partial^2 u}{\partial z^2}+\frac{\sigma B_0}{\rho\left(1+m^2\right)}\left(mv-u\right)-\frac{v}{k}u+ \\ g\beta(T-T_\infty)Cos\alpha+g\beta^*(C-C_\infty)Cos\alpha \tag{14}$$

$$\frac{\partial v}{\partial t}+w\frac{\partial v}{\partial z}+2\Omega u=\mu\left(\frac{1}{1+\beta}\right)\frac{\partial^2 v}{\partial z^2}-\frac{\sigma B_0}{\rho\left(1+m^2\right)}\left(mu+v\right)-\frac{v}{k}v \tag{15}$$

Combining Eq. (14) and Eq. (15), we obtain

$$\frac{\partial q}{\partial t}-w\left(1+\varepsilon Ae^{nt}\right)\frac{\partial q}{\partial z}+2i\Omega q=\mu\left(\frac{1}{1+\beta}\right)\frac{\partial^2 q}{\partial z^2}-\frac{\sigma B_0}{\rho(1-im)}q+ \\ g\beta(T-T_\infty)Cos\alpha+g\beta^*(C-C_\infty)Cos\alpha-\frac{1}{K}q \tag{16}$$

To uniformly express the physical problem mathematically, the subsequent non-dimensional quantities and parameters are provided

$$q^*=\frac{q}{w_0},w^*=\frac{w}{w_0},\ z^*=\frac{w_0\,z}{v},U_0^*=\frac{U_0}{w_0},U_\infty^*=\frac{U_\infty}{w_0},\ t^*=\frac{t\ w_0^2}{v},\theta=\frac{T-T_\infty}{T_w-T_\infty},\phi=\frac{C-C_\infty}{C_w-C_\infty},$$
$$M^2=\frac{\sigma B_0^2 v}{\rho w_0^2},\Pr=\frac{v\rho C_p}{k_1}=\frac{v}{\alpha},Sc=\frac{v}{D},Gr=\frac{vg\beta(T_w-T_\infty)}{w_0^3},Gm=\frac{v\,g\beta^*(C_w-C_\infty)}{w_0^3},\ k=\frac{w_0^2 k}{v^2} \tag{17}$$
$$R=\frac{\Omega v}{w_0^2},H=\frac{vQ_0}{\rho C_p w_0^2},\ K_c=\frac{K_c v}{w_0^2},Q_1=\frac{v\,Q_1\left(C_w-C_\infty\right)}{w_0^2(T_w-T_\infty)},Du=\frac{DK_T}{vC_sC_p}\frac{\left(C_w-C_\infty\right)}{(T_w-T_\infty)}$$

When reduced, the governing equations (2) through (5) use non-dimensional variables

$$\frac{\partial q}{\partial t}-(1+A\varepsilon\,e^{nt})\frac{\partial q}{\partial z}=\lambda_1\frac{\partial^2 q}{\partial z^2}-\left(\frac{M^2}{1-im}+2iR+\frac{1}{k}\right)q+Gr\,Cos\alpha\ \theta+Gm\ Cos\alpha\ \phi \tag{18}$$

where $\lambda_1=\left(\frac{1}{1+\beta}\right)$

$$\frac{\partial\theta}{\partial t}-(1+A\varepsilon e^{nt})\frac{\partial\theta}{\partial z}=\frac{1}{\Pr}\frac{\partial^2\theta}{\partial z^2}-H\,\theta+Q_1\phi+D_u\frac{\partial^2\phi}{\partial z^2} \tag{19}$$

$$\frac{\partial\phi}{\partial t}-(1+A\varepsilon e^{nt})\frac{\partial\phi}{\partial z}=\frac{1}{Sc}\frac{\partial^2\phi}{\partial z^2}-K_c\phi \tag{20}$$

Given are the corresponding boundary conditions

$$q=U_0,\quad \theta=1+\varepsilon\,e^{nt},\ \phi=1+\varepsilon e^{nt}\qquad \text{at } z=0 \tag{21}$$

$$q=0,\quad \theta=0,\quad \phi=0\qquad \text{as}\quad z\to\infty \tag{22}$$

2. Solution of the Problem

A group of partial differential equations represented by Eq. (18) and Eq. (20) not amenable to closed-form solution. But suppose they can be reduced to a set of analytically solvable Differential equations in a dimensionless form. This can be done by representing velocity, temperature, and concentration as follows.

