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MHD Free Convection Rotating Flow Absorbing Second Grade Fluid with Hall and Ion Slip Effects

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Abstract - We have explored theoretically the Hall and ion slip impacts on an unsteady laminar MHD convective rotating flow of heat generating or absorbing second grade fluid over a semi-infinite vertical moving permeable surface. The effects of parameters on velocity, temperature and concentration are demonstrated graphically and described in detail. The thermal and solutal buoyancy forces contribute to the resultant velocity ever-increasing to high. The temperature distribution is trim downs through an increasing in heat source parameter. The velocity, temperature and concentration is analysed graphically, and computational results for the skin friction, Nusselt number and Sherwood number are also obtained.
Key words - MHD,Hall effect,ion slip effect,second grade fluid.

1. INTRODUCTION

The survey associated to free convective flow movement with in the existence of temperature resource has drained substantial concentration of numerous investigators for the duration of last few decades, since of its extensive purpose in astrophysical disciplines and cosmical study etc. Those types of flows engage in recreation and vital function in chemical engineering, aerospace science and technology etc. The gyratory fluids are extremely imperative for the reason that of its happening in an assortment of expected phenomenon and technological requirements by the Coriolis force. The comprehensive regions of numerous sciences are full of a quantity of momentous and requisite characteristics of rotational fluids. Coriolis force effect is an essential than viscous and nonreactive forces. Moreover, strengths of magnetic and Coriolis are comparable in terrible nature. The time dependent fluctuating flows have numerous applications in a lot of domains such as chemical engineering, paper manufacturing and many other scientific and industrial fields. Asghar et al. [1] have researched the flow of a non-Newtonian fluid provoked owing toward the fluctuations for a absorbent plate. Choudhury and Das [2] explored the visco-elastic magnetohydrodynamic (MHD) free convective flow in the course of permeable medium in the occurrence of radiation and chemical reaction phenomenon through heat and mass transportation. Deka et al. [3] have researched that a free convective consequences for MHD flow through an infinite perpendicular oscillating surface by constant heat discharge. Das et al. [4] have researched mass transportation effects on free convective MHD flow of a viscous fluid enclosed through a oscillating porous plate in the slip flow managed by heat source. The imperative investigation repared by Hayat et al. [5] for the flow of a non-Newtonian fluid for a oscillating surface. Manna et al. [6] addressed results of radiation on time addicted MHD free convective flow over a fluctuating vertical porous plate entrenched in an absorbent medium through oscillating heat flux. Shen et al. [7] researched the Rayleigh-Stokes predica-ment for a temperature and comprehensive second order fluid through an important fragmentary derivative modeling. Singh and Gupta [8] studied free convective MHD flow of viscous fluid during a permeable medium enclosed along with a fluctuating porous plate in slip flow management through mass transportation. Jhansi Rani and Murthy [9] explored the radiation and absorption consequences on a time dependent convective flow through a semi-infinite, inclined porous plate embedded in a porous medium through the heat and mass transport. Veera Krishna et al. [10–13] researched the MHD flows for an incompressible, electrically conducting fluid in two-dimensional channels. The results of heat radiation on MHD nanofluid flow between two parallel rotating plates are premeditated through Sheikholeslami et al. [14]. Rashid et al. [15] explored a precise modeling for two dimensional stream wise transverse magnetic fluid flows with heat transfer around a porous obstacle. Ellahi et al. [16] addressed the blood flow of Prandtl liquid through tapered and stenosed arteries in permeable walls with magnetic field. Ellahi et al. [17] explored a new hybrid technique supported on pseudo-spectral colloca-tions inside the intellect of least-squares technique is used to scrutinize the MHD flow of non-Newtonian fluid. Oahimire and Olajuwon [18] addressed the effects of Hall current, chem-ical reaction and heat radiation on heat and mass transportation of MHD flow of a micro-polar liquid through a porous medium.

Recently Veera Krishna et al. [19] explored heat and mass transportation on unsteady MHD fluctuating flow of blood through a porous arteriole. Prakash and Muthtamilselvan [20] researched the effect of radiation on transient MHD flow of micropolar

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liquid connecting absorbent vertical conduit through the boundary conditions of the third type. The heat generation or absorption and thermo-diffusion for an unsteady free convection MHD flow of radiating and chemical reacting second grade fluid at an infinite ver-tical surface through a permeable medium in addition to adopting the Hall effects into description and has been researched by Veera Krishna and Chamkha [21]. Krishna et al. [22] discussed the heat and mass transfer on MHD rotating flow of second grade fluid past an infinite vertical plate embedded in uniform porous medium with Hall effects. Most recently, Veera Krishna and Chamkha [23] addressed the diffusion-thermo, radiation-absorption, Hall and ion-slip effects on hydromagnetic natural convective rotating flow for nanofluids over a semi infinite absorbent moving plate with invariable heat source. Therefore, within the present analysis, we have explored theoretically the Hall and ion slip impacts on an unsteady laminar MHD convective rotating flow of heat generating or absorbing second grade fluid over a semi-infinite vertical moving permeable surface.

