Ultra Scientist Vol. 26(2)A, 159-172 (2014).
www.ultrascientist.org

ISSN 2231-3478 (Print)
2319-8052 (Online)

Combined Effect of Radiation, Rotation and Hall Current on Heat and Mass Transfer Flow Past an Accelerated Porous Plate with Suction/Injection and Internal Heat Generation/Absorption

[1]N. P. SINGH and [2]J. S. RAJPUT

[1]Department of Mathematics, CL Jain (PG) College,
Firozabad-283203 (INDIA)
[2]Department of Mathematics, Krishna Girls Engineering College,
Kanpur-209 217 (INDIA)

(Acceptance Date 15th July, 2014)

Abstract

Combined effect of Hall current, rotation and radiation on unsteady heat and mass transfer flow of a viscous, electrically conducting, incompressible fluid past an accelerated porous plate is investigated analytically. The plate is subjected to suction and injection. The fluid is gray, absorbing-emitting but non-scattering medium and the Rosseland approximation is used to describe the radiative heat flux in the energy equation. The non-dimensional equations governing the flow are solved by the use of Laplace transform technique. Numerical computations for effects of different parameters on the velocity, the temperature, the concentration field, the skin-friction, the Nusselt number and the Sherwood number are obtained, shown graphically or presented in tabular form followed by detailed discussion.

Nomenclature

B_0 : $(=\mu_e H_0)$ uniform magnetic field,
C' : species concentration,
C'_w : concentration at the plate,
C'_∞ : concentration of ambient fluid,
C_p : specific heat at constant pressure,
D_T : thermal diffusivity,
E : rotation parameter,
S : suction parameter,
Sc : Schmidt number,
T' : temperature of the fluid,

Corresponding Author : E-92, Rajeev Nagar, Yashoda Nagar,
Kanpur-208011, UP, India, E mail : jsrajput2684@gmail.com.

T'_∞ : temperature for away from the plate,

T'_w : temperature of the plate,

t' : time,

U_0 : free stream velocity,

x', y', z' : distances along x', y' and z'-axis,

u', v', w' : velocity components along x', y', z'- direction,

Greek Symbols :

μ : coefficient of viscosity of the fluid,
ρ : density of the fluid,
υ : kinematic viscosity of the fluid,
σ : electrical conductivity of the fluid,
σ^* : Stefan-Boltzman constant,
ω' : frequency of oscillations,
Ω : constant angular velocity.

I. Introduction

The study of the effect of external rotation on thermal concentration has attracted significant experimental and theoretical interest because of its general occurrence in geophysical and oceanic flows[1]. Some of the areas of applications in engineering include the food processing, chemical processing industries, solidification and centrifugal casting of metals and rotating machinery[11]. In the context of space technology and in the processes involving high temperature, the effects of radiation are of vital importance. Recent developments in hypersonic flights, missile re-entry, rocket computation chambers, power plants for interplanetary flights and gas cooled nuclear reactors have focused attention on thermal radiation as a mode of energy transfer and emphasize the need for improved understanding of radiative transfer in these processes[6,19]. Hall effects are likely to be important in many astrophysical and geophysical situations as well as in flows of laboratory plasma. Current interest in the study of magnetohydrodynamics of rotating fluids is due to several important problems as such, the internal rotation rate of the sun, the structure of rotating magnetic stars, the planetary and solar dynamo problem, centrifugal machines etc[7,8].

Investigated laminar flow of electrically conducting liquid in a homogenous magnetic field[12]. Thereafter, the problem was extended in numerous ways with or without Hall current effect. Examined Hall effect on hydromagnetic flow of a viscous fluid between two flat parallel plates[35]. Studied the flow of viscous fluid past a semi-infinite plate with Hall effect[14]. made major contribution to the study of hydromagnetic boundary layer flows with Hall current effect[10]. Sequentially, Hall current effects have been examined[9,24,25,27,28,29] under different physical situations and fluid boundary conditions[21,22,23,31]. Investigated heat transfer effects in rotating system, whereas heat and mass transfer have been discussed ignoring rotating system[26,30,32]. Studied the effects of Hall current on a steady free convective heat and mass transfer flow through a porous medium under the influence of strong magnetic field[2]. Recently, investigated unsteady MHD free convection and mass transfer flow in a rotating system, with Hall current, viscous dissipation, Joule heating and thermal diffusion[3]. Investigated Hall effects in MHD convection flow due to a rotating disk[15,16]. More recently, discussed hydromagnetic flow of an incompressible homogeneous viscous liquid over an accelerated porous plate with suction/ injection in rotating system analytically using Laplace transform technique[22]. In the proposed study, the problem is considered with radiative and Hall current effects as well as mass transfer effects[33].