$$q = q_0(z) + \varepsilon e^{nt} q_1(z) + O(\varepsilon^2) \tag{23}$$

$$\theta = \theta_0(z) + \varepsilon e^{nt} \theta_1(z) + O(\varepsilon^2) \tag{24}$$

$$\phi = \phi_0(z) + \varepsilon e^{nt} \phi_1(z) + O(\varepsilon^2) \tag{25}$$

Eq. (23), Eq. (24) and Eq. (25) are replaced into Eq. (18), Eq. (19) and Eq. (20), Combining corresponding terms, the Ignoring and more elevated representations of $O(\varepsilon^2)$, we get

$$\lambda_1 \frac{\partial^2 q_0}{\partial z^2} + \frac{\partial q_0}{\partial z} - \left[\frac{m^2}{1-im} + 2iR + \frac{1}{k}\right] q_0 = -Gr\,\theta_0\,Cos\alpha - Gm\,\phi_0\,Cos\alpha \tag{26}$$

$$\lambda_1 \frac{\partial^2 q_1}{\partial z^2} + \frac{\partial q_1}{\partial z} - \left[\frac{m^2}{1-im} + 2iR + \frac{1}{k} + n\right] q_1 = -Gr\,\theta_1\,Cos\alpha - Gm\,\phi_1 Cos\alpha - A\frac{\partial q_0}{\partial z} \tag{27}$$

$$\frac{\partial^2 \theta_0}{\partial z^2} + \Pr\frac{\partial \theta_0}{\partial z} - H\Pr\theta_0 = -\Pr\left(Q_1\,\phi_0 + D_u\,\frac{\partial^2 \phi_0}{\partial z^2}\right) \tag{28}$$

$$\frac{\partial^2 \theta_1}{\partial z^2} + \Pr\frac{\partial \theta_1}{\partial z} - \Pr(H+n)\theta_1 = -\Pr\left(A\frac{\partial \theta_0}{\partial z} + Q_1\phi_1 + D_u\,\frac{\partial^2 \phi_1}{\partial z^2}\right) \tag{29}$$

$$\frac{\partial^2 \phi_0}{\partial z^2} + Sc\frac{\partial \phi}{\partial z} - Sc\,Kc\,\phi_0 = 0 \tag{30}$$

$$\frac{\partial^2 \phi_1}{\partial z^2} + Sc\frac{\partial \phi_1}{\partial z} - Sc(n+K_c)\phi_1 = -ASc\frac{\partial \phi_0}{\partial z} \tag{31}$$

The corresponding boundary conditions are

$$q_0 = U_0, q_1 = 0,\ \ \theta_0 = 1,\ \theta_1 = 1,\ \phi_0 = 1,\ \phi_1 = 0 \qquad \text{at } z = 0 \tag{32}$$

$$q_0 = 0, q_1 = 0,\ \ \theta_0 = 0,\ \theta_1 = 0,\ \phi_0 = 0,\ \phi_1 = 0 \qquad \text{as } z \to \infty \tag{33}$$

Solving Eq. (28) to Eq. (33) under the boundary conditions (34), We discover the field of velocity, temperature, and concentration

$$q(z,t) = b_9 \exp(-m_1 z) + b_{10} \exp(-m_3 z) + b_{11} \exp(-m_5 z) + \varepsilon e^{nt} \begin{pmatrix} b_{12} \exp(-m_1 z) + b_{13} \exp(-m_2 z) + b_{14} \exp(-m_3 z) + \\ b_{15} \exp(-m_4 z) + b_{16} \exp(-m_5 z) + b_{17} \exp(-m_6 z) \end{pmatrix} \tag{34}$$

$$\theta(z,t) = b_3 \exp(-m_1 z) + b_4 \exp(-m_3 z) + \varepsilon e^{nt} (b_5 \exp(-m_1 z) + b_6 \exp(-m_2 z) + b_7 \exp(-m_3 z) + b_8 \exp(-m_4 z)) \tag{35}$$

$$\phi(z,t) = \exp(-m_1 z) + \varepsilon e^{nt} (b_1 \exp(-m_1 z) + b_2 \exp(-m_2 z)) \tag{36}$$

Skin Friction:

Very important physical parameter at the boundary is the skin friction which is given in the non-dimensional form and derives as

$$\tau = \left(\frac{\partial u}{\partial y}\right)_{y=0} = -\left(\left(b_9 m_1 + b_{10} m_3 + b_{11} m_5\right) + \varepsilon e^{nt} \begin{pmatrix} b_{12} m_1 + b_{13} m_2 + \\ b_{14} m_3 + b_{15} m_4 + b_{16} m_5 + b_{17} m_6 \end{pmatrix} \right) \tag{37}$$

Nusselt Number:

In Another physical parameter like rate of heat transfer in the form of Nusselt number expressed by

$$\mathrm{Nu} = -\left(\frac{\partial \theta}{\partial y}\right)_{y=0} = b_3 m_1 + b_4 m_3 + \varepsilon e^{nt}(b_5 m_1 + b_6 m_2 + b_7 m_3 + b_8 m_4) \tag{38}$$

Sherwood Number:

The rate of mass transfer in the form of Sherwood number are also derived by

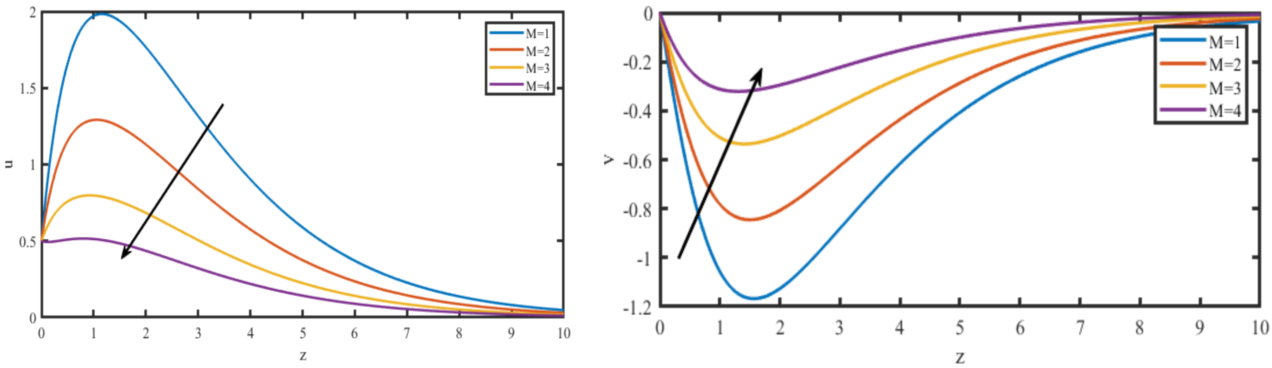
$$Sh = -\left(\frac{\partial C}{\partial y}\right)_{y=0} = \left((m_1) + \varepsilon e^{nt} (b_1 m_1 + b_2 m_2)\right) \tag{39}$$

3. Results and Discussion

The preceding sections employ the perturbation approach to solve the governing equations and boundary conditions analytically. Finally, a suitable non-dimensional flow parameter's effects on together primary (u), secondary (v) velocity, temperature (θ), and concentration (ϕ) distribution are It includes both graphic representations of non-dimensional quantities, as well as tabular representations of non-dimensional quantities. It specifies the comparative significance of momentum and mass communication by employing dispersal in the hydrodynamic limit layer. As the

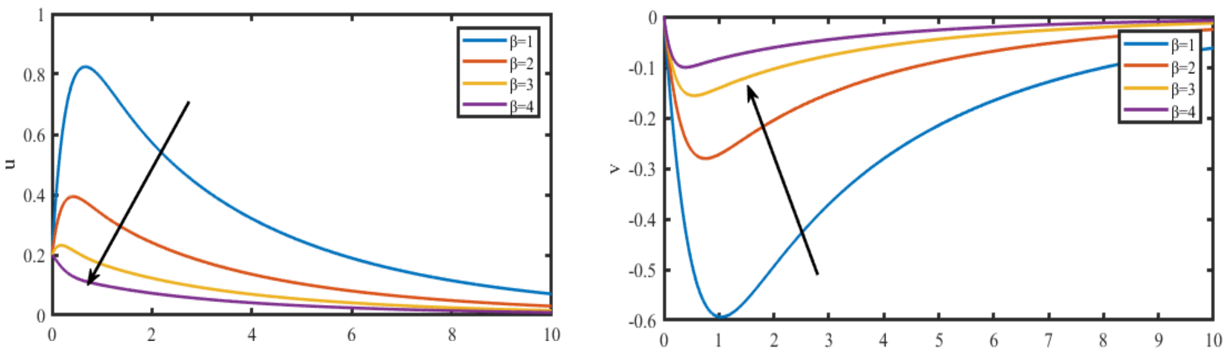
Schmidt number decreases, the fluid's mass diffusivity will as well. In Figure 2 to Figure 10, we take M=2, K=0.5, Gr=5, β=0.5, α=π/3, γ=π/6, Gm=3, R=1, m=0.2, Pr=0.71, Q_1=1, Du=0.5, H=1, Sc=0.22, Kc=1, n=0.5, t=0.5.

Figure 2 explains the significance of the Hartmann digit M on the various velocity components. An improvement in the Hartmann the principal speed decreases as a result of the number u -component while simultaneously generating an enhancement in the secondary velocity v-component, due to the consequence of Lorentz energy. Figure 3-5, represents the variation in velocity for different values of Jeffrey parameter (β), inclined parameter (α) and aligned magnetic field parameter (γ) respectively. An upsurge in the magnitude of Jeffrey parameter restricts the flow velocity. Because of increasing values of β produces a high resistance in the flow due to the higher viscosity of the fluid. The same behavior as observed in inclined and aligned magnetic field parameter (Figure 4 and 5).



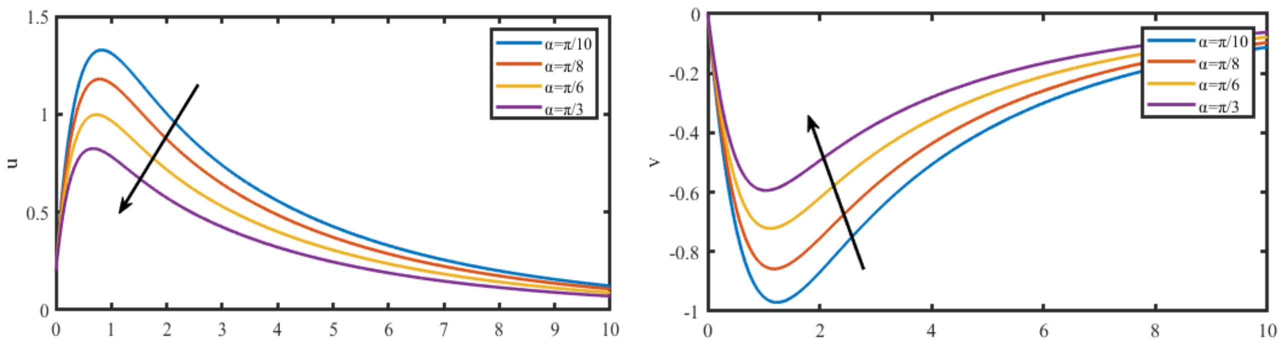
(a) (b)