2.Formulation of the problem

We consider the heat and mass transport on an unsteady two dimensional MHD convective flow of a viscous laminar heat generating/absorbing second grade fluid over a semi-infinite vertical moving porous plate embedded in a uniform porous medium and applied to a uniform transverse magnetic field taking Hall and ion slip effects into account. The Cartesian coordinate scheme is chosen such that the xx-axis is kept along the wall in the upward direction and the z-axis is occupied perpendicular to this. A uniform magnetic field of strength B_0B_0 is proceeding in the transverse direction to the flow. Initially undisturbed state. both the fluid and plate are in rigid rotation by the uniform angular velocity $\Omega\Omega$ about the perpendicular to the plate. Also both the fluid and the plate are at respite to invariable temperature and concentration at the surface. The constitutive equation for the fluids of second grade is in the following form

$$\mathbf{T} = -p\mathbf{I} + \mu\mathbf{A}_1 + \alpha_1\mathbf{A}_2 + \alpha_2\mathbf{A}_1^2 \qquad (1)$$

where Tis the Cauchy stress tensor, $\mathbf{II}$ is the identity tensor, pp is the static fluid pressure, $\mu\mu$ is the dynamic viscosity co-efficient, $\alpha_1\alpha_1$ and $\alpha_2\alpha_2$ are the normal stress moduli, i.e., $\alpha_1\alpha_1$ is the elastic coefficient and $\alpha_2\alpha_2$ is the transverse viscosity coefficient, and the kinematic tensors $\mathbf{A}_1\mathbf{A}_1$ and $\mathbf{A}_2\mathbf{A}_2$ are defined through

$$\mathbf{A}_1 = (\text{grad } \mathbf{V}) + (\text{grad } \mathbf{V})^{\mathrm{T}}\mathbf{A}_1 = (\text{grad } \mathbf{V}) + (\text{grad } \mathbf{V})^{\mathrm{T}},$$

$$\mathbf{A}_2 = \frac{\mathbf{dA}_1}{\mathrm{dt}} + \mathbf{A}_1(\text{grad } \mathbf{V}) + (\text{grad } \mathbf{V})^{\mathrm{T}}\mathbf{A}_1 \qquad (2)$$

where $\mathbf{VV}$ is the velocity vector, grad is the gradient operator and $\mathrm{d/dtd/dt}$ denotes the material time derivative. Since the fluid is incompressible, it can undergo only isochoric motion and hence, divV$= 0= 0$ and the equation of motion is,

$$\rho\frac{\mathrm{d}\mathbf{V}}{\mathrm{dt}} = \text{div } \mathbf{T} + \rho\mathbf{F} \qquad (3)$$

where$\rho\rho$ is the density of the fluid and FF is the body force. If the fluid modeled by the Eq. (2) is to be compatible with thermodynamics, in the sense that all motions of the fluid meet the Clausius-Duhem inequality and the assumption that the specific Helmholtz free energy of the fluid takes its minimum value in equilibrium, then the material moduli must be satisfied as follows (Benharbit and Siddiqui $14\%14\%$):

$$\mu \geqslant 0, \alpha_1 \geqslant 0, \alpha_1 + \alpha_2 = 0 \qquad (4)$$

This, then, was shown to give to the theory a rather well behaved and pleasant stability and boundedness structure. It was also shown that if $\alpha_1\alpha_1$ was taken negative, the remainder of (4) being preserved, then in quite arbitrary flows instability and unboundedness were unavoidable. However, it is well known that for most non-Newtonian fluids of current rheological interest, conclusions (α) (α) are contradicted by experiments.

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$\mu \geqslant 0, \alpha_1 \leqslant 0, \alpha_1 + \alpha_2 \neq 0$

Which were supposedly obtained by data reduction from experiments for those fluids it is assumed to be constitutively described by as a second grade fluid, and it showed that such values for the material moduli led to anomalous behavior, thus questioning whether the fluid under consideration in the experiments could be described as a second grade fluid.

The unsteady hydro magnetic flow in a rotating system is controlled by the continuity, momentum, energy and concentration equations in the form as,

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{V}) = 0$$
$$\rho\left(\frac{\partial \mathbf{V}}{\partial t} + (\mathbf{V} \cdot \nabla)\mathbf{V} + 2\Omega \times \mathbf{V} + \Omega \times (\Omega \times \mathbf{r})\right) = \nabla \cdot \mathbf{T} + \mathbf{J} \times \mathbf{B} \quad (5)$$

where $\boldsymbol{J}\boldsymbol{J}$ is the current density, B is the total magnetic field, $\nabla\nabla$ is the operator, $\mathbf{TT}$ is the Cauchy stress tensor for second grade fluid, $\Omega\Omega$ is the angular velocity as well as rr is radial co-ordinate specified through

$r^2 = x^2 + y^2 r^2 = x^2 + y^2$.

The equation of energy can be specified in various manners, such as,

$$\rho\left(\frac{\partial h}{\partial t} + \nabla(\mathrm{hV})\right) = -\frac{Dp}{Dt} + \nabla \cdot (k_t \nabla T) + \Phi \quad (6)$$

where hh is the unambiguous enthalpy this is related to particular internal energy as $h = e + p/\rho h = e + p/\rho$, Tis the total temperature, $k_t k_t$ is the conductivity of thermal energy, and $\Phi\Phi$ is the dissipation variable portraying the work done versus forces of viscosity, this is irrevocably changed into internal energy. This is specified as

$$\Phi = (\tau . \nabla)\mathbf{V} = \tau_{\mathrm{ij}} \frac{\partial \mathrm{V_i}}{\partial \mathbf{x}_{\mathrm{j}}} \quad (7)$$

The pressure term on the RHS of Eq. 7 is generally abandoned. It is developed the equation of energy and assumed that, the conductive heat transport is controlled as a result of Fourier's law through the conductivity of thermal energy of the fluid. Also, radiative heat transfer and internal heat generation due to a probable chemical or nuclear reaction is deserted.