II. Formulation of the Problem :

In cartesian coordinate system, we consider unsteady, laminar, non-dissipative flow of an electrically conducting, heat generating/ absorbing, viscous fluid past an accelerated oscillating porous plate embedded in a porous medium. The x'-axis and y'-axis are in the plane of the plate and z'-axis normal to it with velocity components u', v' and w' in these directions respectively. The whole system is in a rigid body rotation about z'-axis, *i.e.*, normal to the plate, with constant angular velocity Ω in the presence of uniform magnetic field which acts normal to the flow region. Initially, when $t' \le 0$, the plate and the fluid are at rest with temperature T'_∞ and concentration C'_∞. When $t' > 0$, the plate is accelerated with velocity U_0; such that a non-tortional oscillation of a given frequency ω is imposed on the plate to generate unsteady flow. The temperature of the plate and the concentration at the plate are instantaneously raised to T'_w and C'_w respectively and thereafter maintained constant; such that the temperature T'_w and concentration C'_∞ are independent of the distance x'. Since, uniform suction is normal to the plate and acts towards it, $w' = -w'_0$; as such $w'_0 > 0$ for suction and $w'_0 < 0$ for injection. The magnetic Reynolds number is assumed to be small so that the induced magnetic field is negligible in comparison to the applied magnetic field. Also, the magnetic dissipation and viscous dissipation are neglected. There is no applied or polarization voltage imposed on the flow field so that the electric field $\vec{E} = 0$; as such the magnetic field produces the Lorentz force in the presence of Hall effect[13]. Besides, the proposed analysis is based on the following assumptions[12-13]:

1. The plate is long enough, as such all physical quantities are functions of z' and t' only.
2. The magnetic field $\vec{H} = \left(H_{x'}, H_{y'}, H_{z'}\right)$, by the use of the relation $\vec{\nabla}.\vec{H} = 0$, implies $H_{y'} = H_0$ (constant), everywhere in the fluid.

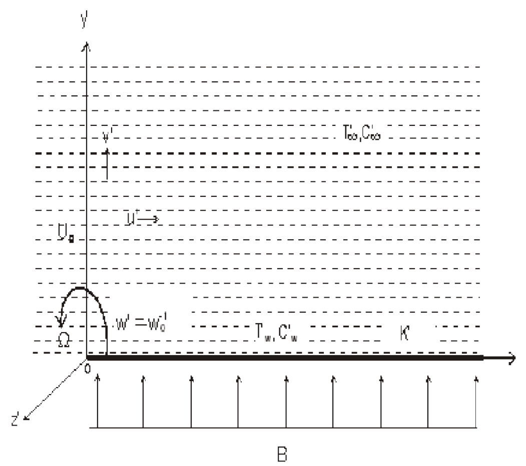

Fig. 1: Physical model and coordinate system.

3. For partially ionized fluid, the electron pressure, the thermoelectric pressure and the ion-slip are negligible. Therefore, the generalized Ohm's law in absence of electric

field taking Hall current into account yields[34]:

$$J_{x'} = \frac{\sigma B_0^2}{1+m^2}(mu' - v') \text{and} \quad J_{y'} = \frac{\sigma B_0^2}{1+m^2}(u' + mv'),$$

where $B_0 (= \mu_e H_0)$ is uniform magnetic field and $m(= \omega_e \tau_e)$ is the Hall parameter.

4. The fluid is considered to be gray, absorbing-emitting but non-scattering medium and the porous medium is regarded as an assemblage of small identical spherical particles fixed in the space[20].
5. The Rosseland approximation is used to describe the radiative heat flux in the energy equation and the radiative heat flux in the x'-direction is considered negligible in comparison with z'-direction[19].

Within the frame work of the above mentioned simplifications, the equations governing the flow are:

$$\frac{\partial u'}{\partial t'} - w_0' \frac{\partial u'}{\partial z'} - 2\Omega v' = \upsilon \frac{\partial^2 u'}{\partial y'^2} - \frac{\upsilon}{K'} u' - \frac{\sigma B_0^2}{\rho\left(1+m^2\right)}(u' + mv') \tag{1}$$

$$\frac{\partial v'}{\partial t'} - w_0' \frac{\partial v'}{\partial z'} + 2\Omega u' = \upsilon \frac{\partial^2 v'}{\partial y'^2} - \frac{\upsilon}{K'} v' - \frac{\sigma B_0^2}{\rho\left(1+m^2\right)}(v' + mu') \tag{2}$$

$$\frac{\partial T'}{\partial t'} - w_0' \frac{\partial T'}{\partial z'} = \frac{K_T}{\rho C_p} \frac{\partial^2 T'}{\partial z'^2} - \frac{1}{\rho C_p} \frac{\partial q_r'}{\partial z'} - \frac{Q'}{\rho C_p}(T' - T_\infty') \tag{3}$$

$$\frac{\partial C'}{\partial t'} - w_0' \frac{\partial C'}{\partial z'} = D_T \frac{\partial^2 C'}{\partial z'^2}. \tag{4}$$