Fig. 2. The velocity profiles for both (a) u and (b) v plotted versus Magnetic field parameter (M)



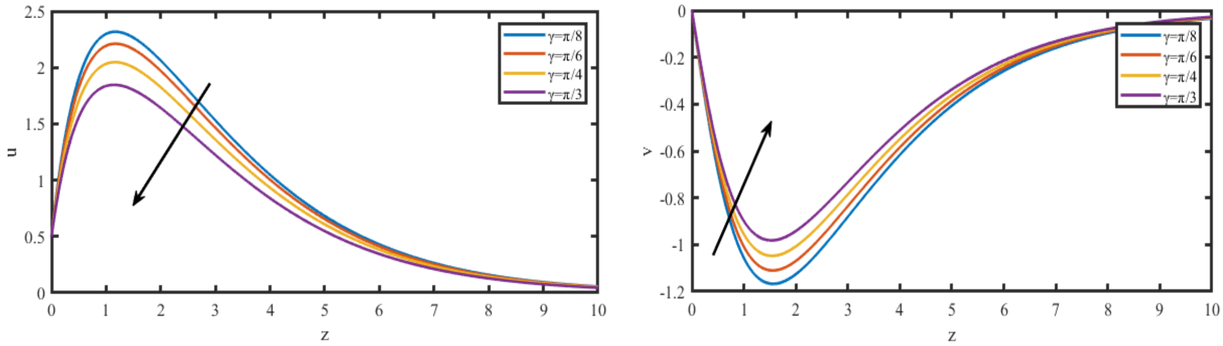
(a) (b)

Fig. 3. The velocity profiles for both (a) u and (b) v plotted versus Jeffrey parameter (β)



(a) (b)

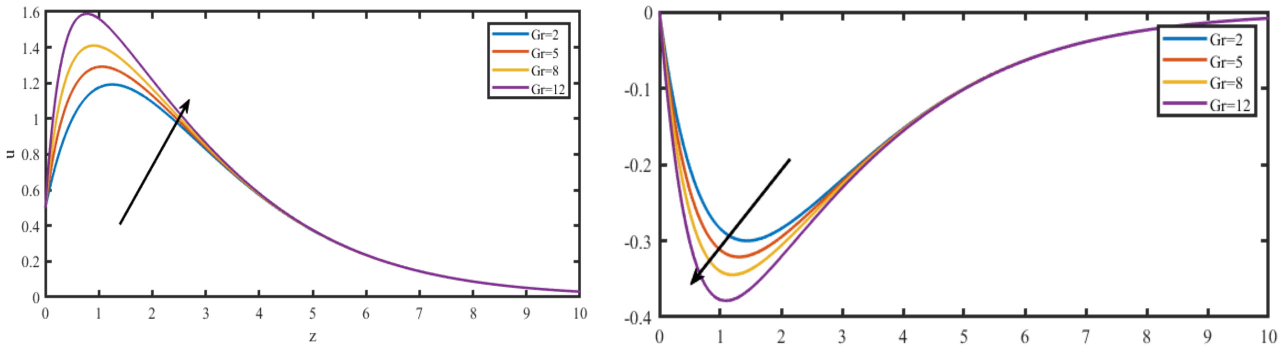
Fig. 4. The velocity profiles for both (a) u and (b) v plotted versus inclined parameter (α)



(a) (b)

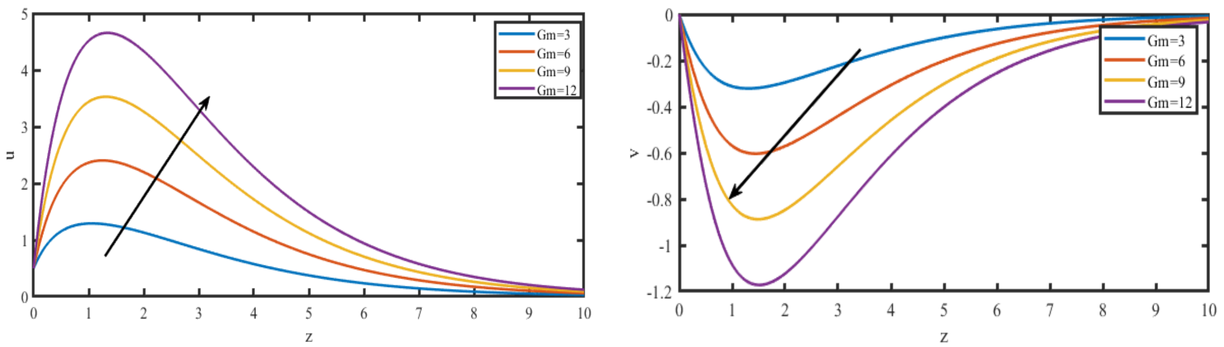
Fig. 5. The velocity profiles for (a) u and (b) v plotted versus aligned magnetic field (γ)

The effect of the Grashof number Gr on the primary and secondary speed profiles is shown in Figure 6. Because misinterpreted Gr principles can cause buoyancy forces to increase and viscous forces to decrease, Gr evaluates the relationship between a fluid's thermal buoyancy and viscous force. Describes the fluid's internal resistance will also reduce when viscosity lowers, which will increase fluid velocity. The result of the adjusted Grashof number Gm on both velocity distributions is seen in Figure 7. The SolutalGrashof number Gm calculates the ratio of buoyancy to viscous force acting on a fluid; raising Gm causes buoyancy to rise and viscous forces to decrease. Internal fluid resistance will decrease, resulting in an increase in the fluid's speed.