The equation of mass transfer with chemical reaction is specified by,

$$\frac{\partial C}{\partial t} = D\nabla^2 C - K_c(\mathrm{C} - \mathrm{C}_\infty) \quad (8)$$

The entire thermo-physical characteristics are assumed to be constant of the momentum equation in linear form; it is estimated in accordance with the Boussinesq approximation. The plate is extending to infinitely hence all the physical variables are function of zz and the time tt merely. Under these assumptions, the governing equations that portray the physical conditions for the flow with respect to the rotating frame are specified by,

$$\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} = 0 \quad (9)$$

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$$\frac{\partial u}{\partial t}+w\frac{\partial u}{\partial z}-2\Omega v=-\frac{1}{\rho}\frac{\partial p}{\partial x}+v\frac{\partial^2 u}{\partial z^2}+\frac{\alpha}{\rho}\frac{\partial^3 u}{\partial z^2\partial t}+\frac{B_0J_y}{\rho}-\frac{v}{k}u+g\beta(T-T_\infty)+g\beta*(C-C_\infty) \quad (10)$$

$$\frac{\partial v}{\partial t}+w\frac{\partial v}{\partial z}+2\Omega u=-\frac{1}{\rho}\frac{\partial p}{\partial y}+v\frac{\partial^2 v}{\partial z^2}+\frac{\alpha}{\rho}\frac{\partial^3 v}{\partial z^2\partial t}-\frac{B_0J_x}{\rho}-\frac{v}{k}v \quad (11)$$

$$\frac{\partial T}{\partial t}+w\frac{\partial T}{\partial z}=\frac{k_1}{\rho C_p}\frac{\partial^2 T}{\partial z^2}-\frac{Q_0}{\rho C_p}(T_w-T_\infty) \quad (12)$$

$$\frac{\partial C}{\partial t}+w\frac{\partial C}{\partial z}=D\frac{\partial^2 C}{\partial z^2}-K_c(C_w-C_\infty)\frac{\partial C}{\partial t}+w\frac{\partial C}{\partial z}=D\frac{\partial^2 C}{\partial z^2}-K_c(C_w-C_\infty)$$
(13)

It is assumed that the permeable surface actuates with a constant velocity in the direction of fluid flow. Also, the temperature and concentrations at the wall and the suction velocity is expeditiously unreliable by means of time.

$$u=U_0, v=0, T=T_w+\varepsilon(T_{w'}-T_\infty)e^{i\omega t}$$
$$C=C_w+\varepsilon(C_{w'}-C_\infty)e^{i\omega t} \quad \text{at} \quad z=0$$
$$u\to U_\infty, v\to 0, T\to T_\infty, C\to C_\infty \quad \text{as} \quad z\to\infty \quad (14)$$

The suction velocity at the surface is moreover a steady or a segment of time. Then, the velocity of suction perpendicular to the plate is assumed in the frame be,

$$w=-w_0\left(1+\varepsilon Ae^{i\omega t}\right) \quad (15)$$

where AA and $\varepsilon\varepsilon$ are optimistic constants, which fulfills the constraint $\varepsilon A \lll 1\varepsilon A \lll 1$ and w_0w_0 is extent of suction velocity and nonzero productive constant. The negative symbol designates the suction be achieve the plate.

It is introducing the non-dimensional variables,

$$q*=\frac{q}{w_0}, w*=\frac{w}{w_0}, z*=\frac{w_0z}{v}, U_0^*=\frac{U_0}{w_0}, U_\infty^*=\frac{U_\infty}{w_0}q*=\frac{q}{w_0}, w*=\frac{w}{w_0}, z*=\frac{w_0z}{v}, U_0^*=\frac{U_0}{w_0}, U_\infty^*=\frac{U_\infty}{w_0},$$

$$t*=\frac{tw_0^2}{v}, \theta=\frac{T-T_\infty}{T_w-T_\infty}, \phi=\frac{C-C_\infty}{C_w-C_\infty}t*=\frac{tw_0^2}{v}, \theta=\frac{T-T_\infty}{T_w-T_\infty}, \phi=\frac{C-C_\infty}{C_w-C_\infty},$$

$$M^2=\frac{\sigma B_0^2 v}{\rho w_0^2}, K=\frac{kw_0^2}{v^2}, \Pr=\frac{v\rho C_p}{k_1}=\frac{v}{\alpha}, R=\frac{\Omega v}{w_0^2}M^2=\frac{\sigma B_0^2 v}{\rho w_0^2}, K=\frac{kw_0^2}{v^2}, \Pr=\frac{v\rho C_p}{k_1}=\frac{v}{\alpha}, R=\frac{\Omega v}{w_0^2},$$

$$\mathrm{Gr}=\frac{v\beta g(T_w-T_\infty)}{w_0^3}$$

$$\mathrm{Gm}=\frac{v\beta g*(C_w-C_\infty)}{w_0^3}, H=\frac{vQ_0}{\rho C_p w_0^2}, S=\frac{w_0^2\alpha_1}{\rho v^2}\mathrm{Gm}=\frac{v\beta g*(C_w-C_\infty)}{w_0^3}, H=\frac{vQ_0}{\rho C_p w_0^2}, S=\frac{w_0^2\alpha_1}{\rho v^2},$$

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$\mathrm{Sc} = \frac{\upsilon}{\mathrm{D}}, \mathrm{Kc} = \frac{\mathrm{K_c}\upsilon}{\mathrm{w_0^2}}\mathrm{Sc} = \frac{\upsilon}{\mathrm{D}}, \mathrm{Kc} = \frac{\mathrm{K_c}\upsilon}{\mathrm{w_0^2}}$.