For an optically thick gray fluid in non-scatter medium, there is emission in addition to absorption[4] and the absorption coefficient depends on wave length[5]. Hence, we can use the Rosseland approximation for the radiative heat flux expressed in equation (3); as such, we take[17].

$$q_r' = -\frac{4\sigma^*}{3k^*} \frac{\partial T'^4}{\partial z'}. \tag{5}$$

Here σ^* is the Stefan-Boltzman constant and k^* is the absorption coefficient. Taking into account small temperature differences within the flow, T'^4 can be expanded in Taylor's series about the free stream temperature T_∞'. Choosing first term only and neglecting the higher order terms, we get:

$$T'^4 \cong 4T_\infty'^3 T' - 3T_\infty'^4. \tag{6}$$

Substituting (5) and (6) in (3), we obtain:

$$\frac{\partial T'}{\partial t'} - w_0' \frac{\partial T'}{\partial z'} = \frac{K_T}{\rho C_p} \frac{\partial^2 T'}{\partial z'^2} - \frac{1}{\rho C_p} \frac{16\sigma^* T_\infty'^3}{3k^*} \frac{\partial^2 T'}{\partial z'^2} - \frac{Q'}{\rho C_p}(T' - T_\infty') \tag{7}$$

The initial and boundary conditions are:

$t' \le 0:\ \ u' = 0,\ \ v' = 0,\ \ T' = 0,\ C' = 0$ for all z'.

$t' > 0:\ \ u' = U_0,\ v' = 0,\ T' = T_w',\ C' = C_w'$ at $z' = 0$.

$u' \to 0,\ v' \to 0,\ \ T' \to T_\infty',\ \ C' \to C_\infty'$ as $z' \to \infty$. (8)

We introduce following non-dimensional quantities and parameters:

$$u = \frac{u'}{U_0},\quad v = \frac{v'}{U_0},\quad z' = \frac{z' U_0}{\upsilon},\quad t = \Omega t',\quad T = \frac{T' - T_\infty'}{T_w' - T_\infty'},$$

$$C = \frac{C' - C'_\infty}{C'_w - C'_\infty},\ N = \frac{4\sigma^* T'^3_\infty}{k^*},\ K = \frac{K' U_0^2}{\upsilon^2},$$

$$E = \frac{2\Omega\upsilon}{U_0^2},\quad S = \frac{\Omega w'_0}{U_0},\quad M = \frac{B_0}{U_0}\sqrt{\frac{\sigma\upsilon}{\rho}}.$$

Substituting above stated non-dimensional variables and parameters, the equations governing the flow, using $q = u + iv$, reduce to following non-dimensional form:

$$\frac{E}{2}\frac{\partial q}{\partial t} = \frac{\partial^2 q}{\partial z^2} + S\frac{\partial q}{\partial z} - (M_1 + iE_1)q. \qquad (9)$$

$$\frac{E}{2}\frac{\partial T}{\partial t} = \frac{1}{Pr}\left(1 + \frac{4}{3N}\right)\frac{\partial^2 T}{\partial z^2} + S\frac{\partial T}{\partial z} - HT. \qquad (10)$$

$$\frac{E}{2}\frac{\partial C}{\partial t} = \frac{1}{Sc}\frac{\partial^2 C}{\partial z^2} + S\frac{\partial C}{\partial z}, \qquad (11)$$

where $M_1 = \frac{M^2}{1+m^2} + \frac{1}{K}$ and $E_1 = E - \frac{mM^2}{1+m^2}$.

The values $S < 0$ corresponds to injection velocity where as the values $S > 0$ corresponds to suction velocity. The case for $S = 0$ shows that there is neither suction nor injection. The heat generation/absorption parameter (H) represents heat generation when ($H < 0$) whereas heat absorption when ($H > 0$).

The initial and boundary conditions (8) in non-dimensional form are:

$$\begin{aligned} &t \le 0: \quad q=0, \quad T=0, \quad C=0 \quad \text{for all } z.\\ &t > 0: \quad q=1, \quad T=1, \quad C=1 \quad \text{at } z=0.\\ &q \to 0,\ T \to 0,\ C \to 0 \quad \text{as} \quad z \to \infty 0. \end{aligned} \qquad (12)$$

Now, we proceed to obtain the solution of equations (9)-(11) under the conditions (12).