(a) (b)

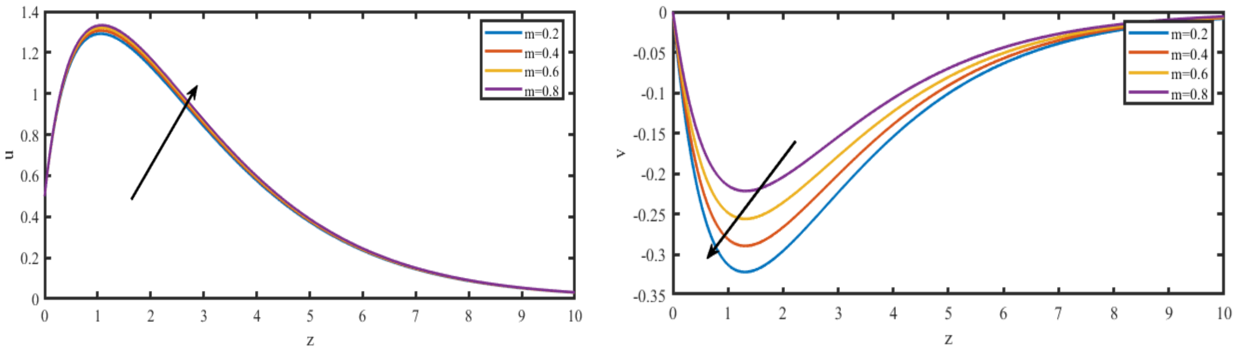
Fig. 6. The velocity profiles for both (a) u and (b) v plotted versus Grashof number (Gr)



(a) (b)

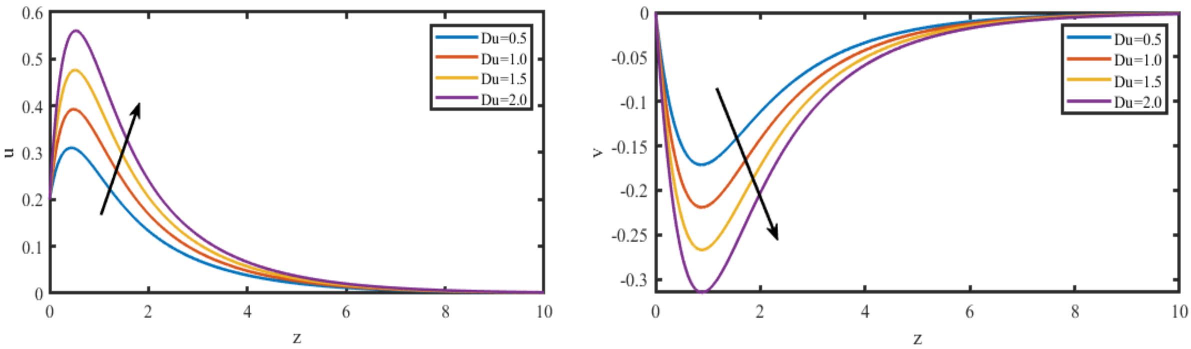
Fig. 7. The velocity profiles for both (a) u and (b) v plotted versus Modified Grashof number (Gm)

Figure 8 shows how the velocity outlines behave when the Hall specification is used. By raising the Hall constraint m across the fluid media, the principal velocity and secondary velocity are both improved. It was found that the motivation Frontier stratum thicknesses across all liquids section rose together with the resultant speed, which served as reinforcement in the Hall factor. The impact of the Dufour number on the primary and secondary velocities is seen in Figure 9, which may be found here. It demonstrates that the initial velocity rises with higher values of the Dufour number, but the behaviour of the second velocity is shown to be the opposite. This pattern occurs as a consequence of the production of energy flow, which permits an increase in velocity.