Making use of the non-dimensional variables, the governing equations are diminished to

$$\frac{\partial q}{\partial t} - \left(1 + \varepsilon A e^{i\omega t}\right)\frac{\partial q}{\partial z} = \frac{dU_\infty}{dt} + \frac{\partial^2 q}{\partial z^2} + S\frac{\partial^3 q}{\partial z^2 \partial t} - \lambda q + \mathrm{Gr}\ \theta + \mathrm{Gm}\ \phi$$

$$\frac{\partial \theta}{\partial t} - \left(1 + \varepsilon A e^{i\omega t}\right)\frac{\partial \theta}{\partial z} = \frac{1}{\mathrm{Pr}}\frac{\partial^2 \theta}{\partial z^2} - H\theta \tag{16}$$

$$\frac{\partial \phi}{\partial t} - \left(1 + \varepsilon A e^{i\omega t}\right)\frac{\partial \phi}{\partial z} = \frac{1}{\mathrm{Sc}}\frac{\partial^2 \phi}{\partial z^2} - \mathrm{Kc}\phi \tag{17}$$

The boundary conditions be,

$$q = U_0, 0 = 1 + \varepsilon e^{i\omega t}, \phi = 1 + \varepsilon e^{i(\rho)} \quad q = U_0, 0 = 1 + \varepsilon e^{i\omega t}, \phi = 1 + \varepsilon e^{i(\rho)} \quad \text{at} \quad z = 0 \quad z = 0$$

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

By using of perturbation technique $(\varepsilon << 1)(\varepsilon << 1)$, the velocity, temperature and concentration are assumed be,

$$q = q_0(z) + \varepsilon e^{i\omega t} q_1(z) + O(\varepsilon^2)$$

$$\theta = \theta_0(z) + \varepsilon e^{i\omega r}\theta_1(z) + O(\varepsilon^2)$$

$$\phi = \phi_0(z) + \varepsilon e^{i\omega t}\phi_1(z) + O(\varepsilon^2)$$

we obtained the equations of zeroth and first order be,

$$\frac{d^2 q_0}{dz^2} + \frac{dq_o}{dz} - \lambda q_0 = -\mathrm{Gr}\ \theta_0 - \mathrm{Gm}\ \phi_0 \tag{18}$$

$$\frac{d^2\theta_0}{dz^2} + \mathrm{Pr}\ \frac{d\theta_0}{dz} - H\mathrm{Pr}\ \theta_0 = 0 \tag{19}$$

$$\frac{d^2\phi_0}{dz^2} + \mathrm{Sc}\ \frac{\mathrm{d}\phi_0}{\mathrm{dz}} - \mathrm{ScKc}\ \phi_0 = 0 \tag{20}$$

$$(1 + \mathrm{Si}\omega)\frac{d^2 q_1}{dz^2} + \frac{dq_1}{dz} - \lambda q_1 = -\mathrm{Gr}\ \theta_1 - \mathrm{Gm}\ \phi_1 - \mathrm{A}\frac{\mathrm{dq_o}}{\mathrm{dz}} - \mathrm{i}\omega \tag{21}$$

$$\frac{d^2\theta_1}{dz^2} + \mathrm{Pr}\ \frac{d\theta_1}{dz} - (i\omega + H)\mathrm{Pr}\ \theta_1 = -A\mathrm{Pr}\ \frac{d\theta_0}{dz} \tag{22}$$

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$$\frac{d^2\phi_1}{dz^2} + \text{Sc}\,\frac{\mathrm{d}\phi_1}{\mathrm{dz}} - (\mathrm{i}\omega + \mathrm{Kc})\mathrm{Sc}\,\phi_1 = -\mathrm{ASc}\frac{\mathrm{d}\phi_0}{\mathrm{dz}} \tag{23}$$

Corresponding boundary conditions are,

$$q_0 = U_0, q_1 = 0, \theta_o = 1, \theta_1 = 1, \phi_o = 1, \phi_1 = 1 \text{ at } z = 0$$

$$q_0 = 0, q_1 = 0, \theta_0 = 0, \theta_1 = 0, \phi_o = 0, \phi_1 = 0 \text{ at } z \to \infty$$

$$q = a_3 e^{-m_5 z} - a_4 e^{-m_3 z} - a_5 e^{-m_1 z} + \varepsilon e^{i\omega t}\{-(a_6 + a_7 + b_3 + b_4 + a_8 + a_9 + a_{10} + a_{11})e^{-m_6 z} + a_8 e^{-m_5 z} + a_6 e^{-m_4 z} + (a_7 + a_9)e^{-m_3 z} + b_3 e^{-m_2 z} + (b_4 + a_{10})e^{-m_1 z} + a_{11}\} \tag{24}$$

$$\theta = e^{-m_3 z} + \varepsilon(a_1 e^{-m_4 z} + a_2 e^{-m_3 z})e^{i\omega t} \tag{25}$$

$$\phi = e^{-m_1 z} + \varepsilon(b_1 e^{-m_2 z} + b_2 e^{-m_1 z})e^{i\omega t} \tag{26}$$

It is observed that in case of substantially deliberate movement of the fluid. i.e., As soon as the viscous dissipation expression is deserted, the temperature and concentration profiles are mostly influenced by Prandtl number and source parameter; Schmidt number and chemical reaction parameter of the fluid accordingly. Taking into consideration,

$$q_0 = u_0 + iv_0 q_0 = u_0 + iv_0 \text{ and } q_1 = u_1 + iv_1 q_1 = u_1 + iv_1$$

The velocity distribution of the flow can be articulated as into oscillating parts,

$$q(z,t) = q_0(z) + \varepsilon q_1(z)e^{i\omega t}$$
$$u + iv = u_0 + iv_0 + \varepsilon u_1 \cos\omega t + i\varepsilon u_1 \sin\omega t + i\varepsilon v_1 \cos\omega t - \varepsilon v_1 \sin\omega t \tag{27}$$