III. Solution of the Problem :

Applying Laplace transform, the solutions of the equations (10)-(11) and (9) respectively, satisfying conditions[1,18] (12) are:

$$T(z,t) = \exp(-K_1 z)\,G(\alpha_1 z, 1.0, \alpha_2, t). \qquad (13)$$

$$C(z,t) = \exp(-K_2 z)\,H(\beta_1 z, 1.0, \beta_2, t). \qquad (14)$$

$$q(z,t) = \exp(-K_3 z)\,I(\gamma_1 z, 1.0, \gamma_2, t), \qquad (15)$$

where $\alpha_1 = \sqrt{\frac{E\,Pr}{2(1+N)}}$, $\alpha_2 = \frac{S^2 Pr + 4H(1+N)}{2E(1+N)}$,

$K_1 = \frac{S\,Pr}{2(1+N)}$, $K_2 = \frac{S\,Sc}{2}$, $K_3 = \frac{S}{2}$, $\gamma_1 = \sqrt{\frac{E}{2}}$,

$\gamma_2 = \frac{S^2 + 4(M_1 + iE_1)}{2E}$, $\beta_1 = \sqrt{\frac{E\,Sc}{2}}$,

$\beta_2 = \frac{S^2 Sc}{2E}$,

and
$$F(Z_1, Z_2, Z_3, Z_4) = \frac{1}{2}\exp\left(Z_1\sqrt{Z_2 Z_3}\right) erfc\left(\frac{Z_1 Z_2}{2\sqrt{Z_4}} + \sqrt{Z_3 Z_4}\right) + \frac{1}{2}\exp\left(-Z_1\sqrt{Z_2 Z_3}\right) erfc\left(\frac{Z_1 Z_2}{2\sqrt{Z_4}} - \sqrt{Z_3 Z_4}\right)$$

IV. Nusselt Number, Sherwood Number and Skin-Friction :

The rate of heat transfer in terms of Nusselt number (Nu), the mass transfer in terms of Sherwood number (Sh) and the skin-friction (τ) at the plate at z=0 is:

$$Nu = \left(\frac{\partial T}{\partial z}\right)_{z=0} = K_1 + \alpha_1 P(0.0, 1.0, \alpha_2, t). \tag{16}$$

$$Sh = \left(\frac{\partial C}{\partial z}\right)_{z=0} = K_2 + \beta_1 Q(0.0, 1.0, \beta_2, t). \tag{17}$$

$$\tau = \left(\frac{\partial q}{\partial t}\right)_{z=0} = K_3 + \gamma_1 R(0.0, 1.0, \gamma_2, t), \tag{18}$$

where $G(Y_1,Y_2,Y_3,Y_4) = \sqrt{Y_2Y_3}\exp\left(-Y_1\sqrt{Y_2Y_3}\right) erfc\left(\frac{Y_1}{2}\sqrt{\frac{Y_2}{Y_4}} - \sqrt{Y_3Y_4}\right).$

$$+\sqrt{Y_2Y_3}\exp\left(Y_1\sqrt{Y_2Y_3}\right) erfc\left(\frac{Y_1}{2}\sqrt{\frac{Y_2}{Y_4}} + \sqrt{Y_3Y_4}\right)$$

$$-2\sqrt{\frac{Y_2}{\pi Y_4}}\exp\left(-\frac{Y_1^2Y_2}{4Y_2} - Y_3Y_4\right).$$

V. Results and Discussion

The equations governing the flow, in non-dimensional form, are expressed in equations (9)-(11) and the relevant initial and boundary conditions are shown in (12). The solutions for temperature $T(z,t)$, concentration field $C(z,t)$ and complex velocity $q(z,t)$ are obtained by the Laplace transform technique and expressed in (13)-(15). In the discussion, the velocity component (u) is called as primary velocity, whereas the velocity component (v) is termed as 'secondary velocity' or cross-flow. To get physical insight of the problem, the primary velocity (u), secondary velocity (v), temperature field (T) and concentration distribution (C) are evaluated numerically and plotted. The effects of rotation parameter (E), suction parameter (S>0), injection parameter (S>0), Hall parameter (m), magnetic parameter (M) and permeability parameter (K) are observed on primary velocity (u) and secondary velocity (v). The effects of Prandtl number (Pr), Stark thermal radiation parameter (N), internal heat generation parameter (H<0) and heat absorption parameter (H>0) are noticed on temperature distribution, whereas the effect of Schmidt number (Sh) is examined on concentration field. The effects of above mentioned parameters on skin-friction due to primary velocity (τ_{pri}) and secondary velocity (τ_{sec}), rate of heat transfer (Nu) and rate of mass transfer (Sh) at the plate are presented in tabular form. To be realistic, numerical values of the Prandtl number are chosen to be Pr=0.71, Pr=1.0 and Pr=7.0, which correspond to air, electrolyte solution and water at 20^0C respectively. The values of Schmidt number (Sc) are chosen for Hydrogen (Sc=0.22), Water-vapour (Sc=0.60), Oxygen (Sc=0.60), Ammonia (Sc=0.78) and Carbon-dioxide (Sc=1.0); the species of most common interest present in air. The values of magnetic parameter are taken to be large because these values correspond to a strong magnetic field; generally encountered in nuclear engineering and in the generation of electric power with the flow of electrically conducting fluids.