(a) (b)

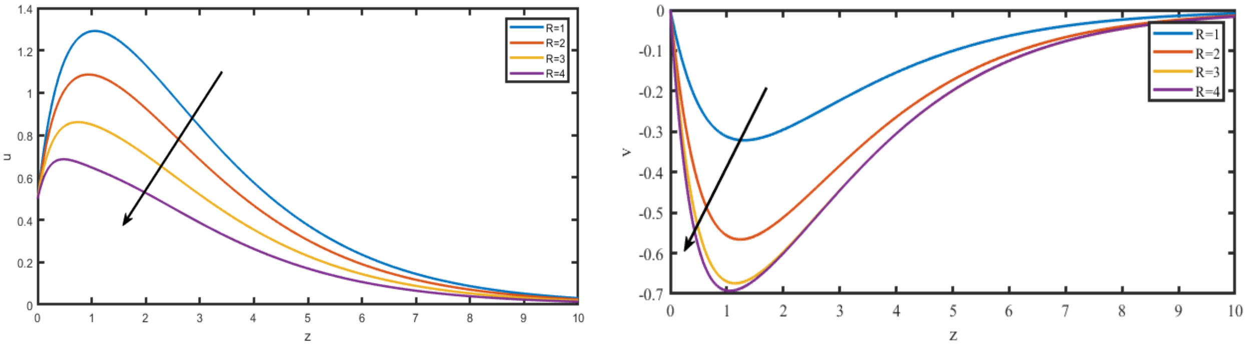
Fig. 8. The velocity profiles for both (a) u and (b) v plotted versus Hall parameter (m)



(a) (b)

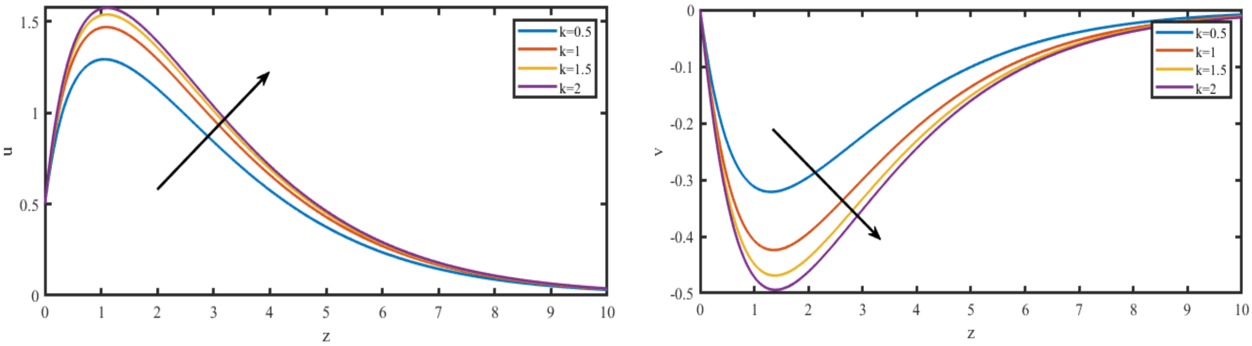
Fig. 9. The velocity profiles for both (a) u and (b) v plotted versus Diffusion thermo parameter (Du)

The main and secondary velocity curves for several dissimilar rotation factor (R) consequences are displayed in Figure 10. These contours are shown in the figures that are provided. Figure 10 makes it abundantly evident that when the value of R grows, both the main velocity profile (u) and the tertiary velocity profile (v) begin to drop. This is the case because of the relationship between the two. Because rotation affects the whole boundary layer area, it is almost always the case that the main fluid velocity will drop as a result. However, owing to the expansion of R, v will grow in the region near the plate but decrease in the part that is a significant distance away from it. This is due to the fact that the Coriolis force has a substantial impact on the area that is close to the rotation axis. In fact, it is obvious from looking at Figure 11 the fact with the intention of a rise in the permeability specification (K) compels another velocity to condense, ushering to an accumulation in the prevalent velocity segment u. The preliminary velocity segment u rises outstandingly due to the outcomes of the Hall wind on the entire liquid area.



(a) (b)

Fig. 10. The velocity profiles for both (a) u and (b) v plotted versus Rotation parameter (R)



(a) (b)

Fig. 11. The velocity profiles for both (a) u and (b) v plotted versus Porous parameter (K)

Figure 12, makes it abundantly evident that an increase in the values of the Dufour number leads to an accompanying rise in the temperature of the fluid. This occurs due to the production of energy flow, which increases the temperature. The radiation absorption parameter influence on temperature is seen in Figure 13, These figures make it abundantly evident that an increase in the radiation absorption parameter increases the temperature. The temperature distribution of the fluid flow is enhanced as a result since high temperatures are connected to thermal radiation. The impact of Prandtl number (Pr) on temperature profiles is shown in Figure 14. The ratio of thermal diffusiveness to kinematic viscosity is known as the Prandtl number. A similar trend can be seen in Figure 15, which depicts an increase in the heat source parameter (H). Because temperature source characteristics reflect the transfer of warm energy and the absorption of temperature, it was projected that raising the value of H would make the temperature disparities less obvious. As a direct result, the diameter of the layers comprising the heat frontier is diminished.