Equating real in addition to imaginary parts,

$$u(z,t) = w_0\big(u_0(z) + \varepsilon(u_1\cos\omega t - v_1 \sin\omega t)\big)$$
$$v(z;t) = w_0\big(v_0(z) + \varepsilon(u_1 \sin\omega t + v_1\cos\omega t)\big) \tag{28}$$

Then the part for the unsteady velocity profiles for $\omega t = \pi/2 \omega t = \pi/2$ are specified by

$$u\left(z, \frac{\pi}{2\omega}\right) = w_0(u_0(z) - \varepsilon v_1(z)) \tag{29}$$

$$v\left(z, \frac{\pi}{2\omega}\right) = w_0(v_0(z) + \varepsilon u_1(z)) \tag{30}$$

For engineering curiosity, the non-dimensional skin friction, Nusselt and Sherwood number at the surface of the plate $z = 0 z = 0$ are specified by,

$$\tau = \left(\frac{dq}{dz}\right)_{z=0}, Nu = -\left(\frac{d\theta}{dz}\right)_{z=0} \tau = \left(\frac{dq}{dz}\right)_{z=0}, Nu = -\left(\frac{d\theta}{dz}\right)_{z=0} \text{and } \mathrm{Sh} = -\left(\frac{\mathrm{d}\phi}{\mathrm{d}z}\right)_{z=0} \mathrm{Sh} = -\left(\frac{\mathrm{d}\phi}{\mathrm{d}z}\right)_{z=0}$$
(31)

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3.DISCUSSION OF THE NUMERICAL RESULTS

The unsteady magneto hydrodynamic free convection flow of an incompressible electrically conducting second grade fluid bounded by an infinite vertical porous surface in a rotating system taking hall current into account under the presence of heat source and chemical reaction. The closed form solutions for the velocity $q = u + iv$, temperature θ and concentration C are obtained making use of perturbation technique. The velocity expression consists of steady state and oscillatory state. It reveals that, the steady part of the velocity field has three layer characters while the oscillatory part of the fluid field exhibits a multi layer character. Further, it is to observed that from Figures.1 (a-h) the velocity *u* reduces and *v* enhances with increasing Schmidt number *Sc*, first the velocity *u* increases and then experiences retardation where as *v* reduces in the entire fluid region with increasing chemical reaction parameter Kc. With increasing Prandtl number Pr the velocity *u* reduces and *v* enhances in the complete flow field. This implies that an increase in Prandtl number Pr leads to fall the thermal boundary layer flow. This is because fluids with large have low thermal diffusivity which causes low heat penetration resulting in reduced thermal boundary layer. Likewise the velocity *u* enhances and *v* decreases with increasing the frequency of oscillation ω and time *t*. The resultant velocity reduces with increasing Kc or Sc and increases with increasing Pr and time *t*. The temperature profiles exhibit in the Figures.2 (a-d) for different variations in source parameter *S*, Prandtl number Pr, the frequency of oscillation ω and time *t*. It is observed that Prandtl number Pr leads to decrease the temperature uniformly in all layers being the heat source parameter fixed. It is found that the temperature decreases in all layers with increase in the heat source parameter *S*. It is concluded that the heat source parameter *S* and Prandtl number Pr reduces the temperature in all layers. The temperature increases with increasing the frequency of oscillation ω and time *t*. The concentration profiles are shown in the Figures .3 (a-d) for different variations in Schmidt number Sc, the chemical reaction parameter Kc, the frequency of oscillation ω and time *t*. It is noticed that the concentration decreases at all layers of the flow for heavier species such as CO_2, H_2O and NH_3 having Schmidt number 0.3, 0.6 and 0.78 respectively. It is observed that for heavier diffusing foreign species, i.e., the velocity reduces with increasing Schmidt number Sc in both magnitude and extent and thinning of thermal boundary layer occurs. Likewise, the concentration profiles decrease with increase in chemical reaction parameter Kc. It is concluded that the Schmidt number and the chemical reaction parameter reduces the concentration in all layers. The concentration increases with increasing the frequency of oscillation ω and time *t*.