Fig. 2(a) depicts variations in the profiles of representative primary velocity (u) and Fig. 2(b) depicts profiles of secondary velocity (v) with respect to non-dimensional distance z for different values of magnetic field interaction parameter (M) in the range $(10 \le M \le 16)$ for fixed values m=0.5, K=2.0, E=4.0 and S=3.0. It is observed that an increase in

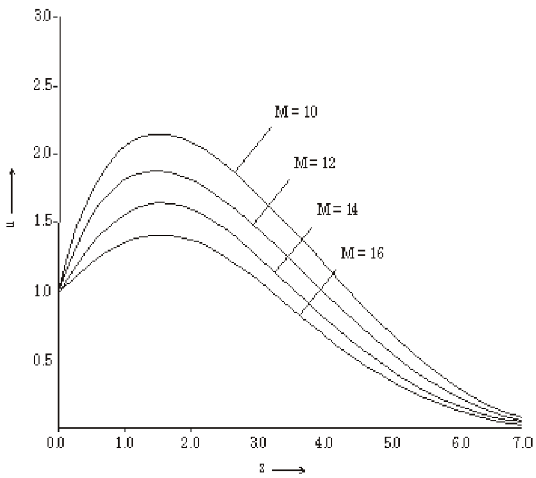

Fig. 2(a): Effect of magnetic interaction parameter (M) on primary velocity (m=0.5, K=2.0, E=4.0 and S=3.0).

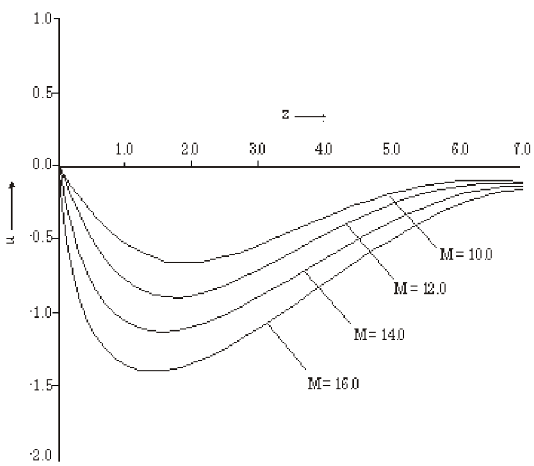

Fig. 2(b): Effect of magnetic field (M) on secondary velocity (m = 0.5, K = 2.0 and S = 5.0)

magnetic interaction parameter decreases the primary velocity but increases secondary velocity. The primary velocity increases in the vicinity of the plate and becomes maximum at approximately and then decreases as z increases, whereas the secondary velocity decreases near the plate and becomes maximum at z=1.5 approximately and thereafter increases as z increases.

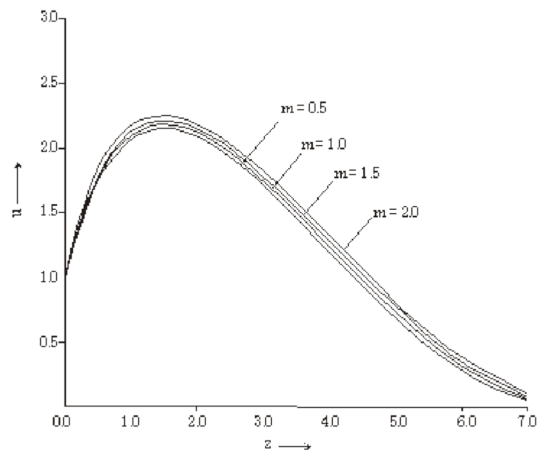

Fig.3(a): Effect of Hall parameter (m) on primary velocity (m = 10.0, K = 2.0, E = 4.0 and S = 3.0)

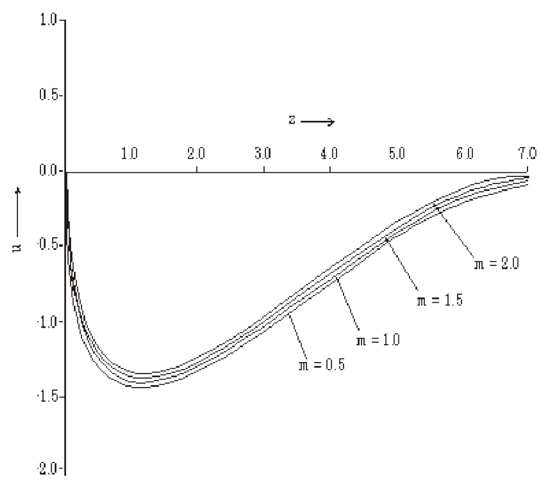

Fig.3(b): Effect of Hall parameter (m) on secondary velocity (M = 10.0, K = 2.0, E = 05.0 and S = 5.0)

Fig. 3(a) and Fig. 3(b) show variations in the profiles of primary velocity (u) and secondary velocity (v) versus non-dimensional z for different values of Hall parameter (m) in the range ($0.5 \le m \le 2.0$) for fixed values M=10.0, K=2.0, E=4.0 and S=3.0. It is noticed that an increase in Hall parameter increases the primary velocity as well as the cross-flow.