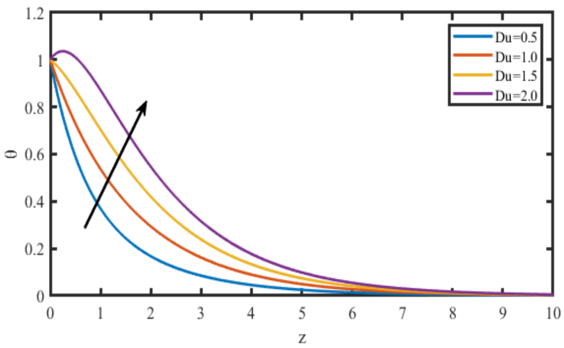


Fig. 12. Effect of dufour parameter Du on Temperature profiles

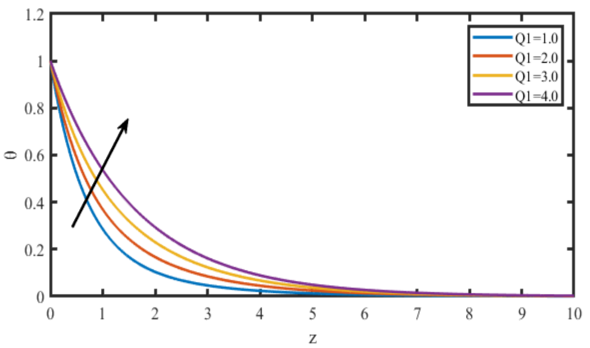


Fig. 13. Effect of radiation absorption parameter Q1 on Temperature profiles

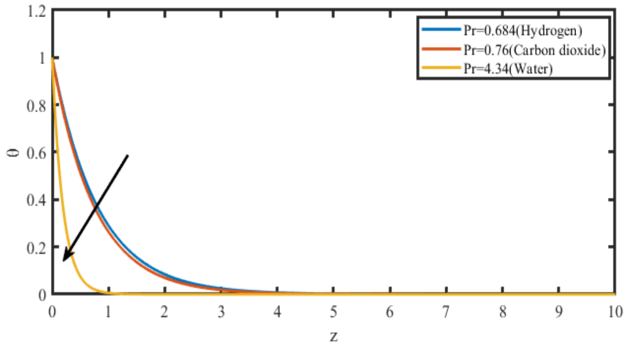


Fig. 14. Effect of Prandtl number parameter Pr on Temperature profiles

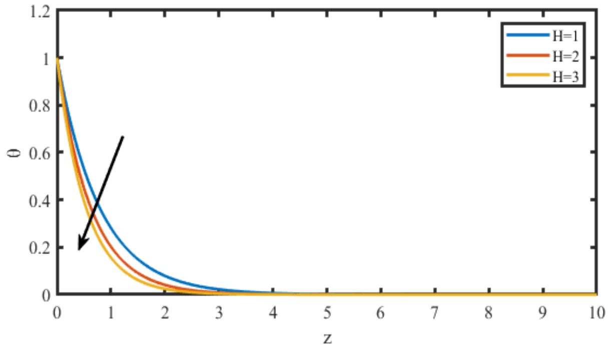


Fig. 15. Effect of Heat source parameter H on Temperature profiles

Figure 16 analyzes a chemical reaction's impact on concentration profiles. A destructive chemical process is examined in this study (Kr > 0). As chemical reactions increase, the distributions of concentration shrink. The chemistry is physically accompanied by characterized by many disturbances for a destructive purpose. Therefore, fluid flow concentration distributions are reduced as a result of high molecular motion, which increases transport phenomena. Figure 17 illustrates the behavior of the Schmidt number (Sc) on the concentration curves. The momentum to mass diffusivity ratio is represented by the Schmidt number Sc.

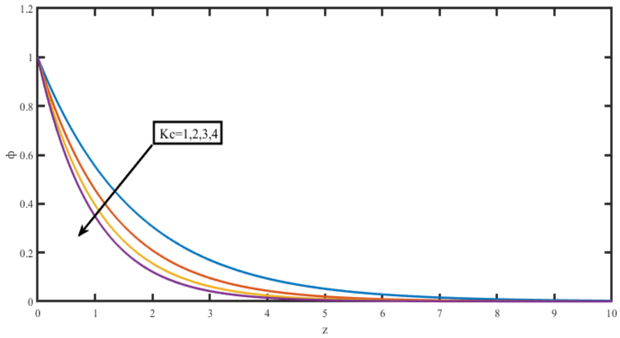


Fig. 16. Effect of Chemical reaction parameter Kr on Concentration profiles

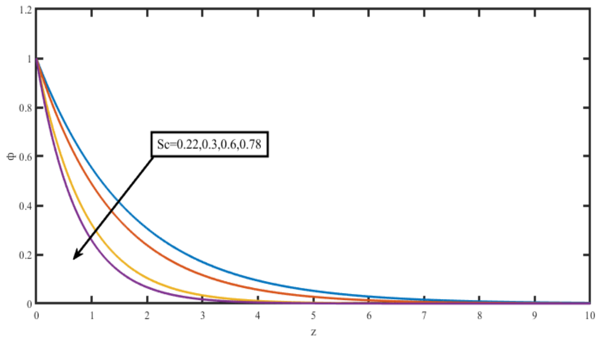


Fig. 17. Effect of Schmidt number parameter Sc on Concentration profiles

The extent of skin friction is recapped in Table 1. An accumulation in the Hartmann factor will diminish the quantity of conflict encountered by the skin friction because the power of Lorentz diminishes the contention and drag it generates on gelatinous liquid. The same behavior has observed, while enhanced angle of Inclination, Radiation absorption, hall parameter. The reversal behavior has observed with enhances of Porous media, Rotation, Gr, Gm, Dufour parameters.