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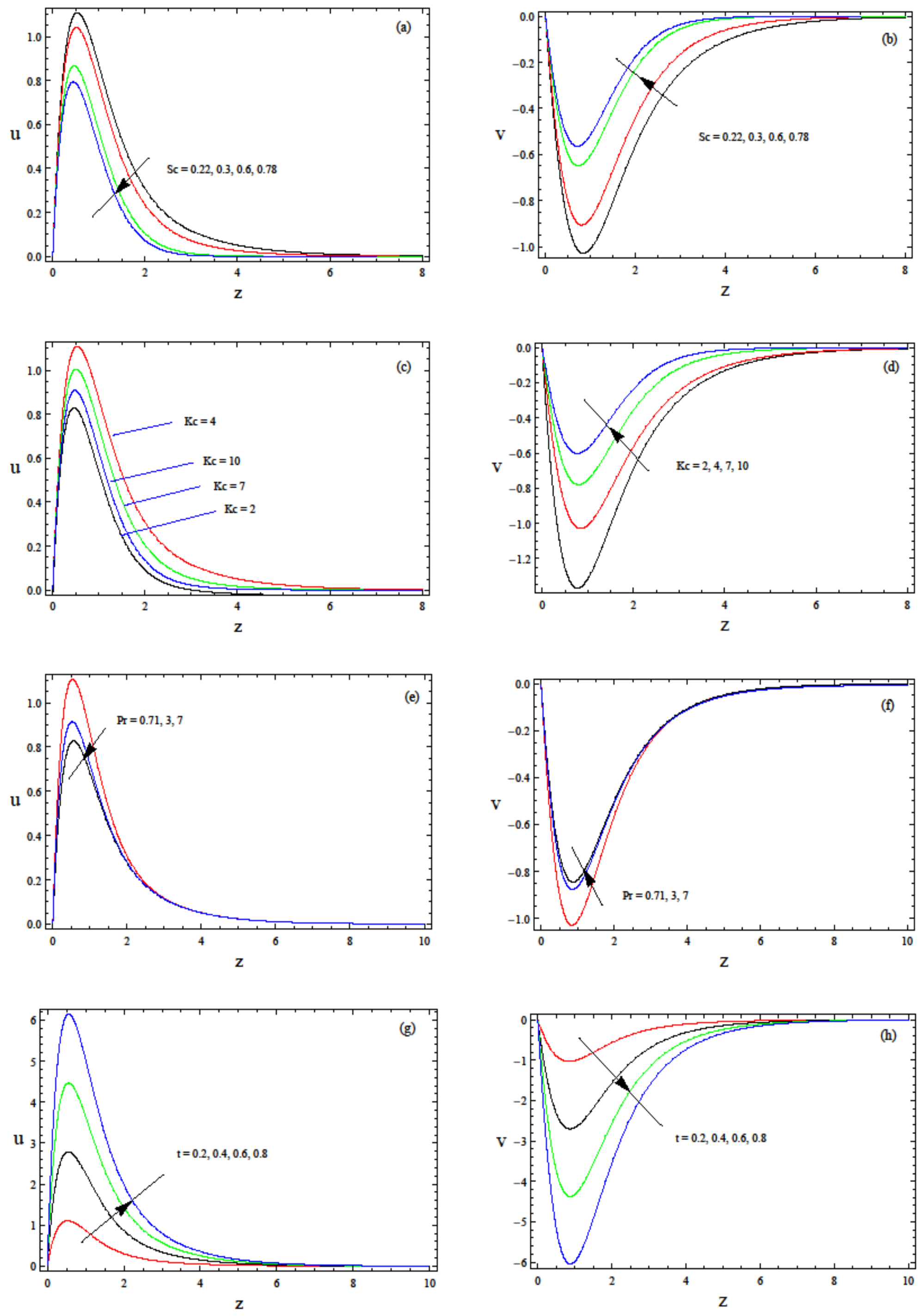

Fig. 1. The velocity profiles for the components u and v for Sc, Kc, Pr and t with $A = 0.05$; $\omega = 5\pi/2$; $\varepsilon = 0.001$, $t = 0.2$

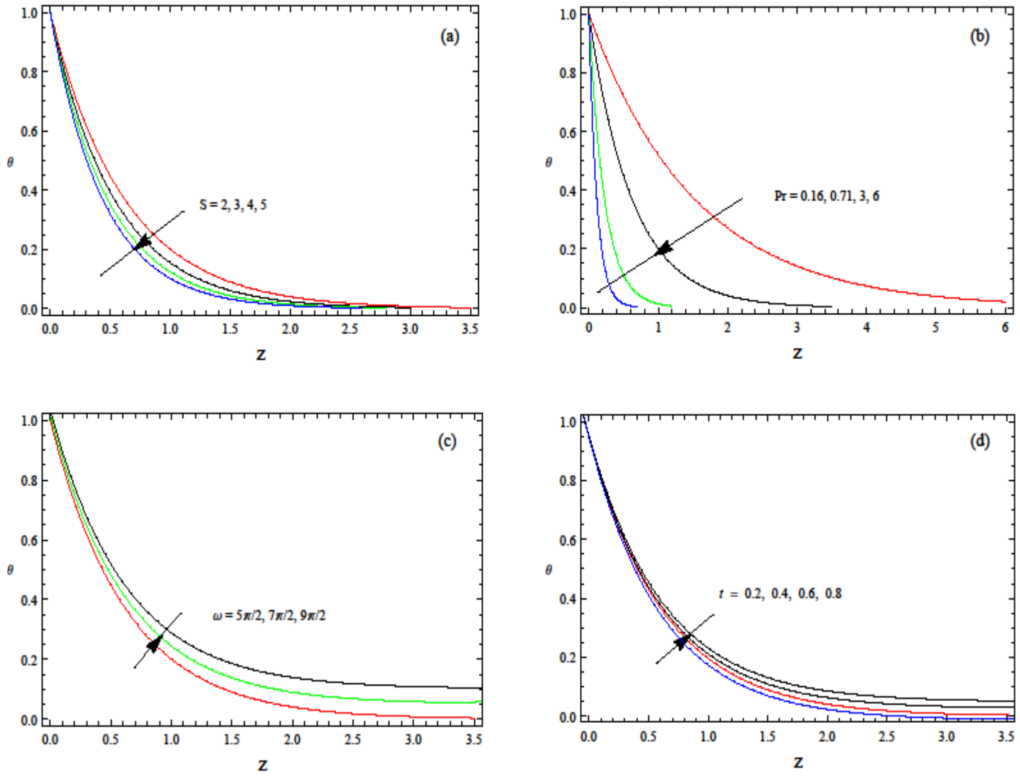

Fig. 2. The temperature profiles for θ with $A=0.05$; $\omega=5\pi/2$; $\varepsilon=0.001$, $t=0.2$