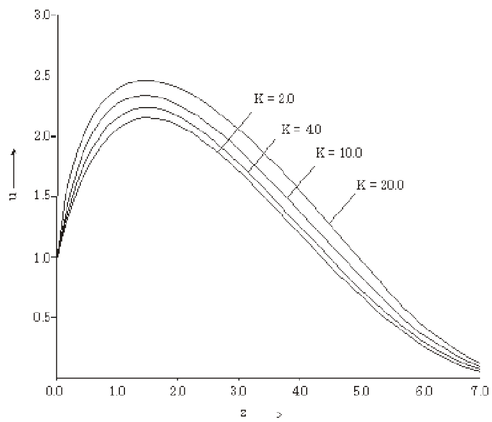

Fig. 4(a): Effect of parameter (K) on primary velocity
(M = 10.0, m = 0.5, E = 4.0 and S = 3.0)

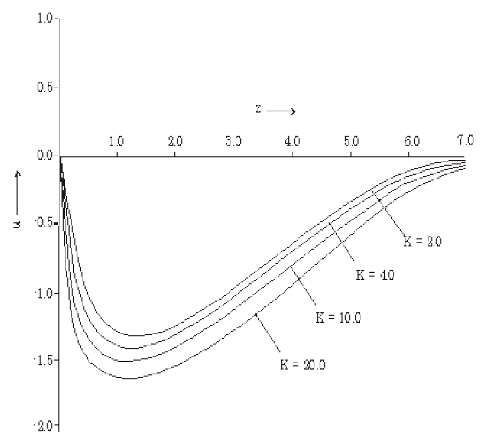

Fig.4(b): Effect of permeability parameter (K) on secondary velocity (M = 10.0, m = 0.5, E = 5.0 and S = 5.0)

Fig. 4(a) and Fig. 4(b) are intended to illustrate variations in the profiles of primary velocity (u) and the profiles of cross-flow (v) against non-dimensional distance z for different values of permeability parameter (K) in the range ($2.0 \le K \le 20.0$) for fixed values M=10.0, m=0.5, E=4.0 and S=3.0. It is observed that the permeability parameter increases the primary velocity but decreases the cross-flow.

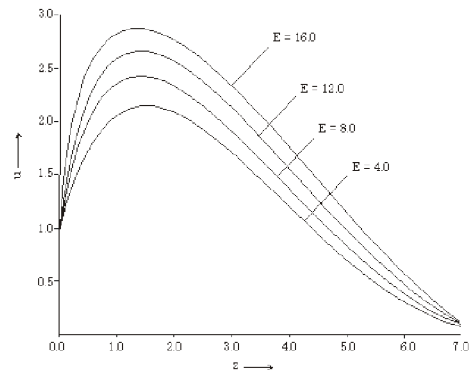

Fig.5(a): Effect of rotation parameter (E) on primary velocity
(M = 10.0, m = 0.5, K = 2.0 and S = 3.0)

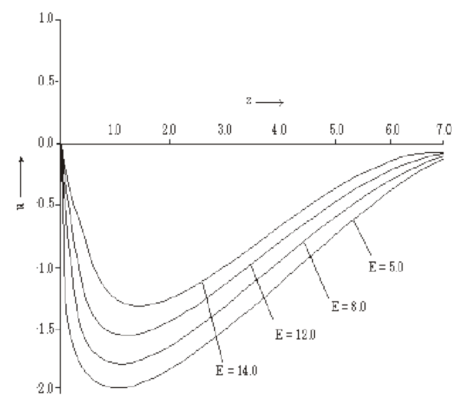

Fig.5(b): Effect of rotation parameter (E) on secondary velocity
(M = 10.0, m = 0.5, K = 2.0 and S = 5.0)

Fig. 5(a) and Fig. 5(b) demonstrate variations in the profiles of primary velocity and the profiles of cross-flow with respect non-dimensional distance *z* for different values of rotation parameter (*E*) in the range $(4.0 \leq E \leq 16.0)$ at fixed values *M*=10.0, *m*=0.5, *K*=2.0 and *S*=3.0. It is observed that an increase in rotation parameter increases the primary velocity but decreases the secondary velocity. Physically, increase in rotation implies that the fluid near the surface of the plate is forced outward due to action of centrifugal force generated by the rotation; as such the primary velocity increases, whereas the cross-flow decreases being normal to the primary flow.