Table 1
The shear stress (An t = 5, k = 0.5, Q_1 = 1, e = 0.01, Du = 0.5, m = 0.2, α = π/6)

M	K	R	Gr	Gm	α	γ	D_u	Q_1	m	τ
2	0.5	1	3	5	π/6	π/3	1	1	0.2	0.64521
3	0.5	1	3	5	π/6	π/3	1	1	0.2	0.78522
4	0.5	1	3	5	π/6	π/3	1	1	0.2	0.77852
2	1.0	1	3	5	π/6	π/3	1	1	0.2	1.93654
2	1.5	1	3	5	π/6	π/3	1	1	0.2	2.07852
2	0.5	2	3	5	π/6	π/3	1	1	0.2	1.65745
2	0.5	3	3	5	π/6	π/3	1	1	0.2	1.74585
2	0.5	1	5	5	π/6	π/3	1	1	0.2	2.45522
2	0.5	1	10	5	π/6	π/3	1	1	0.2	3.87855
2	0.5	1	3	8	π/6	π/3	1	1	0.2	1.97852
2	0.5	1	3	10	π/6	π/3	1	1	0.2	4.45211
2	0.5	1	3	5	π/4	π/3	1	1	0.2	6.45221
2	0.5	1	3	5	π/3	π/3	1	1	0.2	2.78521
2	0.5	1	3	5	π/6	π/3	2	1	0.2	3.14563
2	0.5	1	3	5	π/6	π/3	3	1	0.2	4.54521
2	0.5	1	3	5	π/6	π/3	1	2	0.2	2.94523
2	0.5	1	3	5	π/6	π/3	1	3	0.2	1.97852
2	0.5	1	3	5	π/6	π/3	1	1	0.4	2.04563
2	0.5	1	3	5	π/6	π/3	1	1	0.6	1.97852

Table 2 lists the numerical various of the Nusselt number Nu that were calculated using the analytical expression for different values of Pr, H, Q_1, Kc. Table 2 shows that the Nusselt number Nu grows as Pr, H, and Kc increase while decreasing as time F increases. This suggests that thermal radiation and diffusion both contribute to speed up the plate's heat exchange. Heat transfer speed to the plate decreases over time.

Table 2
The Nusselt number (Nu) (A = 5, Ɛ = 0.01, Sc = 0.22, Du = 0.5)

Kc	H	Q_1	Du	Pr	Nu
1					0.47852
2					0.61254
3					0.77852
	2				1.56554
	3				1.97852
		2			0.97852
		3			0.96547
			1.0		0.25211
			1.5		1.24571
				3.0	3.12544
				7.0	7.12547

Table 3 lists the numerical the Sherwood number's values Sh that were calculated using the analytical equations for a mixture of values of Sc, Kc, Du and t. Table 3 shows that while the rate of mass transfer drops as So increases, it increases when Sc, Kc and t increase. This suggests that the rate of mass transfer at the plate is generally increased by mass diffusion, chemical response restriction, and time. The opposite is true for thermal radiation, thermal diffusion, and Soret number. The main speed results and the secondary rapidity outcome of Chen *et al.,* [5] was in perfect agreement (Table 4).

Table 3
The Sherwood number (A = 5, e = 0.01)

Kc	Sc	Du	Q_1	Sh
1	0.22	0.5	1	0.547852
2				0.645887
3				0.752114
	0.33			0.862214
	0.44			0.912147
		1.5		2.021477
		2.5		1.321447
			2	1.852214
			3	0.921547

Table 4
Comparison of results for primary velocity (A = 5, n = 0.5, t = 0.5, ϵ = 0.01, U_0 = 0.5, m = 0, Sc = 0.22, H = 1, Q_1 = Du = 0)

M	K	Gr	Gm	Previous results Raghunath and Mohanaramana [9]	Present Values
2	0.5	5	3	0.703484	0.702144
3				0.452455	0.465471
4				0.302545	0.312547
	1.0			0.797822	0.746521
	1.5			0.835478	0.845874
		8		0.934587	0.936547
		12		1.161458	1.175221
			5	0.780458	0.745211
			7	0.851458	0.865474

An examination of Hall's impact currents, and diffusion thermo effect numbers on top of an incompressible, viscous, electrically conductive Jeffrey fluid that undergoes heat and mass relocate as it passes through a never-ending vertical plate set into a porous media in the presence radiation absorption and chemical reaction has been presented. Correct results of the main equations were generated utilising the regular perturbation method. Fluid velocity, heat, and species concentration are shown in fine-grained graphs, and their interactions with other physical variables are discussed.

Hall current, permeability of porous media, Radiation absorption, Diffusion thermo parameter, thermal buoyancy force, concentration buoyancy force and mass diffusion tend to accelerate fluid flow in both primary and secondary flow directions. Magnetic field, Jeffrey parameter and Rotation parameter tend to retard fluid flow in both primary and secondary flow directions. Prandtl number and Heat source parameter has a tendency to reduce fluid temperature whereas Radiation absorption and Diffusion thermo specification has a reverse effect on it. Chemical reaction and Schmidt number tends to reduce species concentration whereas mass diffusion has a reverse effect on it.

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