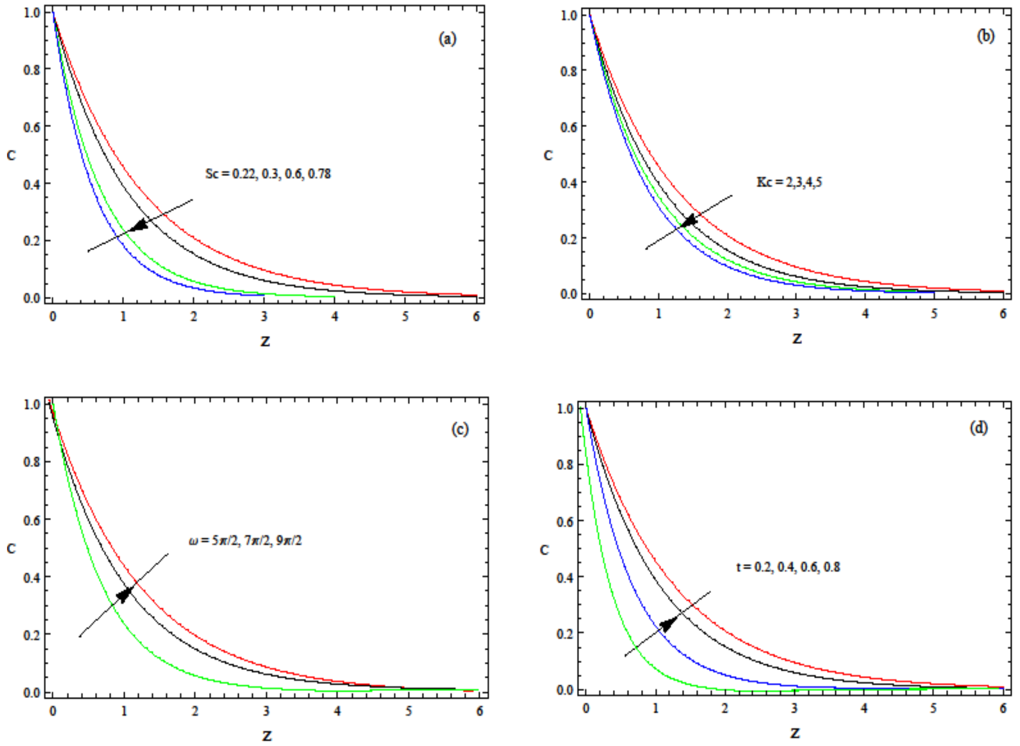

Fig. 3. The Concentration profiles for C with $A=0.05$; $\omega=5\pi/2$; $\varepsilon=0.001$, $t=0.2$

Table 1 is characterized the magnitudes of skin friction. An enlargement of Hartmann number goes ahead to diminishes in Skin friction. Because the Lorentz force on viscous fluid reduced the frictional drag. The similar behaviour is scrutinized through an augment in rotation parameter, Prandtl number and heat source parameter. Additionally, an enlargement in permeability parameter K goes ahead to bring to bear higher skin friction in enormity on the boundary of the surface, while the similar nature is

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scrutinized for the same when an augment in radiation-absorption parameter, Schmidt number, chemical reaction parameter, thermal Grashof number, mass Grashof number, Hall and ion slip parameters near the boundary of the surface. Since from the Table 2, an increment in chemical reaction parameter, Schmidt number, Prandtl number, heat source parameter, frequency of oscillation and time goes ahead to an enhancement in Nusselt number. It is reduced with an increasing in radiation-absorption parameter.

Table.1 The Shear stresses (n=0.5, A=0.5, t=0.5, u_0=0.5, ε =0.001)

M	K	R	Pr	Gr	Gm	Sc	Kc	H	Q1	be	bi	S
2	0.5	1	0.71	5	3	0.22	1	1	1	1	0.2	2.457624
3												1.809272
4												1.543358
	1.0											2.838459
	1.5											2.974925
		2										2.390174
		3										2.376257
			3									1.238521
			7									1.206082
				10								4.387113
				15								6.367006
					6							3.631735
					9							4.833842
						0.3						3.006961
						0.6						13.48957
							2					3.427082
							3					5.085501
								2				1.196454
								3				1.145125
									2			5.962632
									3			9.556867
										2		2.885719
										3		3.106757
											0.4	2.499888
											0.6	2.549612

Table.2 The Nusselt number (A=0.5, ε =0.001)

K_c	Q_1	Sc	H	Pr	n	t	Nu
1	1	0.22	1	0.71	0.5	0.5	0.639327
2							0.762751
3							0.836533
	2						-0.22994
	3						-0.09965
		0.30					0.725139
		0.60					0.916283
			2				1.161886

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			3				1.521334
				3			3.309965
				7			7.458498
					1		0.640091
					1.5		0.641096
						1	0.639783
						1.5	0.64037

4.REFERENCES

[1] S. Asghar, M.R. Mohyuddin, T. Hayat, A.M. Siddiqui, The flow of a non-Newtonian fluid induced due to the oscillations of a porous plate, Math. Prob. Eng. 2 (2004) 133–143.

[2] R. Choudhury, S.K. Das, Visco-elastic MHD free convective flow through porous media in presence of radiation and chemical reaction with heat and mass transfer, J. Appl. Fluid Mech. 7 (2014) 603–609.

[3] R.K. Deka, U.N. Das, V.M. Soundalgekar, Free convection effects on MHD flow past an infinite vertical oscillating plate with constant heat flux, Ind. J. Math 39 (1997) 195–202.

[4] S.S. Das, R.K. Tripathy, S.K. Sahoo, B.K. Dash, Mass transfer effects on free convective MHD flow of a viscous fluid bounded by an oscillating porous plate in the slip flow regime with heat source, J. Ultra Scientist of Phys. Sci. 20 (2008) 169–176.