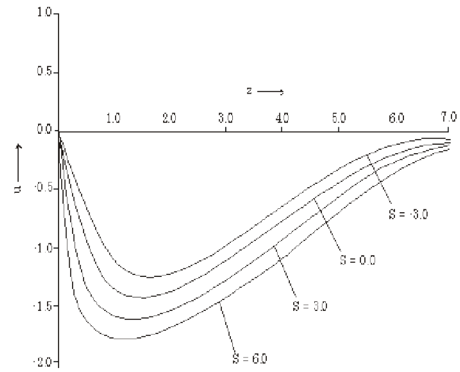

Fig. 6(b): Effect of suction/injection parameter (S) on secondary velocity (M = 10.0, m = 0.5, K = 2.0 and E = 2.0)

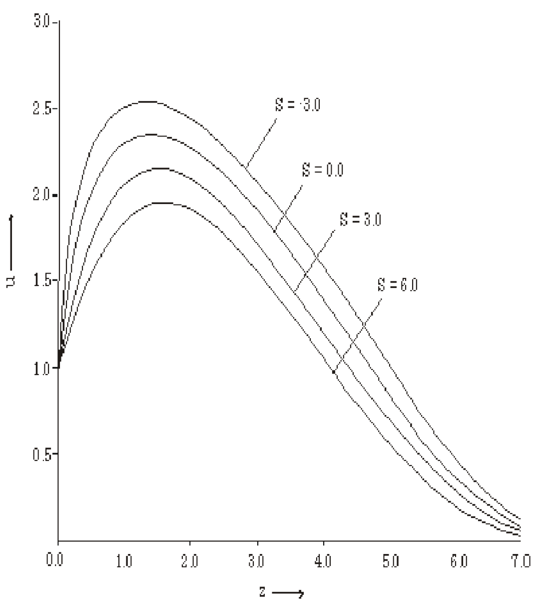

Fig. 6(a): Effect of suction/ injection parameter (S) on primary velocity (M = 10.0, m = 0.5, K = 2.0 and E = 5.0)

Fig. 6(a) and Fig. 6(b) respectively, illustrate variations in the profiles of primary velocity and secondary velocity due to change in suction/injection respectively. It is observed that the primary velocity decreases with increase in suction but increases with increase in injection. The effect of suction/injection on secondary velocity is opposite to that of primary velocity due to normal to primary velocity.

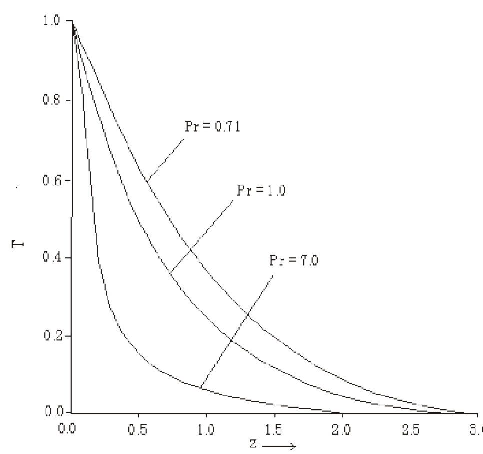

Fig. 7: Effect of Prandtl number (Pr) on temperature (H = 4.0 and N = 5.0)

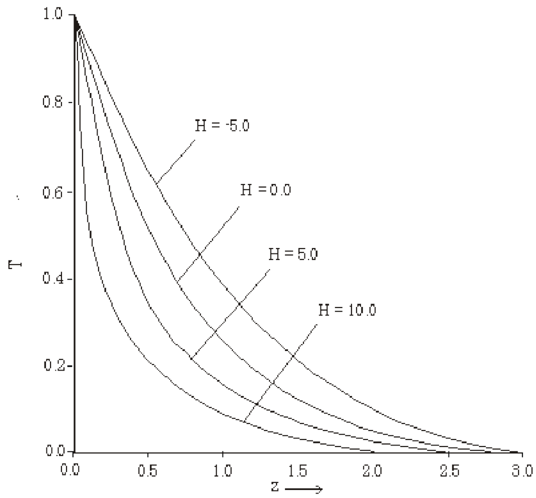

Fig.8: Effect of heat generation/ absorption parameter (H) on temperature (Pr = 1.0 and N = 5.0)

Fig. 7 depicts the effect of Prandtl number (*Pr*) on temperature for fixed *H*=4.0 and *N*=5.0. It is observed that the profiles for temperature decrease steeply for water as compared to electrolyte solutions. Physically, higher *Pr*-value fluids transfer heat more efficiently in comparison with lower *Pr*-value fluids; so that increase in Prandtl number decreases the temperature. Fig. 8 shows that increase in heat generator (*H*<0) increases the temperature whereas heat absorption (*H*>0) decreases the temperature. The case *H*=0 shows the typical physical situation when there is neither suction nor injection.

The effect of thermal radiation (*N*) on temperature field is shown in Fig. 9. It is noted that increase in thermal radiation decreases the temperature. Fig.10 shows the effect of Schmidt number (*Sc*) on representative profiles of concentration field. It is noted that an increase in smith number decreases the concentration field. In fact, the gases with lower Schmidt number are lighter than gases with higher Schmidt number; as such the gases with increased Schmidt number corresponds to decreased concentration field.