[5] T. Hayat, M.R. Mohyuddin, S. Asghar, A.M. Siddiqui, The flow of a visco-elastic fluid on an oscillating plate, Z. Angew. Math. Mech. 84 (2004) 65–70.

[6] S.S. Manna, S. Das, R.N. Jana, Effects of radiation on unsteady MHD free convective flow past an oscillating vertical porous plate embedded in a porous medium with oscillatory heat flux,Adv. Appl. Sci. Res. 3 (2012) 3722–3736.

[7] F. Shen, W. Tan, Y. Zhao, T. Masuoka, The Rayleigh-Stokes problem for a heated generalized second grade fluid with fractional derivative model, Nonlinear Anal. Real World Appl. 7 (2006) 1072–1080.

[8] P. Singh, C.B. Gupta, MHD free convective flow of viscous fluid through a porous medium bounded by an oscillating porous plate in slip flow regime with mass transfer, Ind. J. Theo. Phys.53 (2005) 111–120.

[9] Veera Krishna.M., Subba Reddy.G., Unsteady MHD reactive flow of second grade fluid through porous medium in a rotating parallel plate channel, J. Anal., 27(1), pp. 103-120, 2019.https://doi.org/10.1007/s41478-018-0108-3.

[10] M. Veera Krishna, B.V. Swarnalathamma, Convective heat and mass transfer on MHD peristaltic flow of Williamson fluid with the effect of inclined magnetic field, AIP Conf. Proc. 1728 (2016), https://doi.org/10.1063/1.4946512 020461.

[11] B.V. Swarnalathamma, M. Veera Krishna, Peristaltic hemodynamic flow of couple stress fluid through a porous medium under the influence of magnetic field with slip effect, AIP Conf. Proc. 1728 (2016), https://doi.org/10.1063/1.4946654 020603.

[12] M. Veera Krishna, M. Gangadhar Reddy, MHD free convective rotating flow of Visco-elastic fluid past an infinite vertical oscillating porous plate with chemical reaction, IOP Conf. Series Mater. Sci. Eng. 149 (2016), https://doi.org/10.1088/1757-899X/149/1/012217 012217.

[13] M. Veera Krishna, G. Subba Reddy, Unsteady MHD convective flow of second grade fluid through a porous medium in a rotating parallel plate channel with temperature dependent source, IOP Conf. Series Mater. Sci. Eng. 149 (2016), https://doi.org/10.1088/1757-899X/149/1/012216 012216.

[14] M. Sheikholeslami, D.D. Ganji, J.M. Younus, R. Ellahi, Effect of thermal radiation on magnetohydrodynamics nanofluid flow and heat transfer by means of two phase model, J. Magn. Magn. Mater. 374 (2015) 36–43, https://doi.org/10.1016/j.jmmm.2014.08.021.

[15] S. Rashidi, M. Dehghan, R. Ellahi, M. Riaz, M.T. Jamal-Abad,Study of stream wise transverse magnetic fluid flow with heat transfer around a porous obstacle, J. Magn. Magn. Mater. 378 (2015) 128–137, https://doi.org/10.1016/j.jmmm.2014.11.020.

[16] R. Ellahi, S.U. Rahman, S. Nadeem, K. Vafai, The blood flow of Prandtl fluid through a tapered stenosed arteries in permeable walls with magnetic field, Commun. Theor. Phys. 63 (3) (2015) 353–358.

[17] R. Ellahi, E. Shivanian, S. Abbasbandy, T. Hayat, Analysis of some magnetohydro dynamic flows of third order fluid saturating porous space, J. Porous Media 18 (2) (2015) 89–98,https://doi.org/10.1615/JPorMedia.v18.i2.10.

[18] J.I. Oahimire, B.I. Olajuwon, Effect of Hall current and thermal radiation on heat and mass transfer of a chemically reacting MHD flow of a micro-polar fluid through a porous medium, J.King Saud University Eng. Sci. 26 (2014) 112–121, https://doi.org/10.1016/j.jksues.2013.06.008.

[19] M. Veera Krishna, B.V. Swarnalathamma, J. Prakash, Heat and mass transfer on unsteady MHD Oscillatory flow of blood through porous arteriole, Appl. Fluid Dyn. Lect. Notes Mech.Eng. XXII (2018) 207–224, https://doi.org/10.1007/978-981-10-5329-0_14.

[20] D. Prakash, M. Muthtamilselvan, Effect of radiation on transient MHD flow of micropolar fluid between porous vertical channel with boundary conditions of the third kind,Ain Shams Eng. J. 5 (2014) 1277–1286, https://doi.org/10.1016/j.asej.2014.05.004.

[21] M. Veera Krishna, A.J. Chamkha, Hall effects on unsteady MHD flow of second grade fluid through porous medium with ramped wall temperature and ramped surface concentration,Phys. Fluids 30 (2018), https://doi.org/10.1063/1.5025542 053101.

[22] Krishna, M.V., Reddy, M.G., Chamkha, A.J., Heat and mass transfer on MHD rotating flow of second grade fluid past an infinite vertical plate embedded in uniform porous medium with Hall effects, Applied Mathematics and Scientific Computing, Trends in Mathematics, 1, pp. 417-427. https://doi.org/10.1007/978-3-030-01123-9_41.

[23] Veera Krishna, M., Chamkha, A.J., Hall and ion slip effects on MHD rotating boundary layer flow of nanofluid past an infinite vertical plate embedded in a porous medium, Results in Physics,15, 102652, https://doi.org/10.1016/j.rinp.2019.102652.