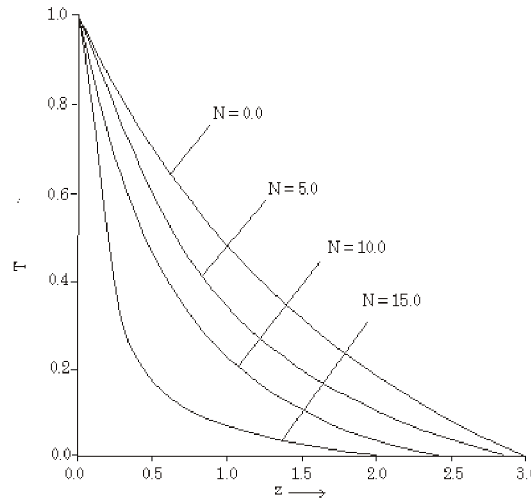

Fig. 9: Effect of thermal radiation (N) on temperature (Pr = 1.0 and H = 4.0)

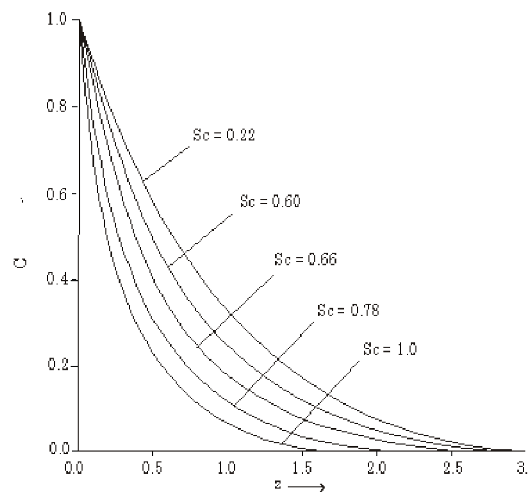

Fig.10: Effect of Schmidt number (Sc) on concentration field.

Table 1
Variations in skin-friction due to primary velocity (τ_{pri}) and secondary velocity (τ_{sec}) at the plate z = 0

E	S	m	M	K	τ_{pri}	τ_{sec}
2.0	1.0	0.5	10.0	2.0	1.95764	-1.28793
4.0	1.0	0.5	10.0	2.0	2.46853	-2.14385
2.0	2.0	0.5	10.0	2.0	1.48697	-1.14986
2.0	0.0	0.5	10.0	2.0	1.32795	-1.06983
2.0	-2.0	0.5	10.0	2.0	2.13587	-1.16972
2.0	1.0	1.0	10.0	2.0	1.66931	-1.12937
2.0	1.0	0.5	15.0	2.0	1.37426	-0.98798
2.0	1.0	0.5	10.0	10.0	1.99498	-1.33864

Table 2 Variations in Nusselt number (Nu) at

Pr	N	H	Nu
1.0	4.0	2.0	0.79325
7.0	4.0	2.0	0.98794
1.0	8.0	2.0	0.61093
1.0	4.0	0.0	0.82165
1.0	*4.0*	*-2.0*	*0.84932*

Table-1 shows the effects of different parameters (E, S, m, M, K) on the plate shearing stresses τ_{pri} and τ_{sec}. The primary shearing stress (τ_{pri}) increases owing to the increase of E, $S<0$ and K but decreases owing to increase of $S<0$, m and M. The results of these parameters are opposite on the secondary shearing stress (τ_{sec}). Finally, the Table-2 represents the effects of different parameters (Pr, N, H) on the rate of heat transfer in terms of Nusselt number (Nu). The rate of heat transfer increases with increase in Prandtl number but decreases with increase in Stark thermal radiation parameter. In case of increase in heat generation parameter ($H<0$), the rate of heat transfer increases; whereas in case of heat absorption parameter ($H>0$), the rate of heat transfer decreases.

VI. Conclusions

In this paper, we have studied the effects of the thermal radiation, rotation, suction/injection with Hall effect, permeability effect, heat generation/absorption effect on convection flow of a viscous, electrically conducting, incompressible fluid along a porous plate in rotating system. The equations governing the fluid velocity, temperature and concentration field were solved by use of Laplace transform technique. The conclusions of the study are as follows:

1. The primary velocity increases with increase in rotation, injection Hall parameter, permeability suction, but decreases with increase in magnetic field or suction.
2. The secondary velocity increases with increase in magnetic field, Hall parameter and suction parameter, whereas decreases with increase in rotation, permeability or injection parameter.
3. The temperature increases owing to increase in heat generation but decreases owing to increase in heat absorption, Prandtl number

or Stark thermal radiation parameter.

4. Increase in Schmidt number (*Sc*) decreases the concentration field.
5. The skin-friction on the plate due to primary velocity decreases with increase in magnetic field, suction or Hall parameter whereas it increases with increase in rotation, permeability or injection parameter.
6. The skin-friction on the plate due to secondary velocity decreases with increase in injection, permeability or rotation but increases with increase in magnetic field, suction or Hall parameter.
7. The rate of heat transfer increases with increase in Prandtl number or heat generation parameter but decreases with increase in heat absorption or radiation parameter.

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